Invited Talks: Abstracts and Biographical Information

Martha Siegel, *Undergraduate Research in Applied Mathematics for Fun and Profit*

Biographical Information: Martha J. Siegel is Professor of Mathematics at Towson University. She is stepping down from the current Secretary of the Council of University System Faculty of the University System of Maryland, Co-PI of the Towson University CoSMIC Scholars Program, and recently completed a 14-year term as Secretary of the Mathematical Association of America.

Dr. Siegel holds a Ph.D. in stochastic processes from the University of Rochester and served a post-doctoral fellowship in operations research and mental health at the School of Hygiene and Public Health of the Johns Hopkins University.

Abstract: Student teams working on applied projects for industrial and government sponsors is one way to engage in research that informs students and faculty. The talk will describe some of the most exciting projects and explain how to start a consulting service of your own.

Christine Shannon, How To Solve It – Approximately!

Biographical Information: Christine Shannon grew up near Detroit, Michigan where she attended Marygrove College and graduated summa cum laude with a major in Mathematics. She earned a Ph.D. in mathematics at Purdue University writing a dissertation on the second dual of C(X). She later earned a master's degree in computer science from the University of Kentucky and has been teaching in both fields ever since. She taught at Georgetown College for many years before coming to Centre in 1989, where she is a professor of mathematics and computer science. Dr. Shannon has been designated as the Haggin Professor of Science since 1997.

Abstract: Some problems are very hard to solve. Even if we know how to find an exact solution, the size of the problem may make it infeasible to compute a solution in a reasonable amount of time and/or space. The area of genetic algorithms has opened a new way of developing heuristics for optimization problems. This talk will be based on an undergraduate research project conducted with a student at Centre and will deal with a large scheduling problem. In the process I will touch on what I think constitutes a good undergraduate research project and why the merger of mathematics and computer science can offer fertile ground for asking interesting questions.

David Shannon, *Are All the Good Problems Solved?*

Biographical Information: Dr. Shannon received his Ph.D. at Purdue University in 1971 under the mentorship of S.S. Abhyankar in the fields of algebraic geometry and commutative algebra. He has taught at Transylvania University since 1977. Within the MAA, he has been chair of the KYMAA and coordinated the AMC for Kentucky for several years.

Abstract: My talk will be directed to undergraduate students, especially those who contemplate a career doing mathematics and teaching mathematics. My field of interest is algebraic geometry and commutative algebra. I will focus my remarks on:

- What is algebraic geometry? (A very short definition!)
- Some "elementary" but "difficult" problems in algebraic geometry that have intrigued me over the last forty years – some which have been solved and some which have not.
- Some (brief) reflections on the question: What makes a good mathematics teacher?

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Bruce Reznick, *The Secret Life of Polynomial Identities*

Biographical Information: Dr. Reznick received his undergraduate degree from the California Institute of Technology and his Ph.D. from Stanford University. He has received numerous awards and has held prestigious positions as an active member of the mathematical community. He is currently a professor of mathematics at the University of Illinois, Urbana Champaign where he has been since 1979.

Abstract: Polynomial identities can reflect deeper mathematical phenomena. In his talk, Dr. Reznick will discuss some of the stories behind the following three identities (and their relatives):

$$1024x^{10} + 1024y^{10} + (x + \sqrt{3}\,y)^{10} + (x - \sqrt{3}\,y)^{10} + (\sqrt{3}\,x + y)^{10} + (\sqrt{3}\,x - y)^{10} = 1512(x^2 + y^2)^5 \tag{1}$$

$$x^3 + y^3 = \left(\frac{x(x^3 + 2y^3)}{x^3 - y^3}\right)^3 + \left(\frac{y(y^3 + 2x^3)}{y^3 - x^3}\right)^3, \tag{2}$$

$$(x^2 + \sqrt{2}\,xy - y^2)^5 + (ix^2 - \sqrt{2}\,xy + iy^2)^5 + (-x^2 + \sqrt{2}\,xy + y^2)^5 + (-ix^2 - \sqrt{2}\,xy - iy^2)^5 = 0 \tag{3}$$

Equation (1) has roots in 19th century mathematics; (2) is due to Viéte (1592); (3) was independently found by Desboves (1880) and Elkies (1995). Their stories involve algebra, analysis, number theory, combinatorics, geometry and numerical analysis. Fourteenth powers of polynomials will show up.

Abstracts of Contributed Talks

(u) = undergraduate, (f) = faculty member

Donald Adongo, Murray State University (f)
A TVD Method for Hyperbolic Conservation Laws
Numerical solutions of hyperbolic conservation laws may develop spurious oscillations or be smeared to the extent of not capturing the sharp profiles of the true solution. We discuss a method that maintains the characteristics of the true solution and when applied to certain underlying numerical schemes it raises the order of the underlying schemes by one.

John Albers, Jefferson Community and Technical College (f)
Reconciling Triangle Measurements: An Exercise in Constrained, Multivariable Optimization
One project assigned geometry students is to measure the sides and angles of a triangle and verify that the law of sines and the law of cosines apply. Typically, the calculations only agree to two or three digits because of the inaccuracies involved with using rulers and protractors. An algorithm, and the subject of this presentation, has been developed which minimizes the adjustments needed to fit the law of sines to five digits. As expected, the differences between measured and adjusted values are typically within the measurement error.

Virgil Barnard, Kentucky State University (u)
Interesting Graphing Methods/ Stages of Their Construction
Taking a look at: 3n+1, Spiral Factoring, Symmetry in Primes, and a few others ..., using a few new graphing methods catered to each problem's individual characteristics. The construction of each graph is shown in stages by means of flip-book presentations, with the intent that these concepts then "come to life".

Benjamin Baxter, Nick Cooper and Spencer Egart, Northern Kentucky University (u)
Kill Me Once, Shame on You. Kill Me Twice, Shame on Me
(An MCM Problem B Solution)
We consider the problem of developing a "geographic profile" of a suspected serial criminal. We present a probabilistic model that is used to predict possible locations of the next crime based on the time and locations of past crimes. Using data from five separate previous crime incidents, our model predicts the location of the next crime with 95% confidence.

Robin Blankenship, Morehead State University (f)
Talking the Talk; Walking the Walk: Descriptions of an Inquiry-Based Classroom
Relying on student presentations and group work as the primary means of delivering content presents its own challenges in the classroom. I will discuss various methods of requiring students to present solutions at the board and handle audience interaction, the use of yes-no cards as a time management tool during group work, and empowering students with study methods for both class and test preparation. Emphasis of NCTM process standards and personal responsibility for learning can really take students well out of their comfort zones, so

modifications to promote a positive, safe environment will also be discussed. Finally, I will compare confidence and style of presenting between students who have taken my classes before and students who haven't, and describe accommodations to help ease the latter group into the new situation.

Evan Boyd, Morehead State University (u)
Ranking College Football with Random Walkers
There is a lot of concern with the way college football teams are being ranked, and many systems have been designed to address this issue. We will consider some of these systems, and one in particular which uses a random walker algorithm. We will then show how adding a home-field advantage factor to this particular system affected the overall rankings for the 2009 season. We will compare the results of our modified ranking system with the original random walker rankings which considered only wins and losses. If you don't like Florida, you will probably enjoy this talk.

Joshua Bradley, Morehead State University (u)
Mobile Data Mining Algorithm for the 4G Mobile Network
Due to the rise of location based services and the upcoming fourth generation (4G) cellular network, there is a motivation to define 4G network standards. Mobile users are thought to be predictable on a daily basis. In this presentation, we will focus on the MobileSPADE algorithm which has been designed for the 4G wireless mobile network. This algorithm utilizes data partitioning methods via time frame windows, a classification scheme that defines weekdays and weekends, and various other predictive analytics to extract frequent sequential mobility patterns from past mobility history made by a mobile user. Effects of this research extend to a better consolidation of network resources, location-based services, and improved signal communication reception. Experimental results show that MobileSPADE algorithm exhibits remarkable performance results in the prediction of future locations for various mobile users in the network.

Krystal Brewington, Morehead State University (u)
An Upper Bound for an NxN Knot Mosaic
Knot mosaics studied by Louis H.Kauffman and Samuel J. Lomonaco are each made up of eleven different square tiles called mosaic tiles. In this presentation, we will address the open question of how many true knots are in an NxN knot mosaic and also establish a smaller upper bound than the upper bound of 11^{n^2}.

Woody Burchett, Joy Neace, and Elizabeth Wiggins, Georgetown College (u)
Predicting Behavior of Serial Criminals
Rossmo's formula is used by police agencies to estimate the probable residences of serial criminals based on their past crime locations. This presentation demonstrates how using this formula can generate probabilities of the locations of future crime scenes. The result combines use of this formula with the relationship between crime sites and population density to reduce the size of the estimated region of future sites associated with the criminal.

Eungchun Cho, Kentucky State University (f)
Estimating $\pi_0(X)$ from Samples on X
Topology is useful for representing certain structures in large scale data sets. We show an elementary concept in topological spaces correspond to the statistical concept of clustering. Clustering corresponds to finding connected components of the data in a topological space. If a sufficient number of sample points representative of an underlying set are taken, they can be used to decide the (path) connected components of X. We show how a filtered sequence of simplicial complices built from data points is used to compute the Betti numbers.

Chris Christensen, Northern Kentucky University (f)
Ramping up to World War II
In the 1920s the US Navy began trying to locate and train cryptanalysts for "the next war." As part of that process, a correspondence course in cryptanalysis was offered to selected university faculty – many of whom were mathematicians. The mathematicians who were selected by this process and served as cryptologists during World War II formed an impressive group – a collection who would rival the collection of mathematicians at Britain's Bletchley Park. We will discuss some of the mathematicians who served as cryptologists during World War II and after.

Tyler Clark, Western Kentucky University (u)
Collections of Mutually Disjoint Convex Subsets of a Totally Ordered Set
We present a combinatorial proof of an identity for the Fibonacci number F_{2n+1} by counting the number of collections of mutually disjoint convex subsets of a totally ordered set of n points. We discuss how the problem is motivated by counting certain topologies on finite sets.

Adam Coffman, Indiana University – Purdue University Fort Wayne (f)
Glaeser's Inequality on an Interval
"Glaeser's Inequality" is a theorem of elementary calculus which states that for a function f which is positive on $\boldsymbol{R}$ and has second derivative bounded by M, the first derivative satisfies $|f'(x)|\leq\sqrt{(2Mf(x))}$ at every point x. It is easy to find counterexamples if we change the domain $\boldsymbol{R}$ to an arbitrary interval, but I will present an analogous pointwise inequality for functions on an interval, which specializes to Glaeser's inequality as a limiting case. (Joint work with Y. Pan)

Nick Cooper, Northern Kentucky University (u) – See Benjamin Baxter

Jessamyn Delgado, Morehead State University (u)
Learning Software Evaluation: Hawkes Learning System
Technology is a useful tool in secondary education and college environments. However, in order for it to be effective, the technology has to be well known by all parties using it and supplemental instruction needs to be added to the teaching methods surrounding the specific software or hardware. Morehead State University uses many different educational technology tools in its classrooms, and the focus of this research is on the Hawkes Learning System utilized by the Mathematics, Computer Science, and Physics Department of Lappin Hall. Before determining if the Hawkes Learning System is a successful and effective learning software, the requirements of/for effective learning software must be determined. Once those requirements have been established, an analysis will be conducted to determine if the Hawkes Learning System meets those requirements. Following that analysis, other factors will be introduced that

may have an influence over the effectiveness of this or any educational software. Once all factors have been considered, suggestions will be presented as to how to better utilize the software in the classroom environments on Morehead State University's campus as well as additional information on how the software could be modified to better meet the needs of the students and facilities for Morehead State University. Options for further research will be presented as the conclusion of this current research.

Marcia Edson, Murray State University (f)
A New Generalization of Fibonacci Sequence & Extended Binet's Formula
Consider the Fibonacci sequence $\{F_n\}_{n=0}^{\infty}$ having initial conditions $F_0 = 0, F_1 = 1$ and recurrence relation $F_n = F_{n-1} + F_{n-2}$ $(n \geq 2)$. The Fibonacci sequence has been generalized in many ways, some by preserving the initial conditions, and others by preserving the recurrence relation. In this article, we study a new generalization $\{q_n\}$, with initial conditions $q_0 = 0$ and $q_1 = 1$ which is generated by the recurrence relation $q_n = aq_{n-1} + q_{n-2}$ (when *n* is even) or $q_n = bq_{n-1} + q_{n-2}$ (when *n* is odd), where *a* and *b* are nonzero real numbers. Some well-known sequences are special cases of this generalization. The Fibonacci sequence is a special case of $\{q_n\}$ with $a = b = 1$. Pell's sequence is $\{q_n\}$ with $a = b = 2$ and the *k*-Fibonacci sequence is $\{q_n\}$ with $a = b = k$. We produce an extended Binet's formula for the sequence $\{q_n\}$ and, thereby, identities such as Cassini's, Catalan's, D'Ocagne's, etc.

Spencer Egart, Northern Kentucky University (u) – See Benjamin Baxter

Christopher Estes, Morehead State University (u)
Intrusion Detection in Mobile Wireless Networks Using Data Mining Techniques
As wireless networks become more prominent in our society, security for these networks is a growing issue. Due to the lack of a physical infrastructure these networks are much easier to infiltrate and many old security solutions no longer work. It has become clear that a new method of security needs to be developed and the popular solution to this is through the use of data mining techniques. We focus on the anomaly detection side of intrusion detection and our proposition is to utilize a combination of clustering and classification algorithms in order to build a normal profile for a mobile user, so that any intrusions can be tested against this pattern and found and dealt with more efficiently. In this pursuit we have currently worked with the K-Means clustering algorithm, and looked at various other algorithms such as Apriori, Support Vector Machines, and Frequent Pattern Trees. Our goal is to find the most time efficient method for developing a normal profile and responding to intrusions.

Craig Hamilton, Morehead State University (u)
Knot Mosaics Using Hex-tiles
Knot mosaics using square tiles, studied by Lomonaco and Kauffman, inspired the creation of hex-tile knot mosaics, tessellations of hexagons with one, two, or three strands connecting midpoints of edges in various over and under crossing patterns, used to create knots and links. Results similar to Kuriya's involving mosaic planar isotopy moves and Reidemeister moves will be discussed, in addition to investigating knots that can be constructed within a given radius using a fixed two-strand tile with a single crossing at its center.

Boubakari Ibrahimou, Murray State University (f)
Applying Generalized Additive Mixed Models to Air Pollution Data
Generalized additive mixed models are proposed for overdispersed and correlated data, which arise frequently in studies involving clustered, hierarchical and spatial designs. This class of models allows flexible functional dependence of an outcome variable on covariates by using nonparametric regression, while accounting for correlation between observations by using random effects. In this study, we applied the model to air pollution data to identify trend and seasonality.

Dhanuja Kasturiratna, Northern Kentucky University (f)
Characterizations of Normal Distribution and Applications to Goodness-of-fit Tests
A characterization of normal distribution related to two samples based on second conditional moments will be presented. This characterization will be changed to characterization based on the UMVU estimators of the density functions, then to characterization using Student's t distribution. Using these characterizations, the EDF goodness-of-fit tests for testing the distributional assumptions in ANOVA will be discussed. The above characterization results will then be extended to a characterization of multivariate normal distribution and the corresponding applications to EDF goodness of fit tests will be discussed. The powers of the tests will be studied using Monte Carlo methods for several alternatives.

Julie Lang, Morehead State University (u)
Does the Amount of Lecture Make a Difference in Learning College Algebra?
Results comparing a pilot College Algebra Redesign project to a traditional course will be presented. The College Algebra Redesign at Morehead State University includes reduced lecture time and expands laboratory time. Through the use of technology, students are actively involved in learning algebra and tracking their own progress. Professors use their expertise in addressing individual needs. Additionally, any differences due to instructors and due to the sex of the student will be presented.

Kelli Lang, Transylvania University (u)
The 3n+1 Algorithm and Twin Hailstones
Given a positive integer, the 3n+1 Algorithm generates a hailstone sequence of positive integers. This presentation describes "twin" patterns that emerge in the hailstone sequence: certain consecutive numbers assume the same value after a predictable number of iterations. These patterns have possible connections about the Collatz Conjecture.

Andy Martin, Kentucky State University (f)
Archimedes' Puzzling Work: The Stomachion
The incredible story of the Archimedes Palimpsest – how it was lost, then found, then lost and found again is dramatically told in the Neumann-Prize-winning 2009 book *The Archimedes Codex* by Reviel Netz and William Noel, and in the NOVA documentary *Infinite Secrets*. The last part of this palimpsest is a fragment dealing with a tangrams-like puzzle, the stomachion. Most of this work is missing. Why was Archimedes writing about this?

Andy Martin, Kentucky State University (f)
The Freshman Liberal Arts Math Requirement for Students not Majoring in STEM Subjects
What sort of course is appropriate for (mostly) freshmen with (mostly) weak math backgrounds and skills, who are not planning to major in STEM areas? Kentucky State University, like most liberal arts colleges and universities, has a required 3 credit course, MAT 111 (Contemporary Mathematics). Having taught this twelve times (two this term), I would like to share some thoughts concerning it.

Lauren May, Morehead State University (u)
Does the Rook Card Make a Difference?
The card game *Rook* did not originally include a Rook card. Strategies and statistics for the game were established in The Rook Book. This presentation examines some of those strategies and statistics addressed in the book to determine if including the Rook card makes a difference in game play.

Joy Neace, Georgetown College (u) – See Woody Burchett

Biswajit Panja, Morehead State University (f)
Certification Scheme in Wireless Sensor Networks
Digital signature scheme can provide and retain the authenticity of the nodes. However, existing digital signature schemes cannot directly be applied to the sensor networks because of the hardware limitations. In this presentation, a new protocol named HCSN is introduced to solve the problem. In this scheme, instead of an individual node a group of nodes acts as a certificate authority. It follows the rule of a proxy signature scheme, where the base station as original signer delegates its signing power to a group of nodes. The group of nodes as the proxy signer can sign message on behalf of the base station. After the verifier node receives the signature it can check both validity of the signature and identification of the CA (Certification Authority) nodes. There are two main types of delegation in the proxy signature schemes; they are full delegation and partial delegation. In full delegation the base station sends its private key to the proxy signer. In partial delegation, combination of private key of the base station and ID of the nodes are used to create signature for authentication of nodes. The authentication of the nodes is done by verification of a proxy signature.

Robert C. Powers, University of Louisville (f)
McGarvey's Theorem for Losers
In 1953, David McGarvey showed that if the number of voters is unrestricted, then the set of outputs obtained from majority rule is a very general class of binary relations. We will present an analog of McGarvey's Theorem for a new version of majority rule where the set of outputs is a very general class of ternary relations.

Timothy Schroeder, Murray State University (f)
JSJ-decomposition of Coxeter Manifolds
Associated to any Coxeter system (W,S), there is a contractible CW-complex Σ (the Davis complex) on which W acts properly and cocompactly. Under JSJ-decomposition: Every (non-spherical) such Coxeter manifold has a decomposition into pieces which have hyperbolic, Euclidean, or the geometry or $\mathrm{H}^2 \times \mathbf{E}$.

Duane Skaggs, Morehead State University (f)
Large Identifying Codes in Graphs
An *identifying code* in a graph G is a set of vertices C such that every vertex in G is adjacent to a unique nonempty subset of C. When a graph of order n with at least one edge has an identifying code, it is known that no more than $n - 1$ vertices are needed in any identifying code. We describe graphs which require $n - 1$ vertices in any identifying code. This is joint work with Marietjie Frick and Gerd H. Fricke.

Josh Sparks, Eastern Kentucky University (u)
Investigating Function Convergence Conditions to Determine Total Variation Convergence
It can easily be shown that a sequence of functions, depending on the interval, may also possess a range of combinations of being point-wise convergent, uniformly convergent, and convergent in variation. So, which qualities combined with point-wise convergence actually allow convergence in variation? This report will investigate which conditions a converging sequence of functions (many which do not satisfy uniform convergence) – given that each function $f_n, f \in BV[a,b]\ \forall\, n \in \mathbb{N}$ – will allow for $T_{f_n}[a,b] \rightarrow T_f[a,x]$.

Amanda Stevenson, Northern Kentucky University (u)
Type I Error Rates for Statistical Tests Comparing Two Independent Samples of Quantitative Data: A Simulation Study
When comparing two independent samples of quantitative data, there are a variety of statistical tests that can be used, such as the t-test with pooled variance, the t-test with the Satterthwaite approximation for degrees of freedom, and the Mann-Whitney test. However, each of these tests requires certain assumptions to be met in order for the inference to be valid. The purpose of this talk is to present preliminary simulation study results on the empirical Type I error rates for these three tests under various conditions violating common assumptions.

Ryan Stuffelbeam, Transylvania University (f)
The Collatz Conjecture and the 2-adic Integers
The Collatz Conjecture asks whether the 3n+1 Algorithm always reaches the terminal repetition consisting of twos and ones. Arising from a 2-adic absolute value on the rationals, the 2-adic integers are useful number-theoretic objects. This presentation describes a link between the 3n+1 Algorithm and the 2-adic integers and presents an alternative approach to the Collatz Conjecture.

Amanda Sutherland, University of Louisville (u)
Quaternary Representations in Phylogenetics
A quaternary representation is a one-to-one mapping from the set of all semi-labeled S-trees into the set of all possible quaternary relations on S (where S is a finite set of labels). There is a well-known quaternary representation in phylogenetics and we give a new characterization of this representation.

Jenna Torres, Northern Kentucky University (u)
Lester Hill: Creating Long Cipher Keys
In 1929 Hunter College mathematician Lester Hill developed the first true block cipher by using matrix encryption. In the 1950s, Hill wrote several memorandums describing encryption techniques for Naval Communications and the National Security Agency. One of the ideas that Hill explored was the construction of long keys for Vigenère-like encryption. We will examine one method of constructing long keys that Hill described in a June 1956 memorandum to Naval Communication.

Elizabeth Wiggins, Georgetown College (u) – See Woody Burchett

Di Wu, Western Kentucky University (f)
A Novel Computational Method in Protein Structure Determination and Refinement
Protein structures can be determined experimentally by X-ray Crystallography and Nuclear Magnetic Resonance. However, due to the limitations of these experimental methods, many of protein structures were determined poorly, in terms of resolution and accuracy. Therefore, applications of these protein structures in low resolution are seriously limited. We introduce a novel computational method which considers short and long range potentials. In the new model, we show that protein structures are refined in terms of potential energy, agreement with experimental data and Ramachandran Plot.

Omer Yayenie, Murray State University (f)
Nonexistence of H-convex Cuspidal Standard Fundamental Domain
It is well-known that if a convex hyperbolic polygon is constructed as a fundamental domain for a subgroup of the modular group, then its translates by the group elements form a locally finite tessellation and its side-pairing transformations form a system of generators for the group. Such hyperbolically convex polygons can be obtained by using Dirichlet's and Ford's polygon constructions. Another method of obtaining a fundamental domain for subgroups of the modular group is through the use of a right coset decomposition and we call such domains standard fundamental domains. In this paper we give subgroups of the modular group which do not have hyperbolically convex standard fundamental domain containing only inequivalent cusps.