Mathematical Sciences

UNIVERSITY OF MONTANA SPRING 2016

Margie Dennison: Portrait of an Unusual Math Major

By Matt Roscoe

Margie Dennison with her boys Paulie (L) and Wesley (R) and dogs Pepper and Bullseye somewhere high in the Bitterroot Mountains

Margie Dennison is nearing the end of her coursework towards a degree in mathematics education. She aspires to teach mathematics to middle school students in the Missoula area. Typical of pre-service secondary mathematics teachers, her schedule is filled with a mix of upper division mathematics courses, fieldwork in Missoula-area math classrooms, and education courses required for state certification. But Margie Dennison's story is not the typical story of an aspiring mathematics teacher.

Margie grew up in California. She earned her first undergraduate degree from the University of California at San Diego in 1993. She arrived at UC San Diego with a desire to learn more mathematics en route to a career as a teacher. She had done well in mathematics courses in high school, even passing the Advanced Placement (AP) Calculus Exam. Her aspirations to pursue a mathematics degree were quickly diverted during her first semester of study after taking a Calculus II course. She recalls, "It was one of those classes taught in a huge lecture hall…

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Research in the Desert

By Kevin Joyce

I have been very fortunate to be involved in an ongoing research collaboration with my PhD advisor **John Bardsley** and scientists and mathematicians at the Nevada National Security Site. NNSS is a unique United States Department of Energy owned research facility for large-scale and high-energy experiments designed and conducted by Livermore, Los Alamos, and Sandia National Laboratories. The facility spans approximately 1360 square miles of desert located north of Las Vegas, NV, an area larger than the state of Rhode Island. It is operated under contract by National Security Technologies, LLC (NSTec).

I was affiliated with the Signals Processing and Applied Mathematics group which include former graduates **Aaron Luttman** (PhD 2006), a Principle Scientist, and **Marylesa Howard** (PhD 2013), a Senior Scientist. I have been generously supported as a research assistant through several grants with NSTec and spent two summers there

Research interns Jesse Adams, Maggie Hock and Kevin Joyce

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Inside

Notes from the Chair

By Emily Stone

We have had a busy and productive semester here in the Math building. In the early part of the year our search committee read over 120 files for our two positions, an assistant professor in Analysis, and one in Statistics. From a top 10 list in each area 3-4 were selected for closer scrutiny and ranking. We invited two candidates in Analysis to interview first, followed by three in Stats. At the end of the day we made offers to the top candidate in each area, and both accepted! A very successful search indeed. We will be joined in the fall by Dr. Katia Smirnova, a PhD from UT Dallas, currently doing a postdoc at the University of Wyoming. She specializes in the study of high dimensional sparse data sets, specifically from the Human Microbiome Project.

The Analysis position was filled by Dr. Elizabeth Gillaspy, a PhD from Dartmouth University, currently doing a postdoc at UC Boulder. Elizabeth studies Noncommutative Geometry and C*-algebras, and heads to the University of Bremen next year for another postdoc. She will come to Missoula with her partner, Javier Perez, who specializes in numerical linear algebra, and will work with John Bardsley and the rest of the group in the numerical and statistical analysis of data. I want to express my gratitude and thanks to the members of the search committee, our hard working staff (especially Indy Singh who organized all the interviews) and of course the faculty as a whole for pitching in and making the department and Missoula a place where all five of the interviewees said they would like to live and work.

Another piece of good news from this semester is the College and University level awards received by our faculty. Cory Palmer won the Cox Teaching Award from the College of Humanities and Sciences after a competitive screening process. As a junior faculty member Cory has advised both undergraduate and graduate students in research in Graph Theory, has provided excellent leadership in the area of graduate education, and is uniformly loved in his classes by grad students, math majors, and generalists for his relaxed and understandable style and his approachability.

Bharath Sriraman was chosen for the University Distinguished Scholar award, which he is extremely well qualified for, publishing 165 papers since 2002, delivering invited talks at meetings all over the world, and leading up multiple journals in his areas of expertise: Creativity and Learning Science, International Mathematics Education, Epistemology, and the History and Philosophy of Mathematics.

An update on our developing program in Data Science: We submitted an "Intent to Plan" form for a Master of Science degree in Data Science to the Provost, and have been invited to follow up with documents outlining the degree and the procedure involved in implementing it. The department voted unanimously to continue with the preparation of this submission, which is reviewed by the Provost, the College, the Graduate School, OCHE and finally the Board of Regents. If successful we hope to award our first master degrees in data science in Spring 2017, having filled the pipeline with several first year grad students interested in the program.

Again, I thank the department for their support of this project, and Provost Perry Brown and Deans Jenny McNulty and Chris Comer for their encouragement. It is also an exciting

opportunity for Math and CS to partner together in an important educational endeavor. The students are here, there is industry need for people with these skills, and thanks to past years of hard work by Leonid Kalachev, Brian Steele, and visiting professor Peter Golubtsov, we are ready to launch our graduate program in Data Science.

I will end by noting that we enjoyed visits by various alumni and friends this spring, including Duane and Kathy Adams, Cynthia Bryan, and Tom Stockbridge. We are very lucky to have their support. They elevate the learning environment for our students by funding important scholarships and other educational opportunities, and providing us with essential connections with career Mathematicians and Statistician.

The more I learn about it, the more I am impressed by the high quality operation we run here. We are exemplary in many areas, and provide a great environment in which to work and learn. I look forward to facilitating this again next year. Have a great summer, everyone!

Emily F. Stone

Data Science at UM

By Brian Steele

Brian Steele

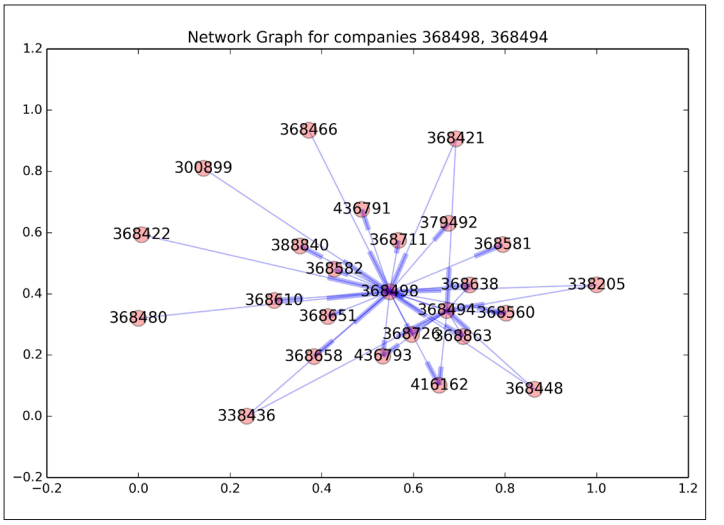
Data science is a nascent field of study. Its inception is attributable to technological advances in areas such as e-commerce, social media, and electronic monitoring and surveillance. One result of these advancements has been the production of nearly inconceivable volumes of data. What's more, the data production rate is in an exponential growth phase. What can be done with it? Data reflects its origins and so, in theory, we may learn about the systems and processes generating the data. But data in its raw form is of little value and most of the time it looks like the Missouri river: a mile wide and an inch deep. Extracting information from data is the raison d'être of data science.

The sources of big data, that is, streaming data and massively large static data sets are so varied that it is often difficult to identify the right method for a specific problem. Even when a method has been identified, applying the method usually requires an original algorithm for reducing the data to useful information. The analyst will end up coding a tailor-made program to apply the method to the data, or perhaps several algorithms to be applied in sequence. The successful practitioner of data science will be knowledgeable of the process of extracting information from data, familiar with common big data problems and solutions, and skilled at programming.

Our program aims to produce graduates that can create new algorithms to solve problems, not simply correctly use existing algorithms. The distinction between using and creating is extremely important. Data science is not statistics with its thousand-page methods textbooks and 75 years of research to support the methods. Data science has no texts for students of mathematics, and with 5 years of research to build on, the practitioner of data science has to do a lot of inventing.

Our program in Data Science focuses on the principles of data reduction and core algorithms for analyzing big data. We have developed original courses in theory, practical methods, and team project solving. They diverge from the traditional lecture format and emphasize hands-on laboratory instruction. The project class solicits companies to submit projects to 3-student teams to solve over the course of a semester.

For example, a project came from InterCall, one of the largest providers of teleconferencing in the world, thanks to the involvement of Advanced Technologies Group, a management and systems integration consultancy with an office in Missoula. InterCall wanted to know more about use and traffic with a longer term objective of optimizing the location of tele-communications equipment. Every conference call creates a log-file record on the device calling into the conference. But identifying information is known only for the conference host. Thus, the call logging system lacks critical information about the origin of call-in connections. The team analyzed one month of call records comprised of approximately 350,000 unique device identifiers and millions of individual records. Approximately 30,000 different companies were represented in the data. Based on the patterns of call-ins, they predicted the ownership of every device. A network analysis of these predictions provided information on the traffic flow between host locations. The figure shows two companies and the other companies that are frequently involved in conference calls to both.



A network graph showing common connections between two companies.

The students developed their solution to the problem from first principles. As it turns out, their method is essentially the same as a data mining technique known as association analysis. In another project aimed at determining an optimal linear prediction function for massively large data sets, a student derived a clever algorithm from first principles in a long weekend. Without realizing it, the student had re-invented the method of least squares, usually attributed to Friedrich Gauss, one of the greatest mathematicians of the nineteenth century. These examples illustrate why we teach first principles of data science: every problem is different and most have to be solved for the first time.

Spring 2016 Scholarship and Award Winners

Joseph Hashisaki Memorial Scholarship
Anastasia Halfpap

The Adams Scholarships
Junior: Soren Ormseth
Senior: Adam Clemons

Anderson Mathematics Scholarship
Katerina Hall

Mac Johnson Family Scholarships
Rachel Ehlers Jennifer Konicek
Glenn Woodworth

Merle Manis Award
Jennifer Powers

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Heather Powers Annalisa Shafer

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Undergraduate Tutorial Scholars
Rachel Ehlers Jennifer Powers
Jennifer Konicek Benjamin Star
Payton Pietron Nicole Zarling

N.J. Lennes Competition
1st place: Alec Patterson
2nd place: Carolyn Graham
Honorable Mention: Soren Ormseth

Carolyn and Johnny Lott Elementary Education Scholarship
Jenna Cady

Graduate Student Distinguished Teaching Awards
Scott Davis Gerald Todd

Graduate Student Summer Research Awards
Elham Bayat-Mokhtari Omid Khormali
Ricela Feliciano-Semidei Nhan Nguyen
Charles Katerba Cody Palmer
Esmaeil Parsa

President's Senior Recognition Awards
Johnathan Bush Andrea Johnson
Rebecca Faust Cody Sevier
Jessica Hurd Annalisa Shaffer

Margie Dennison, continued from page 1

there were two tests and that was it…I got a C on the first one and I was mortified." She goes on, "I aced the final, but, I ended up with a B in the course…that's the one grade that I remember from my original college career." The experience was enough to discourage Margie from taking more courses in mathematics. Instead she studied communications and took a good deal of art history and Italian. She even studied overseas for a year. But, her experience as a freshman in Calculus II stayed with her, "I chickened out…I totally chickened out."

Upon graduation, Margie was hired by a company in the bay area that sold pulse oximeters. She continued with the company for four years – but actively sought out opportunities to transition her career towards teaching. She applied to Teach for America, but was not accepted. Once again, her aspirations were delayed. "I always thought that I would go back to school to become a teacher, maybe back down to San Diego again, but, when I wasn't chosen…when you're twenty-two and you're nervous…well, I became disenchanted with teaching…I got discouraged."

Margie visited Missoula in the late 1990s on a summer vacation. The town was familiar to her. Her grandparents had both grown up in Missoula. Her great-grandfather was Charles Clapp who served from 1921 until his death in 1935 as president of the University of Montana. She fell in love with the town, "We were big bike riders, and, we were tired of the bay area…well, we said, 'We should move to Missoula'," and so they did. She secured a position with Farmers Insurance as an adjuster for injury claims – a job that she would keep for 10 years. She enjoyed the mathematical aspects of the position, but continued to entertain thoughts about teaching mathematics. While still at Farmers, she visited with the certification specialist in the school of education about the courses she would need to take to obtain a mathematics endorsement, "It seemed insurmountable while working full time."

With the arrival of Margie's firstborn son came the decision to stay at home to take up the work of childcare. Another son arrived shortly thereafter. She decided to use the time at home to study for the Graduate Records Exam (GRE) in preparation for a return to school. "When I was studying for the GRE the only thing I liked….well, I just loved reviewing for the math!" But, once her kids were old enough for school and she was able to begin coursework, she hesitated to enroll. With ten days remaining before the start of the spring semester in 2014, she still had not registered, and, questioned whether going back to school was even a good idea at all. Her mother urged her to

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Rainbow over Main Hall last September - Photo by Visiting Assistant Professor Justin Lynd

Margie Dennison, continued from page 4

get in touch with a member of the faculty. She called Professor **Bonnie Spence** and was routed to voicemail. After hanging up, her phone quickly rang, "Bonnie must have called me back less than five minutes later." Strong encouragement from both Professor Bonnie Spence and, later that week, Professor **Jim Hirstein** led to her enrollment. And so, in January of 2014, after a twenty year break, Margie stepped into Professor **Dick Lane**'s classroom to resume her study of calculus.

The first semester back was difficult, and, at times she doubted her ability. But, in an early visit to Professor Lane's office hours where she contemplated dropping Calculus I, he offered, "I think you are right where you need to be." Certainly other faculty members agree with Lane's assessment. Professor **Dave Patterson,** who had Margie as a student in his statistics course, characterizes her effort as, "persistent". Other professors offer similar praise using words like "devoted", "committed", and "hard-working". And, the Math Department is not the only one that has taken note of her commitment to learning. In 2015, Margie was selected as a Noyce Scholar Learning Assistant through the College of Education. Her role in this capacity is to assist learning in introductory mathematics courses while recruiting students to STEM teaching careers. Interestingly, she is paired with Dick Lane, her former Calculus I professor.

Margie claims that she has had to work a little harder than most to understand mathematics, but, recognizes that this might be advantageous to her as a future teacher. She credits her success studying mathematics at UM to the availability of resources. During her first two semesters, she relied heavily on the freely available tutoring provided by the Mathematics Learning Center. Now studying at the upper division, she regularly meets one-on-one with professors during office hours. She often studies in the student study lounge to remain in close proximity to other students and professors. As she looks forward to leading instruction she envisions her future classroom as one where her own experiences of struggle and uncertainty are part of normal mathematical activity, "I would love a rowdy math class…with lots of people talking and arguing…where students are saying, 'Mrs. Dennison you are totally wrong'…and maybe they are wrong or maybe I am wrong", a setting where students, "learn to struggle… [where] it's okay to feel baffled as you slowly pull the little pieces of [mathematics] together." We certainly look forward to visiting your classroom, Mrs. Dennison!

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Sleepless in Seattle, continued from page 8

worked downtown, I was very familiar with the convention center being full, but I was completely unprepared for the sheer number of mathematicians. Every conversation you overheard, whether at a restaurant, on the sidewalk or in a bar was related to math, and I loved it.

The event itself was just as inspiring. Timothy Gowers, a Fields medalist, gave a 3 part lecture series on Finite Fourier Transform on Finite Abelian Groups. This was a particularly interesting lecture series because I never thought I would see the words "Fourier Transform" and "Finite Abelian Groups" in the same sentence, unless it was "How the Fourier transform has nothing to do with finite abelian groups".

The most memorable event for me was John H Conway's talk. John H Conway is a mathematician that I was very excited to listen to. I'd heard he was a fantas-tic speaker and obviously a very talented mathemati-cian. The title was "The History of Surreal Numbers", something I had never heard of. I got into the room early, to get a good seat. The room was packed, there were people standing alongside all the walls, everyone was there to listen to Conway give a 15 minute talk. Right as the talk should have started, the event coordinator said Conway was still at Princeton and wasn't coming. Everyone spilled out of the empty room very disappointed.

Cody Palmer, PhD student in Applied Mathematics: The sessions that I attended were centered on applied math, in particular mathematical biology and disease modeling. I was very happy to get a chance to see Dr. Fred Brauer give a talk on the necessary coupling of in-host and population models. In particular, when modeling the spread of the disease we should not just be modeling infection through some vaguely defined interaction between members of the population. Instead, we should model it from a virus shedding perspective, in which the quantity of the disease is modeled through its shedding from infected members of the population. Overall I found it to be a very useful talk for directing my future work.

My talk came the next day and was on modeling the spread of vector-borne relapsing diseases. These are diseases which are spread usually by insects that have a relapsing character in the host, like Tick-Borne Relapsing Fever. My research has precisely quantified the effect that the number of relapses has on the spread of the disease, namely the more relapses the more likely the disease is to invade the population.

Perhaps the most entertaining of all the sessions that I attended was the session that focused on the application of mathematics to various subjects related to sports. This session had many fantastic talks, including one which justified the Seahawks' infamous choice to throw the ball (which resulted in an interception) near the end zone in Super Bowl 49. There were also talks related to measuring the performance of general managers in baseball, and improving the world ranking system in tennis.

One of the best parts of the JMM is to be in a large group of people who are passionate about math. In the college setting, students often view math as a chore they must complete before they can get their degree. To be surrounded by people who view math as a worthy lifelong pursuit was refreshing and motivating. I came away from the Meetings encouraged and with many new directions for research. I am thankful for the opportunity that was granted to me and my fellow students by the Math Department, and I appreciate the significant resources that our Department makes available for graduate students for their professional and mathematical development.

The Department of Mathematical Sciences increasingly relies on donations to support its activities. In particular, scholarships are very important for our students. Please consider a gift to the *Math Department's Excellence Fund*, to be used where the need is greatest, or to one of the other funds and endowments:

Endowed Scholarship Funds: *The Adams Scholarships, Anderson Mathematics Scholarship, Joseph Hashisaki Memorial Scholarship, Mac Johnson Family Scholarships, Merle Manis Award, William Myers Mathematics Scholarship*

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Degree Recipients 2015-16

Bachelor Degrees

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Shelby L. Frazier
Darby Anne Henderson
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Jessica Yaham Mc Cartney
Jennifer Nelson
Gilia Patterson
Heather Lynn Powers
Dennis Price
Cody Sevier
Annalisa Maria Shaffer
Claire Anne Summers
Ann Suter

Master's Degrees

Intizor Aliyorov
Erik Borke
Scott Davis
Roger MadPlume
D.J. Moritz
Gerald Todd

Doctoral Degrees

Kevin Joyce - Advisor: John Bardsley
Cody Palmer - Advisor: Emily Stone

Research in the Desert, continued from page 1

as paid research intern. Last year I lived in Las Vegas from late May to early August as a summer employee at the North Las Vegas facilities of the NNSS, doing research directly related to my PhD thesis. I was among three other research interns, which included former graduate **Jesse Adams** (MA 2013), who is now a PhD student at the University of Arizona.

During my free time, I took up the weekly hobby of mountain biking in the Red Rock Canyon National Conservation Area, where I amassed spectacular views and a few bumps and scrapes. I also found time to hike in the Mount Charleston Wilderness in the Spring Mountains north of Las Vegas which hosts one of the highest peaks in southern Nevada (11,916 ft).

Our work involves mathematical modeling and writing algorithms and codes for estimation and quantification of uncertainty from measurements given by various experimental diagnostic systems, including high energy X-ray radiography. Specifically, I am interested in quantifying translation invariant blur of imaging systems by estimating the point spread function (PSF) from a calibration image of a sharp edge. This is useful in applications, such as radiography, where imaging a point source is unfeasible due to the difficulty of focusing X-rays. The estimation problem can be cast as the solution to an ill-posed linear inverse problem and we use high-dimensional Bayesian statistical methods that allow us to regularize the problem through prior modeling with a Gauss-Markov random field, which leads to both stable estimation of the solution and quantification of uncertainty in the estimate. This work is the first step in image restoration techniques that mitigate the effects of image blur.

Over the summer, I was able to complete much of the work on the theoretical underpinnings of the measurement model. In late June, I was able to travel back to Missoula with five other members of our group for the Montana Uncertainty Quantification (MUQ) conference hosted and organized by John Bardsley and Aaron Luttman. The conference was described in the last newsletter and was an overall resounding success. I was able to present my current work and meet and catch up with other research colleagues from around the world. Much thanks to the hard work of both John and Aaron for an altogether wonderful conference.

This work has led to a postdoctoral position at NSTec that I will be starting next June. I am very grateful for the numerous opportunities that this research relationship has afforded me. I hope that the connection between the Mathematics department and NSTec remains ongoing, as it has been an invaluable source of collaboration between our department and other mathematicians and scientists working in industry.

Kevin Joyce graduated in May with a Ph.D. in Mathematics.

Graduate studens Quy Cao, Ricela Feliciano-Semidei, Gerald Todd and Nathan Taylor help out at an event to recruit math majors.

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Sleepless in Seattle (Doing Math)

In January, eight of our graduate students attended the Joint Mathematics Meetings, which this year were held in Seattle, WA. The department was able to pay most of their expenses from unrestricted funds, including transportation, hotel, registration and a small per diem. Here, some of the students tell us what they got out of this experience.

Jack Finlay (BA 2013), MA student in Combinatorics: The Joint Math Meetings in Seattle this winter were a wonderful experience – I'm extremely glad I had the opportunity to attend them. Rarely, if ever, does a person find themselves surrounded by that many people devoted to math.

Throughout the week I tried to get to talks about many areas but gravitated toward the graph theory talks. It was interesting to see what techniques people were using to solve the types of open problems I have been grappling with.

Of the talks though the one that was the most fascinating was a three part lecture by Dr. Gowers of Cambridge. His ability to work combining additive combinatorics with complex analysis, both at the most advanced level, was astounding. I left the conference excited to continue my own math pursuits.

Nhan Nguyen, PhD student in Algebra: The joint math meeting in Seattle was one of the most intense math events I have ever been to. Being a Seattle native and having

Nhan Ngyuyen, Jack Finlay and Cody Palmer

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