The Mathematics of Data

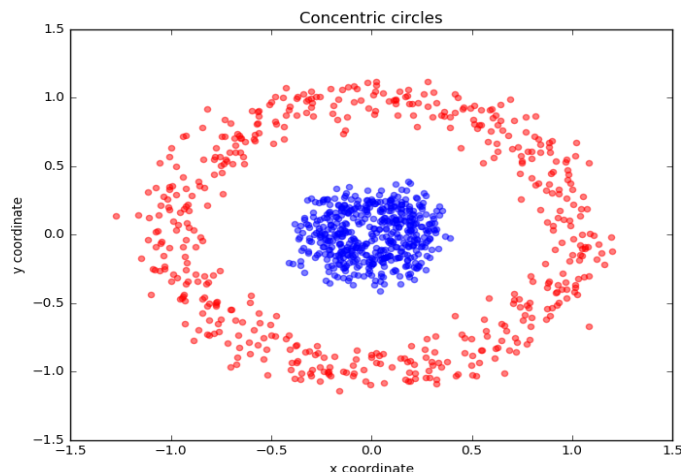"We have data and computers, why do we need math?" asked professor Konstantin Mischaikow in the title of a recent public lecture he gave at the university. His talk provided a definitive answer: data and computers are useless without the tools to interpret them…tools provided by mathematics.

Professor Akram Aldroubi, another visiting speaker, sees it as the latest incarnation of an ancient connection. "'Data Science' is a modern term for something that humans have always done, which is trying to make sense of our world from observations. Mathematics and physics were always at the heart of trying to explain our surroundings from our observations. Thus, it is no wonder that mathematics is an essential part of data science."

Aldroubi and Mischaikow are just two of the world-renowned experts who visited OU as part of *The Mathematics of Data,* a class offered by the department this spring. This one-time class is part of the university's Presidential Dream Course program, which enables faculty to bring famous scholars to campus to interact with OU students and to give a public lecture to the local community.

Professor Mischaikow addressing the class

Data with a distinctive shape

The class was dreamed up by faculty members Alejandro Chavez-Dominguez, Keri Kornelson and Miro Kramar, who recognized that using math to understand data has never been more necessary in our world and more in demand among our students.

The course has been a mix of theory and practice. "We started with an abstract look into linear algebra, which provided a strong foundation to examine the theory of different methods of data analysis," explained Jake Weaver, a senior math major. "We are currently learning how to implement these algorithms in Python, so we can see how these algorithms can work in practice."

Topics have been as varied as the instructors and participants. One famous application of data science the students learned about was "the Netflix problem": attempting to predict how viewers will rate a show or movie based on their past ratings. Like many problems in data science, this can be reduced to a question about a very, very large matrix; specifically, attempting to reconstruct a sparse matrix from a subset of its entries. Thus, students learned that even mindlessly binging television on a couch can be improved by the clever application of linear algebra.

New Faces Around the Department

Shane Allen (Undergraduate Advisor) is a native Oklahoman who received his bachelors of arts in international and area studies from OU in 2006. He is a retired Marine and is currently working on his second bachelor's degree in sociology/criminology. He and his wife Stephanie have two children, Spencer, 8, and Sully, 6.

Where are you from? "I am originally from Piedmont, Oklahoma."

What is your favorite hobby? "When I find the time, I really enjoy fishing or coaching my children's sports teams."

What is your favorite sport? "College football."

Nick Brown (Renewable-Term Faculty) joined OU from South Dakota State University in fall 2021 and works in the First Year Math Program. His research areas are harmonic analysis, graph theory and algebra. He is also interested in educational research in mathematics. Originally from a small town in South Dakota, he is the first in his family to graduate with undergraduate and graduate degrees.

What do you do when you're not doing math? "When I'm not teaching or thinking of math, I enjoy playing with my dog Hope, getting outdoors to play golf, and going to OU sporting events. Thankfully, Norman has some wonderful courses and a great golf community as well as some really great athletes and teams! I also enjoy playing video games and board games with friends."

Mario Morán Cañón (Postdoctoral Associate) works under the guidance of professor Roi Docampo in algebraic geometry and tropical geometry. His research focuses on arc schemes and their schematic properties, especially the local structure. He completed his doctoral degree in France under the supervision of Julien Sebag at the University of Rennes 1 in 2020.
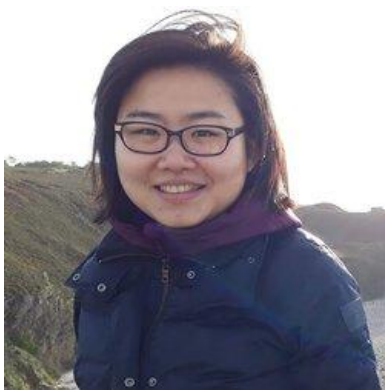
What is your favorite place you've traveled to for math? "Without any doubt, Paris. I already knew Paris before living in France, but I was able to visit this city many times when I was living in Rennes because of the active mathematical community hosted there. Traveling to Paris for academic reasons, I could explore the city and find its hidden gems."

Harrison Gaebler (Postdoctoral Associate) received in July 2021 his doctorate in mathematics from the University of Kansas. Starting in August 2022, he will be a Visiting Assistant Professor at the University of North Texas. His research area is the geometry of Banach spaces.
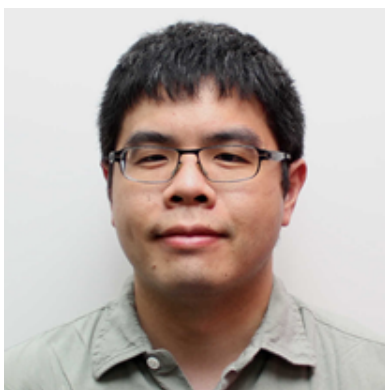
Why did you get into mathematics? "I'd always enjoyed math, but I really wanted to understand the 'why' when I first learned about Riemann sums and the fundamental theorem of calculus."

What is your favorite theorem? "My favorite theorem is that a bounded Banach-valued function on [0,1] is Darboux-integrable if and only if it is Lebesgue almost everywhere continuous."

Yan Mary He (Assistant Professor) obtained her doctorate from the University of Chicago in 2018 under the direction of Danny Calegari and Peter Shalen. She then spent three years as a Postdoctoral Fellow at the University of Toronto and the University of Luxembourg before joining the University of Oklahoma in 2021. She studies (higher) Teichmüller theory, complex dynamics, thermodynamic formalism and interactions of these fields.

What do you think about the OU math department? "The math department at OU has a strong research group in Geometry and Topology and the overall environment of the department is welcoming, friendly and supportive."

Samuel Lin (Postdoctoral Associate) is a researcher in Riemannian geometry working with Ricardo Mendes. His research interest is in spectral geometry and geometric rigidity of symmetric spaces. Before coming to OU, he was a John Wesley Young Research instructor and a lecturer at Dartmouth College.

Why did you get into mathematics? "Originally, I wanted to be a physicist like my father, but then I decided to be "rebellious" and went into math instead. My interest in mathematics began when I was in high school. My father is in theoretical physics, and he has books on mathematical analysis and number theory on his shelf. I read some of the books and fell in love with the rigorous yet concise arguments in there, although I did not completely understand them at that time."

Peter Patzt (Assistant Professor) works in algebraic topology, in particular group homology. He received his doctorate in Berlin, Germany, and held postdoctoral positions at Purdue University and in Copenhagen, Denmark.

What advice do you have for someone considering a career in math? "My main advice is to enjoy doing math. It does not help to stress out about solving every problem or getting this or that job. Becoming a math professor involves a lot of luck and there are so many interesting jobs that will be more than happy to hire a math graduate for their analytical-thinking skills. The less stress you put on yourself, the better your math will be."

A New Name for the College

Have you noticed the change in the name of the College of Arts and Sciences? Since September 2021 it is now the Dodge Family College of Arts and Sciences.

Marty Wold, executive director of advancement, Dodge Family College of Arts and Sciences, says that the name change recognizes a transformational gift that the Dodge family recently made to the college and to the Homer L. Dodge Department of Physics and Astronomy. He says that, according to Dean Wrobel, the college portion of this gift allows for $700,000 per year in scholarship and fellowship support for Arts and Sciences students.

The release linked below contains information about the long relationship between the Dodge Family and the University of Oklahoma and about the recent Dodge family gift.

Undergraduate Advisor Catherine Hall Retires

The department bid farewell to **Catherine Hall**, our undergraduate advisor for the last 10 years. Hall received a bachelor's degree in animal science from Oklahoma State University in 1977. In 1990, she decided to work on a teaching certificate and found out that she could get a math endorsement by taking a few math classes. She took Modern Algebra then decided to go to graduate school in mathematics. Ed Cline, the graduate director at the time, helped guide her course selection, since she had only taken a five-hour course in calculus at OSU and the Modern Algebra class. Twenty years after taking Calculus I, she took Calculus II and then other math courses at OU. She finished her doctorate at OU with the dissertation on *Invariant vectors and level raising operators in representations of the p-adic group GL(3)*. In August of 2012, she started as the undergraduate advisor of the mathematics department. In 2020, Hall received the Dean's Outstanding Academic Advisor award.

Hall did much of the behind-the-scenes work that the department takes for granted. She organized the Math Club meetings, helped get tutors for the Math Center, and organized the Spring Awards Banquet. She represented the department at multiple recruitment events, such as the Women in Science event (for middle school girls in Oklahoma) and Sooner Saturday. She was equally comfortable discussing the finer points of the coursework required for an Engineering major to pick up a math minor as she was helping get preteen girls excited about solving a math puzzle. She was an inspiring woman who retired at the beginning of this year. We will all miss her.

Andy Miller Retires

Another familiar face leaving the department this year is former chair and David Ross Boyd Professor **Andy Miller**. Andy received B.A. (cum laude) from Alfred University (1974), M.S. and Ph.D. from the University of Connecticut (in 1976 and 1981, resp.); with a dissertation titled *On the Homotopy of Spaces of Projectable Homomorphisms*.

He came to OU in 1981 as a Visiting Assistant Professor, earning a permanent position in 1985 and rising through the ranks to earn a David Ross Boyd Professorship in 2012 – one of OU's highest honors. In his time here, he wrote 25 papers (according to MathSciNet) and mentored four Ph.D. students – Yuxing Wang (1996), Timothy Frye (2008), Cherith Tucker (2013) and Rachel Wright (2016). All have gone on to success: Frye taught at Kansas Wesleyan University and now is at McPherson College, Tucker is the chair of the Math Department at Oklahoma Baptist University, and Wright is a lecturer in our department.

Professor Miller served as the chair of the department between 2012 and 2016, and over his 40 years of service, he served on practically every committee in the department, and on many university and statewide committees. Between 1991 and 1996 he was the director of an REU program, offering summer research opportunities for undergraduates. He was a tireless contributor to the department and the discipline in innumerable ways, both large and small, and we wish him all the best in retirement.

COVID Pandemic - Then and Now

The COVID pandemic had a profound impact on the lives of students, faculty and staff in the mathematics department. Over Spring Break 2020, the university shifted all classes to online instruction.

A classroom full of remote attendees in 2020

Effecting this transition presented a herculean task for the mathematics department which teaches roughly 12,000 students per year. Math faculty and student instructors rallied together and collaborated, sharing real-time information about new technologies and best practices, in two online department forums, Viral Math 101 and the RAMP-UP seminar. According to former department chair Noel Brady, "the First Year Math team led our efforts at moving online." The Oklahoma State Regents for Higher Education recognized the achievements of our FYM team by awarding the 2021 Oklahoma Online Excellence Award to the OU First Year Mathematics program.

Two years later, what have we learned?

We can attend meetings via Zoom, including research seminars and collaborations with colleagues around the world, with less interruptions to our daily schedule. Zoom office hours are a better option than in-person office hours for many of our students. Many instructors feel that they now provide more online content (videos, lecture notes) for students. According to professor Deborah Moore-Russo, a common message among instructors is to "be kind" - have empathy for our students and our colleagues. We are all dealing in different ways with the impact of COVID on our lives.

Around the department, life is gradually returning to pre-pandemic normal. The Math (tutoring) Center offers a mix of in-person and online appointment times, and student visits are on the increase. The undergraduate Math Club has started holding in-person meetings. The Math Common room has resumed the tea and coffee service, and Math majors are back using this room for lunch and to study. After a two-year hiatus, the 2022 Department Awards ceremony will be in-person. The department chair, Nikola Petrov, says that the good weather offers more opportunities for social gatherings – "picnics are certainly a great way to get people out of the house and get them to meet other people."

Grad students enjoying the spring picnic

Awards and Recognitions

The department's **First Year Math team** won the Oklahoma State Regents for Higher Education 2021 Online Excellence Award.

Professors **Jing Tao** and **Ying Wang** received the Anadarko Petroleum Corporation Presidential Professorships.

Professors **Javier Alejandro Chávez-Domíngues** and **Justin Malestein** were granted tenure.

Grad student **Nathan Jones** was awarded a SMART scholarship from the U.S. Air Force.

Grad students **Brin Heyer** and **Caleb Mazzei** received the Provost's Certificate of Distinction in Teaching.

Grad students **Tomoya Tatsuno, Steven Lin, Carlos Villanueva** and **Lauren Kriegel** were awarded Summer Research Fellowships.

A record eight grad students were accepted to summer workshops at the Mathematical Sciences Research Institute: **Chary Addanki, James Beyer, Ryan Gueli, Sam Heard, Chih-Kuang Lee, Fahed Mokdad-Reyes, Maya Verma,** and **Lucas Yong.**

The University of Oklahoma

Created by the Oklahoma Territorial Legislature in 1890, the University of Oklahoma is a doctoral degree-granting research university serving the educational, cultural, economic and health-care needs of the state, region and nation. The Norman campus serves as home to all of the university's academic programs except health-related fields. The OU Health Sciences Center, which is located in Oklahoma City, is one of only four comprehensive academic health centers in the nation with seven professional colleges. Both the Norman and Health Sciences Center campuses offer programs at the Schusterman Center, the site of OU-Tulsa. OU enrolls more than 30,000 students, has more than 2,800 full-time faculty members, and has 21 colleges offering 177 majors at the baccalaureate level, 181 majors at the master's level, 87 majors at the doctoral level, 37 majors at the doctoral professional level, 10 undergraduate certificates, and 68 graduate certificates. The university's total annual operating budget is $2.26 billion. The University of Oklahoma is an equal opportunity institution.

The Math Department

The Department of Mathematics at OU is located in the Physical Sciences Center (PHSC) at 601 Elm Ave. in Norman. PHSC is located in the northwest area of the University of Oklahoma Norman campus.

Visit us online at math.ou.edu, connect with us on Facebook, or contact us by mail at:

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