INDUSTRIAL & SYSTEMS ENGINEERING

DATA-DRIVEN EDUCATION

Rooted in the real world

Greetings From Madison!

As we emerge from another Wisconsin winter, I find myself looking back at the last several months and marveling at the resilience and accomplishments of our amazing UW-Madison community. Here in the Department of Industrial and Systems Engineering, we have embraced the return to an in-person experience, adjusting "business as usual" as needed to continue our critical contributions to higher education, research and service to our community.

Our undergraduate program continues to grow, fueled in part by a surge of interest in data science. We continue to adapt to the needs of our students—in this case, by implementing an introductory analytics course that teaches the statistical fundamentals needed to effectively study and analyze data and apply them in engineering settings.

Students with degrees in industrial engineering have more opportunities available to them than ever before. We enjoy seeing their excitement as we introduce them to the possibilities ahead, through our Intro to ISyE course, our alumni panel events, and in the focus areas of our undergraduate curriculum. Some of our undergraduate students have also created a new and exciting mentorship program called "ISyE Connections." This program, highlighted in this newsletter, is unique to our department, and provides a valuable experience for students at all levels of their college journey.

Our graduate students, along with our amazing faculty, continue to pursue research that benefits the greater good. We are excited to share some of the exciting work being done in research areas that have been particularly impacted by the current pandemic and global supply chain challenges.

All our efforts certainly keep us busy, but it's rewarding to see our work pay off. Our students and faculty continue to receive international honors. Our department rankings are on the rise. And we are growing! We are in the process of recruiting additional faculty to the department. I look forward to introducing them in the coming months.

On a personal note, my first months as department chair have been a time of growth—not just for the department, but for me personally. I'm humbled and grateful to lead this amazing community, of which you are an important part. If we haven't yet met, I hope that our paths will cross soon. In the meantime, please know how grateful we are for your interest in and support of our department.

On, Wisconsin!

Laura Albert

Laura Albert
David H. Gustafson Department Chair and Professor

laura@engr.wisc.edu
(608) 262-3002
🐦 @lauraalbertphd

College welcomes inaugural associate dean for inclusion, equity and diversity

Chris Castro joined the college as its inaugural associate dean for inclusion, equity and diversity in January 2022.

Castro brings more than a decade of experience leading efforts to strengthen teaching and learning practices rooted in the principles of inclusion, equity, diversity and justice. He spent the previous six years working for Madison Teaching and Learning Excellence (MTLE), a UW-Madison fellowship that helps early career faculty members professionalize their educational skills.

Castro also serves as a facilitator and educational expert for the National Science Foundation-funded program Aspire: National Alliance for Inclusive and Diverse STEM Faculty, helping to disseminate inclusive teaching practices at the national level.

"For me, there's no such thing as good teaching if we're not starting with the students as human beings," says Castro. "As my colleague Dr. Rosemary Russ in the Department of Curriculum and Instruction says, 'There's no such thing as good teaching if it's not teaching that's grounded in equity, diversity, inclusion and justice.' Starting a conversation about teaching from any other angle has never made sense to me."

While integrating those two perspectives in MTLE, Castro also built relationships with 41 engineering faculty members (from six departments) who participated in the two-semester fellowship program.

As associate dean, Castro is keen to take a collaborative and transparent approach to creating communal solutions while elevating and empowering others.

"I'm going to be on the ground, talking to folks," he says. "I'm not going to be in my office, closed behind a door. I'm going to be building relationships and really getting to know the humans who make up the College of Engineering, so that we can make this a human work, human process, rather than just a policy-driven or metric-driven process. All those things are important, but they're not the most important."

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New intro analytics course teaches students statistical fundamentals for engineering challenges

As interest in data analytics surges, our new *Introduction to Industrial Statistics* course prepares undergraduate students to solve relevant questions using a variety of statistical methods. The course is open to all engineering students. Photo: Joel Hallberg

Dana Tabaza has her eyes on a possible consulting career once she graduates from UW-Madison in a few years. The sophomore is double majoring in industrial engineering and data science while also picking up a certificate in business, a combination she figures will prepare her for fast-paced, nimble work. She joined the Wisconsin Consulting Club in fall 2021 to learn more about the field and connect with other interested students.

And when she told her older industrial engineering peers in the student organization about the topics she was learning in ISyE 210, *Introduction to Industrial Statistics*, during the fall 2021 semester, they were quick to offer some simple advice: Make sure you listen closely during those lectures!

Turns out, the statistical methods on Tabaza's course syllabus were some of the same ones her peers had used in their co-ops and internships.

"A chunk of being a consultant is being able to analyze and look at data and make good decisions from the data," says Tabaza, who grew up in the country of Jordan before moving to Wisconsin and attending high school at Brookfield Central.

Learning statistical fundamentals and then applying them to solve tangible problems is precisely the point behind ISyE 210, our new engineering analytics course. Statistics, course instructor Amanda Smith notes, "is really just a more boring word for data analytics," an ever-sprawling set of practices that are increasingly informing every field.

ISyE developed the course with input from across its faculty, ensuring the content includes the fundamentals students will build upon in subsequent classes as they sharpen the focus of their studies. In spring 2022, the course opened up to all engineering students, giving them an introductory dive into analytics that's more closely tailored to their future careers.

"We wanted to create a course that would give that fundamental training in a practical, hands-on way that would be meaningful and relevant to engineering students," says Smith, who is ISyE's associate chair for undergraduate affairs. "Instead of just formulas and theory, we focus on topics like, 'Here's how we use statistics. Here's the practical, day-to-day reality of working with data. It's messy; you don't always know if it's what you really need. Here's how you begin to understand what your data is telling you and how you can use it well.'"

In the course, advanced first-year students and sophomores learn the basics of probability, a range of data tools in Microsoft Excel, and statistical techniques like linear and multiple regression. They tackle a case study covering statistical quality control, a classic industrial engineering assignment, and work on team projects, applying methods learned in class to datasets of their choosing from an expansive list culled by Smith from the public data science repository kaggle.com.

Smith also infused diversity, equity and inclusion into the project, devising an optimization model to maximize diversity while matching students into teams of four based on voluntarily reported demographic information (ensuring students from underrepresented minority groups weren't the only ones on a given team), skill levels and years in school. The course also covers statistical studies that demonstrate that diverse teams are more effective than homogenous ones, showing students both the analysis and the results.

"Any class will show you examples using formulas," says Smith, "but I hope this class shows relevant examples that students can easily understand and see why statistics is important and make it accessible, make it something that they care about learning."

Liu mines data to meet industry needs

In a manufacturing plant, a nuclear reactor, a traffic network and a host of other complex systems, millions of sensors are constantly collecting torrents of data.

But that data, in and of itself, is not knowledge, says Associate Professor Kaibo Liu.

"The data is like a message," he says. "How can we better transform the data into knowledge, into smart decisions?"

Liu is working to do just that by harnessing data science methods—and developing new ones—to improve quality in manufacturing systems, refine maintenance decisions in nuclear power plants and other smart and connected systems, and enhance sensor system design, data acquisition, monitoring, diagnosis and prognostics across a range of fields.

While the specific topics and techniques vary from project to project, there's a clear connective thread for all of Liu's work: Each endeavor is rooted in a plausible scenario drawn directly from industry with practical values. He says he's trying to bridge the gap between fundamental data science research and industry needs, two perspectives that haven't historically connected.

"I'm interested in industrial data science, which means before I develop something, I need to make sure some people need it with practical impact," says Liu, who's landed early career awards from the Institute of Industrial and Systems Engineers, the Society of Manufacturing Engineers and the American Society for Quality. "Otherwise, I don't want to develop it."

Liu has teamed up with industry partner 3M on several projects, including developing new methods to identify faulty code and spot anomalies in data from manufacturing production lines, indicating problems, and leveraging a technique called transfer learning to examine production processes.

He's also employing transfer learning, a machine-learning tactic that leverages insights from one dataset to analyze similar samples, to model maintenance concerns in nuclear reactors with funding from the U.S. Department of Energy (DOE). It's the second DOE grant he's earned to apply his prognostic modeling to nuclear equipment. Liu has also led several projects funded by Department of Defense agencies, such as the Office of Naval Research, U.S. Army Corps of Engineers and the Air Force Office of Scientific Research, to investigate advanced predictive maintenance strategy for complex smart and connected systems.

Since joining UW-Madison in 2013, Liu has analyzed the neurodegenerative process in Alzheimer's disease, detected solar flares on NASA images of the sun, modeled and predicted real-time travel demand, and more. He also recently coauthored a paper in the *Journal of Machine Learning Research,* considered a top journal in the machine learning field, examining quality in crowdsourcing for collusion detection.

But each of those disparate topics requires a nuanced solution. Liu uses a variety of artificial intelligence and machine learning techniques, including transfer learning, deep learning and reinforcement learning.

"I'm not a person to say I only use this type of method," he says. "It's like you only have one axe and then you try to use that axe to try to cut all kinds of trees."

Liu is passing on his insights through ISyE 412, *Fundamentals of Industrial Data Analytics*, an undergraduate course he developed that uses a blended learning approach. He's also taught an online version for working engineers through the college's Interdisciplinary Professional Programs and created an online knowledge-sharing hub, called IERA, specifically for industrial engineers. In 2020, the Institute of Industrial and Systems Engineers (IISE) honored Liu with its Innovations in Education Award.

A year later, Liu received IISE's Award for Technical Innovation in Industrial Engineering, mainly due to his work with 3M. Both sides are keen to extend their ongoing collaboration, which has prompted several of Liu's graduate students to complete summer internships at 3M and the company to hire graduate Honghan Ye (PhD '21) as a data scientist.

Undergrads get glimpse of real–world challenges in senior design

Less than a month away from the conclusion of their senior design project, undergraduates Josie Beres, Conner Boldt, Jasmine Brewer and Will Gallagher uncovered a considerable problem: Their analysis showed their client's desired goal for their project wasn't actually feasible.

"Our team was kind of panicked," says Brewer, whose group was tasked with reducing manufacturing lead times by implementing generic configurations for anesthesia delivery systems at GE Healthcare.

But the four graduating seniors regrouped, plotted a path forward and found a way to still impress their client in ISyE 450: *Industrial Engineering Design II*, our department's capstone design course.

To deliver that kind of positive result, though, the students had to rebound from the major roadblock they encountered. GE Healthcare had asked them to recommend a production approach that would allow the company to move away from making fully customized products for specific customer orders to producing 10 generic configurations that could be rapidly adapted as needed to meet 80% of customer demand. But after analyzing the relevant data on GE Healthcare's high variety of anesthesia system configurations, they discovered serving the targeted level of demand using only 10 generics wasn't possible.

Undeterred, the students sought guidance from E-Business Chair Professor

Raj Veeramani, the longtime lead instructor for the senior design course, who helped them consider design changes that could consolidate the number of configurations and optimize the manufacturing line workflow to achieve a significant reduction in lead time for demand fulfillment. Armed with these ideas, the foursome pushed forward with the project, sitting down with manufacturing line workers to gain a better understanding of the build process for anesthesia systems and the feasibility and potential impact of their design simplification ideas.

In the end, the students presented a set of recommendations that would allow for any customization to happen near the end of the manufacturing line with 11 generic configurations, covering 70% of customer demand. But they also provided GE Healthcare with their data analysis model, allowing the company to adjust parameters to reflect its priorities (better demand coverage at the expense of more configurations, for example).

As a result, one of GE Healthcare's regional sales teams has already reduced the number of configurations it's offering. Mark Brown, senior lean manufacturing leader at GE Healthcare, says the project has also spurred the company to consider changes at regional distribution centers to accommodate region-specific configurations, as well as how it should devise future designs to better align with customer needs.

"Their investigation allowed us to really question what we were doing from a customer supply standpoint and why we had so many configurations to start with," says Brown. "What we expected to find, we didn't find. And so they had to pivot and dug deeper into the data. It maybe didn't end with the conclusion that we expected, but probably has a bigger impact to the organization than what we expected."

The experience was just as beneficial for the students.

"I feel like that's the best way to learn: getting that actual, tangible experience," says Beres. "Because, yes, you can learn all the concepts in school, but actually being able to apply them and see them in action in the manufacturing line or just a company in general was a great experience."

For their efforts, the team took top honors—along with a cash prize—in our fall 2021 Ratner Senior Design Project Award competition, in which teams compete each semester while working with a range of business clients. Beres and Brewer are now pursuing master's degrees in industrial engineering, with a focus on systems engineering and analytics, through our one-year accelerated program. Beres will intern at GE Healthcare in summer 2022, in part because of her work on the project, while Brewer will intern at Boston Scientific. Boldt and Gallagher graduated in December 2021 and started their careers at AprilAire and Husco, respectively.

Collaboration the key for Li during 'difference-making' career

If there's one thing Professor Jingshan Li knows, it's the importance of collaboration.

Li, an expert in the field of operations research, retired from UW-Madison in September 2021.

Li began his career in the manufacturing segment, working extensively with Chrysler and Ford plants while earning his PhD from the University of Michigan. From there, he spent time working for General Motors in its research division, before helping Toyota while serving as an assistant professor at the University of Kentucky. In 2008, Li began to collaborate with the University of Kentucky Hospital to improve efficiencies in its emergency department, an experience that marked a shift in his work to include a new focus on health systems engineering.

In 2010, Li joined UW-Madison as an associate professor. "I came to Madison to make a difference," says Li.

And make a difference he did.

His research analyzing workflow has enabled healthcare providers to reduce physician workload and improve overall efficiency. His application of machine learning techniques to healthcare challenges has proven beneficial to identifying critical factors impacting the risk of patient readmission after hospital discharge. In fact, Li's work in healthcare became such an important part of his portfolio that in 2017 he was named associate director of the newly formed Wisconsin Institute for Healthcare Systems Engineering.

Li credits much of his success to his fellow researchers.

"The collaborative environment within the department provides opportunities for a lot of new applications and new paradigms of work," he says of ISyE.

Li's penchant for collaboration expanded to his student interactions as well. As part of one of his undergraduate courses, he encouraged his students to reach out to local businesses to find tangible applications for simulation modeling—a request that resulted in him sharing more than a few trips to local restaurants with some lucky students.

This type of interaction resulted in Li being named the "Engineering Faculty who has the Most Positive Influence on Undergraduate Student Careers" by the college in 2015.

He also spent several years teaching courses in the college's Interdisciplinary Professional Programs for working engineers. Of those students, Li says, "I learned a lot from them, too."

After 30 years, Li retired to return to his home and family in China. He will continue his important work as a member of the industrial engineering department at Tsinghua University in Beijing.

Faculty News

Proctor and Gamble Bascom Professor Oguz Alagoz was quoted in a *Scientific American* article called "The COVID Cancer Effect," drawing upon his research modeling the impacts of the COVID-19 pandemic on breast cancer mortality. Alagoz also discussed the topic during an appearance on the Perri Peltz Show on SiriusXM.

Professor and David H. Gustafson Department Chair Laura Albert was elected as president-elect of the Institute for Operations Research and the Management Sciences (INFORMS) for 2022. She will then serve as president in 2023.

Emerson Electric Quality & Productivity Professor John Lee received the college's Byron Bird Award for Excellence in a Research Publication for his work examining the factors that influence how people rely on automation, specifically the concept of trust. His 2004 article in *Human Factors*, the flagship journal of the Human Factors and Ergonomics Society, is the third-most cited paper of the nearly 4,000 papers published in the 60-year history of the journal.

The Center for Health Enhancement Systems Studies, based in ISyE, founded by Professor Emeritus David Gustafson and led by Senior Scientist Todd Molfenter, will lead a national effort to support and strengthen the behavioral health workforce, with a particular focus on opioid-use disorder prevention, treatment, and recovery, through a four-year, nearly $10 million grant from the U.S. Health Resources and Services Administration.

E-Business Chair Professor Raj Veeramani and Vilas Distinguished Achievement Professor Shiyu Zhou are leading a project to apply data science and machine learning techniques to improve business processes and automation through a sponsored research grant from Neenah, Wisconsin-based Jewelers Mutual Group.

Professors Jeff Linderoth and Jim Luedtke earned a best paper award from the journal *Mathematical Programming Computation* for their work outlining an open-source software package called MINOTAUR for solving vexing optimization problems.

Associate Professor Nicole Werner is a collaborator on a $2.4 million grant from the Agency for Healthcare Research and Quality studying the pandemic's impact on antibiotic prescribing and resistance patterns.

Student News

PhD student Reid Parks won first place in the Human Factors and Ergonomics Society (HFES) Healthcare Technical Group student paper award competition for his work identifying barriers to in-home care for children with medical complexity.

PhD student Rachel Rutkowski received the Human Factors and Ergonomics Society's Student Member with Honors Award and was also selected as a Wisconsin Area Health Education Center Scholar.

PhD students Elizabeth Scaria and Veronica White were selected as INFORMS Diversity, Equity and Inclusion Ambassadors and are creating outreach materials to engage high school students around the fields of operations research and the management sciences.

PhD student Adam Schmidt won a best poster award at the Association for Computing Machinery Conference on Equity and Access in Algorithms, Mechanisms, and Optimization for his work on the design and operation of vote-by-mail processes.

Our INFORMS student chapter earned a cum laude student chapter award, while our HFES chapter received an Outstanding Student Chapter gold award.

New partnership links faculty with emerging companies

An innovative public-private collaboration between our college and growth capital firm WISC Partners will connect high-potential regional technology companies with our leading engineering experts.

In the process, the collaboration also will create a new avenue for funding that can supplement existing college revenue from traditional industry collaborations, federal grants and philanthropy.

Based in Madison and Silicon Valley, WISC Partners provides strategic operating capital to promising entrepreneurs. Its founding partners, UW-Madison engineering alumnus and retired chairman of Applied Materials Mike Splinter and UW-Madison business alum and veteran entrepreneur David Guinther, are leveraging deep Silicon Valley experience and worldwide networks to play an active role in accelerating the growth and success of the companies in their portfolio.

For WISC Partners, one aspect of actively nurturing the growth of companies in its portfolio involves tapping the technical expertise and knowledge that UW-Madison engineering faculty offer across an array of disciplines. The engineering faculty provide these critical capabilities as service work and consultants, while not competing with research that might lead to future spin-outs of those activities.

The partnership includes a unique tiered funding model designed to return gains to the university as the WISC Partners ventures appreciate in value, similar to the way in which a venture capital firm's general partners might receive a return on their investment.

"Establishing strong industry partnerships is a strategic goal for our college, and our collaboration with WISC Partners creates an avenue for our faculty to contribute their expertise to enhance the success of emerging technology companies," says Ian Robertson, Grainger Dean of the College of Engineering. "Our faculty are innovators who fully embrace the Wisconsin Idea. They want to work more closely with industry. That involvement helps contribute to and accelerate the growth and success of promising companies, drives revenue for our college and provides our faculty valuable understanding of and experience in the entrepreneurial side of innovation."

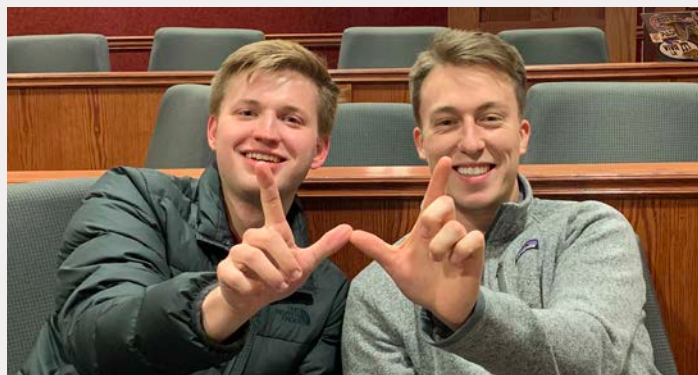# Peer mentorship program creates connections for undergrads

As a first-year student at UW-Madison, Tess Vasilakos got an early lesson in the value of having an older student as a mentor. Not only did then-senior Felix Lichter (BS '20) answer her questions about courses and faculty members and encourage her to get involved with the Institute of Industrial Engineers student organization—he even helped her make sense of the dizzying off-campus housing rental race.

In summer 2022, Vasilakos will intern at Baker Tilly in Chicago, in part because of some helpful information from Lichter, who's a consultant at the firm.

Vasilakos, now a junior, is paying that mentorship forward through ISyE Connections, a program that connects younger students with older ones who can lend their perspectives on coursework, internships, student organizations and life outside of class.

Recent graduate Sofia Noejovich (BS '21), now an associate consultant at Microsoft, started ISyE Connections in summer 2020, drawing inspiration from her own experiences learning from mentors like PhD student Rachel Rutkowski (BS '18, MS '20).

"One thing I learned from engineering school that I know this program reflects is that we all accomplish more when we work together," says Noejovich. "I think we can always benefit from expanding our networks, getting different ideas and also feedback about what it is that we're doing and what our goals are."

Senior Collin Nelson (right) is mentoring sophomore Scott Breidigan through ISyE Connections, a new peer-to-peer mentorship program that's helping our undergrads plot their academic and professional paths. Submitted photo.

Mentors and mentees sign up through an online form and are matched based on their focus area within the industrial engineering major—engineering analytics and operations research; healthcare systems engineering; human factors and ergonomics; or manufacturing and supply chain management—as well as career ambitions, interest in research and more.

"I think just having someone you feel comfortable asking questions to is a really big thing," says program coordinator and senior Molly Hart.