How industrial engineers improve healthcare
Clockwise from upper left: During the Innovation Days competitions, held February 9 and 10, Tom Gerold and Marc Egeland earned $5,000 for the DualX Fracture Fixation system, a lightweight kit for stabilizing broken limbs in the emergency room. Eric Ronning invented a prosthetic hand that could be cheaply created on a 3-D printer for amputees in developing countries. His entry won the top prize and $10,000 in the Schoofs Prize for Creativity, and $11,250 in total prizes. Justin Vanneuwenhoven won $1,000 for Clean Coal, an electric heat source for hookahs; Matthew Kirk won $700 for Javi, a Java-based programming tool for use with LabVIEW; and Michael Szewczyk won $1,000 for the TabTop Double Tablet Laptop, which links two tablet computers. Scott Johanek created NoVo Luggage, a high-end, stable suitcase that can roll in any direction, which won $2,500 in the Tong Prototype Prize and $9,500 in total prizes.
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Interdisciplinary research and education: BIG THINKING FOR BIG CHALLENGES

The common definition of “discipline” illustrates why the word is so deeply rooted in the lexicon of higher education. Discipline is all about rigorous preparation, self-command, willpower, following a strict regimen—many of the traits that are required in the evolution from student to expert in any chosen academic field. Yet many of the truly exciting developments in 21st-century higher education are taking place in the spaces where disciplines collide, when new collaborations are formed and creativity thrives. Our students and researchers still need the disciplinary depth to truly master complex subject matter, but that knowledge becomes even more powerful when combined with that of experts from other diverse fields.

In the words of the late composer Leonard Bernstein, interdisciplinary work means “learning to know something by its relation to something else.” That’s not a luxury, but a necessity, in today’s research environment. Simply put, problems are not neatly confined within disciplines. They don’t respect borders. Large-scale problem-solving will require a blend of solutions ranging from technology and biology to human behavior and public policy.

At UW-Madison, we happen to be very good at this process, as evidenced by one of our newest research facilities, the Wisconsin Institutes for Discovery (WID). This building is a monument to interdisciplinary thinking, with a research roster that includes virtually every discipline in engineering rubbing elbows with systems biology, computational technology, epigenetics and applied economics. Just this spring, R&D Magazine named WID the national laboratory of the year for its “push-the-envelope” concepts that support collaborative research.

The College of Engineering is about to embark on another landmark of interdisciplinary research with the 2013 opening of the Wisconsin Energy Institute (WEI). This building will bring together the groundbreaking scientists and engineers affiliated with the Great Lakes Bioenergy Research Center and the programmatic Wisconsin Energy Institute, and spark collaborations with scientists working on renewable energy, storage, energy systems, fusion and fission, smart grids and energy policy. We believe this building and its associated research network will make a big impact on America’s energy independence.

In the past year, faculty leaders from all engineering departments and I have worked together to define our major college research themes—and without question, all of them require interdisciplinary approaches. The six themes are advancing healthcare, energy independence, environmental sustainability, improving security, advanced manufacturing, and transportation infrastructure. In each theme, we have numerous researchers working together across engineering departments and forging collaborations across campus.

The list of collaborations is far too great to include here, but let me offer two examples. Electrical and computer engineer Hongrui Jiang is doing fascinating work on biological applications of microelectromechanical systems (MEMS), including research on self-focusing contact lenses to correct vision in aging adults. Jiang’s team includes faculty from the departments of surgery, ophthalmology, veterinary medicine, materials science, computer science and chemical engineering. And chemical and biological engineer John Yin is studying systems biology—viewing the human body as a complex ecosystem as a way to better understand disease—with the help of scientists in ecology, mathematics, physics, chemistry and computer science.

Engineers, I believe, inherently think in an interdisciplinary way, because of the socially impactful nature of our profession. Take an iconic engineering project such as bridge construction, for example. This is at its core an exercise in structural engineering, but it’s also a tool for urban planning, a driver of economic opportunity, an environmental impact, a cultural landmark, and potentially a work of art. It will be a better bridge when seen from all perspectives.

After 13 years of leading the college, Dean Peercy announced plans in February 2012 to retire. He will continue to serve as dean until a national search is completed and his successor is on board—likely early in 2013.
From the Lab
research news

M
terials Science and Engineering Assistant Professor Xudong Wang (above, right), postdoctoral researcher Chengliang Sun and graduate student Jian Shi (above, left) have created a plastic microbelt that vibrates when passed by low-speed airflow such as human respiration.

In certain materials, such as the polyvinylidene fluoride (PVDF) used by Wang’s team, an electric charge accumulates in response to applied mechanical stress. This is known as the piezoelectric effect.

The researchers engineered PVDF to generate sufficient electrical energy from respiration to operate small electronic devices. “Basically, we are harvesting mechanical energy from biological systems. The airflow of normal human respiration is typically below about two meters per second,” says Wang. “We calculated that if we could make this material thin enough, small vibrations could produce a microwatt of electrical energy that could be useful for sensors or other devices implanted in the face.”

Researchers are taking advantage of nano- and microscale advances to develop a host of biomedical devices that could monitor blood glucose for diabetics or keep a pacemaker battery charged so that it would not need replacing. What's needed to run these tiny devices is a miniscule power supply. And waste energy in the form of blood flow, motion, heat—or in this case, respiration—offers a consistent source of power.

Wang’s team used an ion-etching process to carefully thin the PVDF while preserving its piezoelectric properties. And because PVDF is biocompatible, he says, the development represents a significant advance toward creating a practical microscale device for harvesting energy from respiration.

Take a deep breath.
You could generate electricity ... with your nose
For decades, engineers have studied low-temperature combustion as a means of creating engines with diesel-like efficiency and no pollutant emissions. Yet, the very nature of low-temperature combustion involves a reaction with little active control: inject the fuels, mixing occurs, and then some time later, combustion starts.

To investigate a new technique for measuring the temperature of a low-temperature combustion reaction throughout that process, Mechanical Engineering Assistant Professor David Rothamer has received the National Science Foundation 2011 Faculty Early Career Development (CAREER) award. Such a tool would help engineers understand what's happening inside the cylinder and ultimately discover ways to optimize the reaction.

With his $405,000 award, Rothamer will research the use of phosphors—substances that emit light—for measuring the temperature of gases in combustion reactions. Phosphors are a useful tracking tool because they are not consumed in a combustion reaction and have easily detectable spectral lines that contrast with those of combustion products, which sometimes emit at ultraviolet frequencies that cannot be detected except in a vacuum. He also will offer a summer outreach program through the UW-Madison Great Lakes Bioenergy Center that will enable teachers to explore the combustion process, with a biofuels focus.

O
n February 9, the National Academy of Engineering (NAE) named two UW-Madison engineering faculty members to its 2012 class of new members. Wisconsin Distinguished Professor of Geological Engineering and Civil and Environmental Engineering Craig Benson and Engineering Physics Professor Emeritus Max Carbon are among 66 new members and 10 foreign associates elected to the NAE in 2012.

Election to the NAE is among the highest professional distinctions accorded to an engineer; membership honors those who have made outstanding contributions to engineering research, practice or education.

The academy cited Benson for improvements in design, construction and monitoring of earthen liners and covers for municipal hazardous and radioactive waste landfills, while it recognized Carbon for establishing engineering educational programs for nuclear reactor design and safety.

In addition, two alumni also were among those named members of NAE. Babatunde Oggunna (PhDChE ’81) is interim dean, William L. Friend Chair of Chemical Engineering and professor in the Center for Systems Biology-DBI at the University of Delaware, Newark. NAE cited him for advancing understanding of radiation damage in metallic and ceramic components.

As a geoenvironmental engineering researcher, Benson focuses on assessing the sustainability of geological and civil engineering systems, reusing and recycling industrial byproducts for sustainable construction applications, and designing and assessing environmental containment systems for municipal, hazardous and radioactive waste. He has conducted research in these areas with government and industry locally, nationally and internationally.

Carbon was founding chair of the UW-Madison Department of Nuclear Engineering, hired in 1958 as part of a growing postwar research emphasis on designing better, more efficient nuclear power plants for generating electricity. Chair from 1958 until his retirement in 1992, Carbon led the department in establishing the nuclear engineering bachelor’s, master’s and PhD curricula; and recruited and hired top faculty and staff, an effort that has raised the program to its current status as among the best in the nation. Carbon also oversaw construction of the university research and training reactor, which achieved initial criticality in early 1961.
In January 2012, Civil and Environmental Engineering Professor Jae (Jim) Park received the Order of Service Merit (red stripes medal) from the president of South Korea for his contributions to the Four Major Rivers Restoration Project, a multibillion-dollar river restoration project in that country. The Order of Service Merit is among the highest and most coveted Korean honors and is comparable to the U.S. Congressional Gold Medal.

Park is an expert in biological processes for removing toxic compounds in waste-treatment processes and from the environment. As the principal academic contributor to the Four Major Rivers Restoration Project, he served as a project advisor and contributed theoretical river-restoration knowledge to the effort. The $18 billion project focused on achieving national water security and flood control and revitalizing the ecosystem in an area of South Korea that includes 63 percent of the country’s population.

That effort holds special significance for Park, a native of South Korea. After he saw severe pollution and ecological damage in the Han River due to industrialization and overpopulation, he traveled to the United Kingdom in 1982 to earn his PhD in river restoration. “This restoration project is part of my dream that came true after almost 30 years,” he says.

From lab bench to lab results:
Diagnostics for developing countries

Biomedical Engineering Professor David Beebe and his collaborator, Oncology Professor Emeritus Richard Burgess, have received a Point-of-Care Diagnostics grant through Grand Challenges in Global Health, an initiative created by the Bill & Melinda Gates Foundation.

The initiative seeks to engage creative minds across scientific disciplines—including those who have not traditionally taken part in health research—to work on solutions that could lead to breakthrough advances for those in the developing world. With the grant, Beebe, Burgess and their collaborators will streamline a process for preparing patient samples such as blood and urine, among others, for point-of-care diagnostics in developing countries.

Their technology could be useful anywhere that quick, accurate lab results are needed. “We're testing to make sure it works under the types of conditions seen in the developing world—including dusty, high temperature and high humidity—as well as adapting it for use with a variety of samples and different types of downstream analysis technologies,” says Beebe. “Ultimately, we hope this technology will contribute to the development of high-performance, low-cost diagnostics to help manage disease monitoring and treatment in the developing world.”

READ MORE: go.wisc.edu/57co5d
The U.S. Department of Transportation awarded a $3.5 million grant to the National Center for Freight and Infrastructure Research and Education (CFIRE). Led by researchers at UW-Madison, CFIRE is a partnership among 10 U.S. universities and encompasses a geographical area that serves the majority of freight traffic in the United States.

The new grant will fund research, outreach and education on multimodal freight systems and will allow CFIRE to continue its innovative freight research as a Tier I University Transportation Center.

Researchers in the center aim to make multimodal freight systems work for economic recovery and quality of life. “The goal of our center is to achieve an interconnected freight system that is safe, clean and efficient,” says Civil and Environmental Engineering Professor Teresa Adams, CFIRE director. “By achieving that goal, we will contribute to the economic competitiveness of our state, region and nation.”

READ MORE: go.wisc.edu/o3b91m

Military communications on the QT

He aims to tune multiple parts of the same antenna structure to radiate at different frequencies, using synthetic “metamaterials” to shape their radiation patterns so that they won’t interfere with one another. Made up of metals, dielectrics and other materials, metamaterials react to electromagnetic waves differently based on their index of refraction, making it possible to manipulate two competing radiation patterns to make them work in tandem within a single antenna. Behdad estimates that a 20-by-20-by-3-centimeter antenna could operate anywhere between 200 MHz and 40 GHz and could be flush with a vehicle surface.

Commercially, his research is relevant in areas such as mobile phones and wireless data connections for personal computers. However, the military implications are even more crucial than preparing for a more connected future: Eliminating large antennas from communications equipment could make U.S. soldiers safer. “If you have something like a huge antenna sticking out of a soldier, it paints a pretty big target on them as they walk in the street,” says Behdad.

READ MORE: go.wisc.edu/wi4qe9

A tip that never gets old

With colleagues at the University of Pennsylvania, and IBM Research-Zürich, UW-Madison engineers fabricated an extremely sharp nanoscale tip made from silicon carbide. The tip, which wears away at a rate of less than one atom per millimeter of sliding on a silicon dioxide substrate, is thousands of times more wear-resistant than previous designs. The advance may help make nanomanufacturing both practical and affordable.

Silicon carbide is an ideal candidate material for a tip. However, the team’s unique fabrication process made it possible to harden the surface, maintain the tip’s original shape, ensure strong adhesion between the hardened tip surface and the underlying material, says Engineering Physics Distinguished Research Professor Kumar Sridharan.

Using plasma-based ion implantation, he and colleagues exposed surfaces of nanoscale silicon tips to carbon ions and then heat-treated them for short durations at more than 2,000 degrees Fahrenheit to form a super-strong silicon-carbide layer. “When dealing with a plasma, it’s like trying to control lightning. We need to pull the ions from the plasma cloud and direct them to the ‘lightning rod,’ or tip, without blunting the tip,” says Sridharan. “If you strike the tip and blunt it, the whole thing is gone. We have to control the environment so that these tips can be made reliably en masse—and we’ve achieved that.”

READ MORE: go.wisc.edu/wi4qe9
They’ve become the subject of myriad YouTube “how-to” videos. Entire department of transportation websites explain how to navigate them. And, they elicit more than a little anxiety and confusion in the minds of drivers entering, circling and exiting them.

Yet, roundabouts are rapidly cropping up in locales ranging from city streets to rural intersections and Interstate off-ramps. In essence, they are the “next big thing” in roadway intersections.

Quite simply, roundabouts provide drivers an efficient, safer alternative to traditional four-way intersections governed by stop signs or traffic signals, says Civil and Environmental Engineering Professor David Noyce. An expert in transportation safety, Noyce directs the Wisconsin Traffic Operations & Safety (TOPS) Lab at UW-Madison. “In typical traffic engineering, there’s a tradeoff between safety and operations. Generally, ‘safe’ equals ‘inefficient,’” he says. “Our research has shown roundabouts offer benefits in both of these.”

TOPS researchers have studied not only roundabout safety and operations, but also the inner workings of seven software packages transportation engineers use to design roundabouts. At the national and international levels, their research not only can improve roundabout design software, but also inform traffic engineers’ decisions related to how to design roundabouts and where to construct them.

In Wisconsin, drivers can encounter any of 150 roundabouts already installed on streets and roads, with another 150 planned by the end of 2015. For one comprehensive evaluation, TOPS researchers studied crashes in 14 Wisconsin multi-lane roundabouts throughout the state. “Even if something happens, your risk of a fatal crash goes way down,” says Andrea Bill, TOPS traffic safety engineering research program manager. In Wisconsin, as well as at the national level, roundabouts have emerged as being very safe, says Noyce. “You may not like them personally, but roundabouts have significantly reduced the probability of a severe accident happening,” he says. “I think that’s a contribution to society.”

**READ MORE:** go.wisc.edu/4o7970

Integrating a complex, single-crystal material with “giant” piezoelectric properties onto silicon, UW-Madison engineers and physicists can fabricate low-voltage, near-nanoscale electromechanical devices that could lead to improvements in high-resolution 3-D imaging, signal processing, communications, energy harvesting, sensing, and actuators for nanopositioning devices, among others.

Led by Harvey D. Spangler Distinguished Professor of Materials Science and Engineering and Physics Chang-Beom Eom, the multi-institutional team published its results in the November 18, 2011, issue of the journal *Science*.

Piezoelectric materials use mechanical motion to generate an electrical signal—or they can use an electrical signal to generate mechanical motion—for example, to generate high-frequency acoustic waves for ultrasound imaging. A major limitation of these advanced materials is that to incorporate them into very small devices, researchers start with a bulk material and grind, cut and polish it to the size they desire. It’s an imprecise, error-prone process that’s intrinsically ill-suited for nano- or microelectromechanical systems.

Eom studies the advanced piezoelectric material lead magnesium niobate-lead titanate, or PMN-PT. Until now, its complexity has thwarted researchers’ efforts to develop simple, reproducible microscale fabrication techniques. Applying microscale fabrication techniques such as those used in computer electronics, Eom’s team has overcome that barrier. “The properties of the single crystal we integrated on silicon are as good as the bulk single crystal,” says Eom.

His team also developed a method for fabricating piezoelectric microelectromechanical systems. Applied in signal processing, communications, medical imaging and nanopositioning actuators, those systems could reduce power consumption and increase actuator speed and sensor sensitivity. Additionally, through a process called energy harvesting, they could convert energy from sources such as mechanical vibrations into electricity that powers other small devices—for example, for wireless communication.

**READ MORE:** go.wisc.edu/jt1cs1
Who Knew?
Bill Murphy is an associate professor of biomedical engineering, materials science and engineering, and orthopedics and rehabilitation. Murphy and his students develop new biomaterials and uses for biomaterials, as well as new approaches for drug delivery and gene therapy. He and various collaborators have founded two spin-off companies, collaborated with several other established companies, and filed 16 patents based on their technologies.

1. **How do you identify research concepts and ideas that have potential as marketable products?**

   First, we determine if there is an underserved clinical need. That kind of insight comes from interactions with clinical collaborators. We also ask if the technology is likely to have a unique advantage when compared to other products that are currently on the market. That comes from our understanding of what we and our collaborators in the clinics tell us about the limitations of what's currently being used. Finally, we have to think about whether or not the technology we're developing has a practical path to commercialization. That encompasses a series of things: the path to regulatory approval, the size of the market, the number of patients that could be affected by it, and the uniqueness of the technology compared to competing technologies.

2. **How do regulations influence the types of technology you choose to research and develop?**

   The impact of the technology has to be in line with the complexity of its regulatory approval. We are interested in developing technologies that have a simpler route to regulatory approval, because then there are a broader range of clinical indications where that technology might be a realistic solution.

   For example, we have a series of projects going on that involve leveraging components of native blood. These projects range from taking platelet-rich plasma fraction that's used clinically now and finding ways to more effectively deliver it, to capturing individual proteins from blood and delivering them back to the patient. Because the blood is taken from the same patient being treated, there is the potential that the regulatory path could be simplified, since therapies derived from the blood are processed with minimal manipulation. That means that the therapy can be prepared in the operating room at the surgeon's discretion. In addition to that, the advantage of working with blood and other patient-derived solutions is that there are many, many factors available that can influence healing. It's then possible to deliver multiple components simultaneously to stimulate the healing process. Given the regulatory path involved, delivery of multiple pro-healing factors is very difficult both technically and practically to achieve using other technological approaches.

3. **Apart from regulatory hurdles, what unique challenges do biomedical technologies face as researchers attempt to commercialize product ideas?**

   One thing that's inherent to the biotech industry is that there isn't always a clearly defined path for testing a technology. That's where we need really strong interactions with clinicians, in particular. Really, they're the end users. The practical issues with the use of a technology have to be considered, as well. For example, we've been developing medical devices that can stimulate healing, and we've focused on devices like sutures, screws, plates and other devices that are used ubiquitously in the operating room. Surgeons know how to use them and there's a protocol in place for their use; surgeons wouldn't require any additional training or new skill sets to adopt the technology. Those practical concerns are hard to figure out until you've had detailed discussions with a broad range of clinicians that are involved in treating these conditions.

4. **When it comes to bringing research into the marketplace, what unique insights can business contacts offer to academic researchers, and vice versa?**

   A really astute businessperson or venture capitalist asks the sorts of questions that don’t often get asked on the scientific side. Questions about the practicality of commercializing a technology, what the
pitfalls might be, who the competitors might be, or how much funding and time will it take to move the technology all the way to market—there are a broad range of concerns that our business contacts bring to our attention. It's introduced to us a whole new set of challenges that we need to address if we're serious about commercializing products and helping patients.

In return, business contacts get a viewpoint on what the leading edge of technology is at the moment. Some of the things we work on in the lab are not designed for near-term commercialization—there are scientific concepts we're exploring that probably won't be therapeutic products for another 20 or 30 years. That gives our business contacts a "first look" into what the future of the field might be.

Where do you make connections with the business world?

It varies quite a bit, based on the technology. Particularly in Madison, there's a network of people who have an interest in biotechnology and biomedical device design. Because that network exists, some of our initial contacts that relate to specific products result in a much broader range of contacts that are more generally related to biotechnology. The Wisconsin Alumni Research Foundation is helpful in connecting us with people—not just in Madison, but elsewhere—who might have an interest in funding technologies or even partnering with us.

Also, our clinical collaborators are helpful. Because they have such an understanding of current products, a lot of them become thought leaders in the industry. They're the sort of people that companies go to when they want to know what the next important technology will be, so they can help us get connected with potential industrial partners.
How industrial engineers improve

By Christie Taylor
During an intensive three-month period in fall 2011, UW-Madison graduate students Renaldo Blocker (left) and Sacha Duff (right) worked long hours in the emergency department of Cedars-Sinai Medical Center in Los Angeles. Whenever a victim of a car accident, stabbing or other incident arrived, they would accompany trauma teams from the moment patients arrived until their surgery was finished.

While the two carried trauma pagers and wore hospital scrubs, they weren’t medical students.

Rather, they are systems engineers, and they were in the hospital collecting data for Industrial and Systems Engineering Professor Doug Wiegmann (center), who is midway through a project to reimagine how operating rooms—and operating room staff—work.

Assistant Professor and Anna Julia Cooper Fellow Enid Montague uses Post-its as part of her process for prototyping technologies that can help patients better manage their health.

**healthcare**

**Longevity**

Research applying industrial engineering principles to healthcare is central to the Department of Industrial and Systems Engineering (ISyE). Such research in the department dates back to the 1970s, when Professor David Gustafson decided to devote his entire career to it. In fact, ISyE faculty were among the first industrial engineers to engage in what’s now called health systems engineering research. Today, more than a dozen professors in the department conduct some kind of healthcare research, whether as a core focus or an application against which they can test new methodologies.

In the United States, ISyE at UW-Madison stands out because it consistently has been involved in health systems research throughout the past four decades, says Professor and Chair Vicki Bier.

This longevity has its advantages. The department is attractive to graduate students because it offers a well-established master’s program in health systems engineering, while undergraduates are required to take a health systems course. Faculty members also offer a short course in the summer to educate health professionals. And when faculty candidates come for interviews, Bier can introduce them to the chief operating officer of UW Hospital. “They’re not starting from scratch when they need medical collaborators,” Bier says.

Additionally, ISyE faculty are encouraged to publish in medical journals to enhance the impact of their research. They receive significant funding from the National Institutes of Health and other healthcare-related entities; the departmental total currently hovers around $65 million in active grants and projects. Directed by Gustafson, who now is a professor emeritus, the Center for Health Enhancement Systems Studies (CHESS) alone secures more than $10 million per year in grants to create online tools to help people with chronic and terminal conditions, as well as to improve healthcare more generally.

**Leadership**

Despite the long tradition of emphasis on healthcare research in industrial and systems engineering at UW-Madison, that focus is just now catching on at other institutions. And applying traditional industrial engineering in a very people-centric way enables UW-Madison researchers to address issues such as patient safety and developing decision-support tools to empower patients. “Healthcare is the new manufacturing,” says Bier. “But we have a greater awareness of and sensitivity to what’s different about working with patients—instead of parts in a factory.”

Its history, as well as its disciplinary adaptability, set the UW-Madison industrial and systems engineering health systems program apart. “That gives us a huge competitive edge—not only in healthcare research, but in terms of collaboration at the UW Hospital, and in recognition at the UW medical school,” says Associate Professor Oguzhan Alagoz, who joined the College of Engineering faculty in 2005 because of its reputation for healthcare research.
But, says Montague, it’s important to know how technology affects a patient’s relationship with his or her providers to ensure that relationship is strong. “When patients trust their doctors, they get better faster,” she says.

Montague’s research consists in part of observation that uses classical psychology: Her team analyzes video of doctor-patient interactions and measures physiological responses such as heart rate for subjects participating in scenarios at her lab. “We reduce them to measurable units to build these models of the interaction and then we look at certain outcomes, like the effects of having a small negative facial expression,” Montague says.

Using this information, Montague’s research group can make recommendations for clinician training that ensures the strongest possible relationships.

Montague’s team also is working on designing technology that can monitor a person’s health and wellness, help them manage long-term health problems such as asthma or diabetes, and persuade them to make changes to improve their overall health. For example, she says, a sedentary person’s surroundings could be fitted with tools to encourage them to move around more. “So if you sit for four hours without moving, the space is aware, and you get a phone call that says, ‘Hey, it’s 60 degrees out. Why don’t you go for a walk?’” says Montague.

Back to the hospital: Wiegmann recently received an additional $1.2 million in U.S. Department of Defense funding for his operating room research, in which he is studying the process of surgery from start to finish to find places where treatment flow is interrupted. For example, surgical teams might not communicate in ways that ensure tasks are completed correctly—a request isn’t heard, or there’s confusion about who should perform it. And, Wiegmann says, the wide variation in how healthcare can be performed means that there’s a dearth of standardization, which also creates confusion when teams don’t work together consistently.

In addition to his healthcare research, Wiegmann also studies accident prevention in such settings as aviation. While there are plenty of differences between the two areas—for example, aviation is a much simpler, centralized system—he says healthcare can benefit from a human factors approach. “A lot of it is trying to come
Associate Professor Oguzhan Alagoz (center) has created diagnostic models that produce a probability of breast cancer based on a woman’s individual attributes and risk factors.

In collaboration with Radiology Associate Professor Elizabeth Burnside (left), Associate Professor Jingshan Li (center) has created diagnostic models that produce a probability of breast cancer based on a woman’s individual attributes and risk factors.

up with some way of improving the coordination of care, either through technology and communication devices, or other types of standardization of the process,” he says. “Industrial and systems engineering and healthcare human factors engineering provide the background and tools to help.”

**SCOPE**

The depth and breadth of UW-Madison ISyE healthcare research is virtually second to none. Faculty also conduct research in such areas as scheduling, patient safety, quality of life and quality of care, clinical decision-making, in-home healthcare, health information management, treatment optimization, and many others.

Through the multidisciplinary Systems Engineering Initiative for Patient Safety (SEIPS), for example, ISyE professors such as Pascale Carayon and Ben-Tzion Karsh work with faculty from the UW medical school to apply human factors, systems engineering and quality engineering to determine how patients benefit if clinicians use computer systems to order medications and procedures. They also assess risks in different aspects of patient care, and how intensive care unit teams can successfully collaborate when, as in the case of “virtual” ICUs, some nurses might be working miles away using specialized telemedicine software.

Associate Professor Jingshan Li is studying ways to reduce emergency room overcrowding. Through the Wisconsin Institutes for Discovery, Professor Michael Ferris develops computer algorithms that can be used to optimize radiation therapy, cancer treatment plans, and other health processes. And Moehlman Bascom Professor Patricia Flatley Brennan also is a registered nurse. In her Living Environment Lab, also housed in the Wisconsin Institutes for Discovery, she and her team observe human behavior in a virtual reality space that can simulate any environment—ranging from a kitchen to an operating room—to understand ways system changes and new devices can improve care and outcomes for patients.

Even those examples, says Bier, are just the tip of the proverbial iceberg. “When we go to meetings in the field, the typical reaction I get from other departments is, ‘Wow. How do you do everything you do in healthcare?’” she says. “UW-Madison is a place where many people build their entire careers around healthcare.”
Biomedical engineering undergrads expect to spend a large chunk of their education working on products that solve real-world medical problems. From admission to the department all the way through to graduation, they take a series of design courses that help them apply a suite of skills and knowledge necessary for devising solutions to challenges that come up daily in the world of medicine. Often, they draw on some fairly disparate—and seemingly unrelated—fields.

For example, why would they need to know how the precision of gyroscopes of a Segway might be affected by the regulations governing a hospital operating room? What could quality woodworking have to do with a device that offers comfortable in-home patient care for a child with cerebral palsy?

“Most of the time, engineering isn’t a straight line,” says Biomedical Engineering Senior Lecturer Mitch Tyler. “You have to learn to draw from different places and different sources in order to synthesize something new and relevant to the problem you’re dealing with.”

Tyler says textbooks and problem sets can only offer a finite number of opportunities for students to test their problem-solving skills. In contrast, BME design courses get students out of their comfort zone and enable them to become more interdisciplinary, more resourceful and more well-rounded engineers.

In addition, real-world design challenges offer students a chance to experience the human, business and practical constraints that just aren’t present in “on-paper” homework.

The human side of engineering

Design projects challenge each student’s experience level in engineering and biology, but some present unique emotional and personal challenges as well. John and Melanie Patterson—a pair of ’98 UW-Madison grads now raising a family in Oregon, Wisconsin—issued such a challenge to BME students by asking if they could make part of the daily routine with their 8-year-old son Marc a little bit easier on their backs. Marc has cerebral palsy and requires diapering, but as he has grown, lifting him up to change him has become more and more taxing for the family.

“He’s well over 50 pounds,” says John Patterson. “Even though we try to stay in good physical health, the repetitive strain was starting to take its toll on our backs.”
The challenge? Create a changing table for Marc that not only supports his disabilities, but fits into the Pattersons’ lives in such a way that they don’t feel his bedroom is filled with hospital equipment.

“We don’t want this giant hunk of metal constantly reminding us that Marc has special needs,” says John. “As a family, I think it’s more important to focus on what he’s able to do and what his abilities are, rather than what he can’t do.”

The design problem—essentially, how to safely and comfortably lift a person—wasn’t especially complicated.

But serving the very personal needs of a client offered invaluable insight for Ben Smith, Lisle Blackbourn, Brett Napiwocki and Michael Kapitz, the biomedical engineering sophomores (now juniors) tasked with filling the Pattersons’ request. “We had a responsibility to represent the program as far as making something that was safe and reliable, something that would definitely work for them,” says Smith. “I figured it was something we could do well.”

While most currently available products that would suit the Pattersons’ needs also looked very clinical, Smith and his team took to heart the family’s desire for something that looked like it belonged in a home. By placing a pneumatic scissor-lift inside two interlocking wooden boxes, the team created a handcrafted changing table that doubles as a padded storage bench.

The result is equally as functional as the clinical products, but suited the Pattersons’ needs better than they could have hoped.

“It seems simple, but having something like the table, which looks nice in the room but is still functional for him without signifying ‘this boy has disabilities,’ is pretty awesome,” says John.

**A crash course in inventing**

The value of experience—in this case, experience with the design constraints of real-world clients—has been the guiding philosophy since the first biomedical design courses were taught in 1998. “It’s the synthesis of all of their hands-on experience, prior art, coursework and just-in-time learning,” says Tyler.

The six-course biomedical engineering design sequence has been a cornerstone of the BME undergraduate curriculum since the department formed in 1999. But the students’ designs don’t gather dust on a shelf. BME students have filed at least 80 patent disclosures for devices and concepts—ranging from keyboard sanitization systems to protective hydrogels for thermal ablation procedures—that started as design projects.

The BME design courses become a valuable springboard for enterprising students to make their first leap into entrepreneurship, as well. “They’re really going from an academic exercise at the beginning of the six-semester sequence to something that could potentially be commercialized,” says Tyler.
Laura Platner and her teammates—including Taylor Powers, Kelsey Hoegh, Tanner Marshall and Daniel Tighe—developed a foam cuff to help prevent infection at the site where a drain tube is placed after a breast mastectomy.

Anthony Sprangers, Alexander Johnson, Patrick Cassidy and Sean Heyrman—the students developing a protective hydrodissection fluid for thermal ablation—have been pursuing a commercial product since wrapping up initial work on the project last spring. “We were at a pretty good point where we wanted to continue it—we felt that it had some potential,” says Sprangers.

The students’ product, which makes thermal tumor ablation safer for patients by providing a gel-like barrier to protect surrounding organs and tissue, has already earned the team accolades. The students took third place in the National Collegiate Inventors and Innovators Alliance 2011 BME Start Competition for Undergraduates, and more recently, they took second place for undergraduates in the Collegiate Inventors Competition, which came with $10,000 to further develop a marketable product.

Their success is well earned, but they acknowledge that being able to consult with their client, Biomedical Engineering and Radiology Assistant Professor Chris Brace, and their advisor, Biomedical Engineering Associate Faculty Associate John Puccinelli, during their BME design coursework played a tremendous role in getting the team to where it is now. “They each have inventions of their own that they’ve tailored into products,” says Johnson. “I think having them as a resource is great for that, too.”

“These are really bright, highly capable young people who are exceptionally well-motivated, resourceful, diligent and capable of handling challenges beyond what they think they can.”

—Mitch Tyler
BME juniors Stephen Young, Zach Weier, Chris Besaw and Ben Smith work to streamline the design of an infant respiratory monitor for preventing sudden infant death syndrome (SIDS) in developing nations.

The thrill of a challenge

Biomedical Engineering Associate Faculty Associate Amit Nimunkar is working with another BME design team eager to leverage its advisor’s experience. After losing their first project mid-semester when their client found a commercially available solution to his problem, the five seniors—James Madsen, Bret Olson, Justin Cacciatore, Blake Marzella and Michael Konrath—were eager to get moving on a prototype for their new project.

Their client, an orthopedic surgeon who lost the use of his legs in a 2011 accident, asked the students to find a way for him to return to the operating room for standing surgeries. The team proposed a four-wheeled motorized platform with controls precise enough to safely support the client as he moves around the operating room.

Minor hurdles only seem to energize the students—and as seniors, they feel more than prepared for their design challenge. “In previous projects, I’ve worked in SolidWorks and MATLAB and all these different computer programs that have helped me build my skills,” says Madsen. “Now it’s all paying off, because I can use my SolidWorks abilities to create a better design, or do these calculations in MATLAB that maybe I couldn’t have done as a 200-level student.”

But the gravity of the solution they're developing is not lost on the students, either. “This is a guy’s livelihood, and it’s going to be used in a place where, if something goes wrong, it can not only hurt him, it could hurt other people,” says Michael Konrath. “Everything we do has to be checked against calculations, really accurate design—it’s a real product.”

The frustration of working against the clock or of working with clients who have unusual expectations and requests might seem daunting, but Tyler says it’s rare that students aren’t up to the challenge. “These are extremely bright, highly capable young people who are exceptionally well-motivated, resourceful, diligent and capable of handling challenges beyond what they think they can,” says Tyler. “Far from being a burden, the added pressure of working on projects with real-world implications becomes especially rewarding for the biomedical engineering students who find themselves under the gun.”

YouTube: Making a difference through design: go.wisc.edu/256117
Some of my classes can be daunting when I’m the only—or one of a few—female members,” says Jessica MacAllister, a UW-Madison undergraduate studying computer engineering.

As a woman pursuing a degree in a STEM (science, technology, engineering or math) field heavily dominated by men, MacAllister (at right, center) isn’t the only female who sometimes feels out of place. Rather, she’s among many women whose collegiate educational path begins in the sciences—and often ends in frustration and isolation.

Yet, even women who leave STEM disciplines do so with good grades. “Many studies have shown that women dropping out of engineering is not an issue of performance,” says Kristyn Masters, a UW-Madison associate professor of biomedical engineering. “In fact, women who leave engineering tend to have higher grade-point averages than men who stay in engineering. However, the lack of a support system and the lack of female role models seem to be more influential in women leaving STEM disciplines.”

Offering a support system that ranges from social connections to academic resources and mentoring connections, the UW-Madison Women in Science and Engineering (WISE) residential learning community is helping to reverse that trend.

Elise Gale, a computer science and math senior who participated in WISE from 2008 to 2010, says WISE was all she could have hoped for and more. “WISE helped me adapt to primarily male classrooms, which was very different from my high school experience,” she says. “Because many WISE women were taking similar classes, it was easy to find people to study with. Most importantly, they were the people I could go to with new college problems—like how to deal with a really bad grade or a study-group conflict. The WISE women were extremely supportive for these first college steps.”

A recent study of UW-Madison student graduation rates shows that WISE plays a key role in retaining women in STEM disciplines through graduation. “WISE improves graduation in STEM degrees, and WISE improves graduation—period,” says Masters, who is the WISE faculty director.

Of WISE participants whose UW-Madison application stated their interest in a STEM field, nearly three-quarters graduated with a degree in a STEM field. Conversely, of a GPA-matched cohort of UW-Madison women who did not participate in WISE, only about half earned their degree in a STEM field. “In other words,” says Masters, “regardless of grade-point average, participation in WISE is associated with a 140-percent increase in the STEM graduation rate for UW-Madison women.”

Similarly, she says, about half the underrepresented minority students who participate in WISE earn their degree in a STEM field, compared with just a third for those who do not participate in WISE.

The benefits to underrepresented women are far-reaching. Quite simply, minority women who declared STEM on their UW-Madison application and participated in WISE have a higher graduation rate than a non-minority woman in the general UW-Madison student population.

“ Irrespective of major—STEM or not—WISE is helping to close the graduation achievement gap between those groups,” says Masters.
Retaining women in STEM disciplines is a growing concern at universities around the country. Such efforts also are gaining renewed commitment nationally.

Throughout his tenure, U.S. President Barack Obama has been vocal about the country’s need to improve student performance and retention in STEM disciplines. His “Educate to Innovate” initiative seeks to increase STEM literacy among all students, increase student competency in STEM disciplines, and expand STEM education and career opportunities for underrepresented groups, including women and girls. The president’s 2013 education budget includes funding for programs and partnerships that aim to help the country meet an ambitious goal of a million additional American graduates in STEM over the next decade.

And in September 2011, at a news conference in which the National Science Foundation rolled out its Career-Life Balance Initiative, First Lady Michelle Obama discussed the importance of supporting women in STEM fields. “If we’re going to out-innovate and out-educate the rest of the world, we’ve got to open doors for everyone,” she said. “We need all hands on deck—and that means clearing hurdles for women and girls as they navigate careers in science, technology, engineering and math.”

At UW-Madison, simply living, studying and socializing with other science-minded women has eliminated some of those hurdles.

“Students have told me that even if they don’t know everyone on the residence hall floor, it’s amazingly reassuring to come back to a community that women have all said, ‘Yes, I like this, too,’” says Ann Haase-Kehl, the WISE program coordinator. “Choosing to be there means a lot.”

About 75 women participate annually in WISE, which got its start in 1995. First-year students apply for WISE, live on a designated floor in Sellery Residence Hall, and organize and participate in social, mentoring and career- and community-building activities throughout the academic year. They study together and can register for special WISE sections of several fundamental courses.
Through a mentoring course for second-year students, WISE also enables women to develop as leaders. As a sophomore, computer science and math student Gale was a peer mentor, as was Aneela Alamgir, who earned a bachelor’s degree in genetics in December 2011. She also participated in WISE for two academic years and says peer mentors made her freshman year a wonderful experience. “I wanted to do the same,” says Alamgir, who became a WISE peer mentor her sophomore year. “It benefited me because I developed and strengthened my leadership skills. I’d like to mentor people in my professional career as a physician and/or academic professor—and so this was a stepping stone in that process.”

Beyond peer and academic support, WISE also has begun to offer summer research funding. Biomedical engineering student Anika Abid, who lived in WISE during the 2010-2011 academic year, received a $4,000 grant. “This grant allowed me to experience a once-in-a-lifetime experience of directly controlling my very own research project in the lab after completing only one year of college,” says Abid, who hopes to become a medical doctor. “I know that this sets me apart from many other people my age.”

While not a past participant herself, WISE faculty director Masters credits a scholarship for women she received as an undergraduate—and the professor who nominated her—for setting her career path. “I got a summer of paid research experience,” says Masters, who holds bachelor’s and PhD degrees in chemical engineering. “I never even knew faculty did research. Then I started working in that lab and I never left. I worked there until the day I left for grad school. That experience changed my life completely.”

Masters’ message to both prospective and current students is very clear: “You deserve to be at UW-Madison,” she says. “You can succeed. And being part of WISE can help you be a more successful student.”
The prospect of living and working in Beijing for a summer made Dhinia Susanti a little nervous, but her internship in China turned out to be the opportunity of a lifetime.

“I thought that the biggest barrier was going to be the language, but in the end, it wasn’t that much of a challenge,” says the electrical and computer engineer, who earned her bachelor’s degree in August 2011. “I was worried about getting around Beijing by myself, but there were English translations everywhere, and the subway system was easy to use.”

The most challenging—and ultimately, perhaps the most rewarding—part of Susanti’s trip was returning to the United States and boiling down all of the ways she grew as a person and engineer into a brief four-minute video.

“I had to think twice about how to tell a story about how I grew up—that I learned a lot, and essentially that this was something very beneficial for me,” she says.

Unfortunately, Susanti didn’t have video or photos of all her experiences. As a result, her video, Made in China, is a hand-written guide to everything she learned and experienced in her time overseas, from seeing Chinese industry firsthand to learning the importance of standing out in a nation of more than one billion people.

Having a portfolio-ready presentation of her work in China came in handy: Susanti landed a job with global IT software and solutions company CA Technologies a few months after she graduated.

Susanti says that working in China in quickly became a key selling point for her as a job candidate. “Right now, China is in the spotlight and people just want to know what’s going on there,” says Susanti. “Traveling abroad is a huge deal, but I would say that traveling to China almost gives you double points. My internship in China helped me to get this job.”

YouTube Made in China: go.wisc.edu/g4080x
For UW-Madison students who take an eight-month engineering co-op with Nelson Global Products in Stoughton, Wisconsin, their first adjustment is working without a formal job description. “We give students the job description of the person they will be working next to,” says Rob Schellin, Nelson Global Products director of engineering. “We give co-ops the same opportunities and responsibilities as the full-time engineers . . . and we will let them rise as high as they want in their involvement.”

This simple, unscripted philosophy is an important part of the growth strategy for Nelson Global, a custom manufacturer of tubing, acoustic, emissions and other fabricated products for multiple markets, including on- and off-highway vehicles. The company just came into existence in May 2011 after being sold by Cummins Inc., where it operated as the Cummins Exhaust Group.

In this suddenly smaller company with a new slate of market opportunities, Schellin says co-ops are a great way to find talent that fits the company problem-solving business model. “We fundamentally believe that when something breaks, it broke for a reason and we need to figure out why,” says Schellin. “We’re looking for people who are wired to think mathematically, rather than with their gut.”

Cooperatives (known as co-ops) are growing in popularity with both students and employers as a practical training experience. Co-op students are hired for eight months as full-time employees and often receive a market-comparable salary. They remain students by enrolling in a one-credit co-op course and filing a work report upon completion.

In the college, Engineering Career Services helped fill more than 250 requests for co-ops in 2011, and staff expect those numbers to rise in coming years as the economy continues to improve, says John Archambault, College of Engineering assistant dean for student development. He estimates that about 75 percent of students completing co-ops within a year of graduation receive full-time offers.
“Co-ops are able to see larger portions of projects from concept through to completion,” Archambault says. “As students are on the site longer, supervisors develop more trust and hand off more challenging and interesting assignments.”

For the companies, it’s like having an eight-month interview process, says Susan Ullman, Nelson Global Products human resources manager. “The campus turns out wonderful engineers and knowledgeable people, and our proximity to Madison is a great benefit,” she says, noting that many students opt to keep their campus apartments during their co-op. “For Nelson, the campus will be a big part of our focus for co-ops and full-time employees going forward.”

The company currently hires four co-op students each year—two for a spring and summer stint, and two summer through fall. Past co-ops within the business have been hired full-time and some are key contributors to the new company.

One of those is Nathan Derks, a 2008 mechanical engineering graduate who is now manager of Nelson’s On Highway Customer Engineering. His 2006 co-op was in one of the company’s other units, and he came back to work again in 2007 with its exhaust group.

“What the co-op taught me was about focusing—there’s a lot more project management in a co-op than you will find in the curriculum,” Derks says. “The ME curriculum was the toolkit; the co-op was the application.”

Schellin says Derks deserves a lot of credit for the design and product development in the company’s thermal management exhaust tubing area. Diesel engines now require after-combustion treatment with a catalytic converter or soot filter. This chemical reaction requires heat to operate, and Derks designs products that maximize heat retention from the engine, resulting in greater efficiency.

Derks’ co-op also became a case of job influencing school. Drawn to the hands-on work available at the company, Derks joined the human-powered vehicle team his senior year, which allowed him to work with steel frames and log more time in the machine shop. He also took a second, non-required statistics course after seeing its importance for design problem-solving.

Derks has now come full circle: In January, he started supervising his own UW-Madison co-op student. “I kind of threw him to the wolves, to be honest,” he says jokingly. “My attitude is, ‘Go do this and you may bring it back wrong, but I’ll correct it and you’ll learn from the experience.’”

Schellin, a 2002 mechanical engineering graduate and alumnus of the Formula SAE team, says he loves to recruit students from the vehicle teams and other competitions because they have that fundamental drive to figure out how things work. Nelson engineers also work best when they are involved in the manufacturing process.

“When they work with people at the plant and use the tribal knowledge of the factory together with their mathematical skills,” he says, “then they can do something really amazing.”

—Brian Mattmiller
A team of 14 engineering mechanics and astronautics students hopes its experiment through the NASA Microgravity University program will solve one of the more vexing problems—dust—of long-term space travel. “There are two main problems with dust in space,” says Julie Mason, one of the EMA seniors leading the team. “First, if the Apollo astronauts had used their same suits for another mission, the dust being collected in the joints would have prevented the suits from working properly. Second, you don’t want to bring the dust back into the spacecraft or space habitat with you.”

As an alternative to forcing astronauts to ship their laundry back to Earth between missions, Mason and her team seek to develop ways for astronauts to clean their own spacesuits as they come inside from the surface of Mars or near-Earth objects like asteroids. Design concepts range from metal brushes to off-the-shelf cleaning supplies to electrodynamic dust shields built right into the suits themselves. “If you could have the dust shield printed on your space suit, push a button, and it would repel the dust, that would help minimize the amount of dust that makes it inside,” says Mason.

Mason and the rest of the team—co-leader Grayson Butler, and Austin Gilbertson, Aaron Riedel, Austin Lemens, Collin Bezrouk, Joe Jaeckel, Lyndsey Bankers, Mike Lucas, Myles McDowell, Nathan Rodgers, Noah Ritter, Peter Sweeney and Sam Moffatt—will test their solutions on a simulated microgravity flight out of Ellington Field in Houston, Texas, in late April. The flight is the culmination of several months of preparation, both for the UW-Madison team and for a high school physics class from East Troy, Wisconsin, that will be testing its own experiment related to heat dispersal alongside the dust-removal tests. “NASA always emphasizes outreach, and we thought mentoring a team might be a good way to go about it,” says Mason. “What better way to get the students involved than to have them design their own experiments?”
A global connection:
Online engineering master's programs ranked No.1

U.S. News and World Report has ranked the University of Wisconsin-Madison No. 1 for its online graduate engineering programs in the categories of teaching practices and student engagement and student services and technology.

UW-Madison is one of only three universities that made the U.S. News and World Report honor roll for top-quality online engineering degree programs.

This important distinction was announced Jan. 9 as U.S. News and World Report released its first ranking of online master’s of engineering programs, which requires eligible programs to pass rigorous standards for quality education. The UW-Madison online engineering graduate programs also ranked among the top five in the faculty credentials and training category.

"UW-Madison is extremely honored to have the quality of our online engineering degree programs recognized as best-in-class by U.S. News and World Report," says College of Engineering Dean Paul Peercy. “These programs are meeting the growing demand of practicing engineers who want to take their careers to a higher level.”

In the teaching practices and student engagement category, the UW-Madison programs were judged on such factors as a high level of student collaboration and participation, instructor availability to answer student questions, small class size, and an instructional designer dedicated to developing courses to meet online learner needs. In the student services and technology category, the UW-Madison programs were ranked highly based on such factors as students’ ability to conveniently receive classes through both audio and visual means, and the use of a centralized student information system.

The online engineering degree programs fill a vital educational need, says Wayne Pferdehirt, director of distance degree programs for the Department of Engineering Professional Development. “We see our online master’s degree programs as a way to provide practicing engineers who are not able to attend courses on campus with an exceptional educational experience that links them to UW-Madison world-class faculty and research,” he says. “We believe that an effective use of online delivery can improve engineering education by engaging working professionals and faculty in collaborative, immediately applicable learning on an international level.”

The College of Engineering and Department of Engineering Professional Development offer a variety of online engineering graduate programs in areas including engineering management, engine systems, polymer engineering and science, technical Japanese, electrical and computer engineering (power electronics), and mechanical engineering (controls).

▸ LEARN MORE: distancedegrees. engr.wisc.edu.
In new building, microgrid lab will spark practical solutions

When the Wisconsin Energy Institute building opens on the UW-Madison campus in early 2013, it will include a high-power microgrid that will combine real and simulated power sources capable of reproducing the inherent technical challenges associated with intermittent energy sources.

“We want to be able to create all of the different operating conditions that are associated with renewable energy sources, including high- and low-wind days, bright sunlight and overcast skies, to develop improved techniques that will enable microgrids to adapt more naturally to these fluctuations,” says Grainger Professor of Power Electronics and Electrical Machines Thomas Jahns.

Microgrids are distributed generation systems that are designed to operate as self-contained local electrical power grids with a combination of sources and loads. They can operate equally well when they are connected to or disconnected from the utility grid, often incorporating on-site renewable energy sources such as wind turbines and solar panels as well as electrical energy storage systems.

Microgrids can provide highly reliable power for commercial buildings, residential neighborhoods and factories, with flexible capabilities that include the ability to export excess power to the grid and operate independently as “islands” when utility blackouts occur. Microgrid research will be a major early focus of the Center for Renewable Energy Systems (CRES), an initiative that aims to help corporate partners explore applications in the fast-growing microgrid industry. Jahns is CRES research director.

The sister organization to the Wisconsin Energy Research Consortium, which directs sponsored research with companies and government agencies, CRES is a synergistic partnership combining the knowledge and skills of the extensive community of energy, power and control researchers with world-class laboratories at Wisconsin’s four largest research engineering schools: UW-Milwaukee, UW-Madison, Marquette University and the Milwaukee School of Engineering. CRES will take on applied R&D projects with individual companies or groups of partnered companies that are interested in commercializing the technology.

WERC and CRES together seek to stimulate both scientific discoveries and technology innovations that will lead to new products and processes, positioning Wisconsin as a nationally recognized hub for energy, power and controls research.

Until the Wisconsin Energy Institute opens, CRES researchers will use an existing lower-power R&D microgrid at UW-Madison to initiate CRES-supported projects.
The new microgrid is being built into specialized high-bay lab space at the Wisconsin Energy Institute (WEI), which is slated for completion in early 2013. A facility that will obtain LEED certification, the WEI building features an open atrium that brings in natural light and serves as a meeting place for energy researchers from around the UW-Madison campus.
Bone is a remarkable organ, says orthopedic surgeon and engineering mechanics graduate James McCarthy (BSEM ’86). It grows and heals itself, and not many organs can do that. It can be cut and gradually lengthened. The bone fills itself in. If done at the right rhythm, a bone can grow to be just about as long as you want it to be.

Bone protects internal organs, including the heart, lungs and brain. It transduces sound so that we can hear. It provides the scaffold upon which to hang all our other parts, and works with muscles, tendons, ligaments and joints to generate and transfer forces so that our bodies can move in three-dimensional space.

In general, bone is a sort of dream material for the engineering mechanics major. But it wasn’t a fascination with bone that motivated McCarthy to become director of pediatric orthopedic surgery at Cincinnati Children’s Hospital.

“After graduating, I applied for and got two jobs,” he says. “One was with Saturn, which was a new, innovative company, and the other was with Hewlett Packard making sonograph equipment. I also had the opportunity to go to medical school. My theory at that time was that if I took a job, I’d never go back to school because I’d be comfortable. So I thought I’d just try medical school for a year, and if I hated it, I hated it. I became more and more intrigued in medical school. Really, it was with the idea that I would be doing biomedical engineering for a company.”

Partway through his medical training, he did some cardiology research in North Carolina and spent some time in pediatrics. All of a sudden, the pieces came together. It all made sense. His engineering physics training was math-heavy and very theoretical. It allowed him to go many different directions, but his medical training forced him to do things he was not comfortable with.

“What I was good at was figuring things out. I could sit in a room and work forever and get to the right answer. That came relatively easily, but what I wasn’t good at was memorizing long lists,” McCarthy says. “I was not comfortable with interfacing with patients on a very personal basis. So in some ways, medicine forced me to round out skills that I didn’t think I had. And I don’t know why, but that intrigued me to some degree.”

McCarthy’s specific clinical interests have an engineering focus. One is cerebral palsy (CP), which is a neurological disorder that affects the way kids walk. About two children per 1,000 live births have cerebral palsy. In the United States, the average lifetime cost for people with CP is about $900,000 per individual, including lost income.

The overlap between CP and engineering is very strong because doctors analyze the biomechanics of the way children walk. Using gait analysis, digital cameras, sensors and force plates, a team of therapists, engineers and surgeons synthesizes all the data and tries
to figure out the best list of surgeries to improve the patient’s function.

“You might think a better way would be to treat them earlier so that they don’t develop issues, but we’re not there yet,” McCarthy says. “In the right patient, you can make a fairly significant improvement in biomechanical functioning. A lot of them walk more upright. A lot walk with less of a limp. You can make some pretty significant improvements in overall gait. That part ends up being fairly dramatic. It’s also possible surgery won’t help them at all and that is where the gait analysis comes in and is very useful.”

McCarthy’s other interest involves much less common limb deformities. Approximately one in 20,000 children have significant deformities of the lower extremities. His team works to correct those through placement of external fixtures. The devices go on the outside of the leg and the leg is manipulated either by cutting the bone or using another technique that changes it over time.

“It’s very mechanical and very three-dimensional. What’s even more intriguing is when we ask if there are better ways of doing it,” McCarthy says. “Can we use an implantable device? That’s what I worked on at UW-Madison with Heidi Ploeg and Michael Zinn in the Department of Mechanical Engineering. By developing an implant, we’re trying to correct the deformity without having a large device attached to the outside of the leg.”

This approach would have huge advantages, especially for children, because braces or pins wouldn’t be visible on a patient’s leg. McCarthy says the challenge is to devise something that can be lengthened at a controlled rate and is strong enough to support the stresses of the body. Since only about 5,000 of these products would be needed per year, there isn’t much interest or funding available.

The research is progressing, but McCarthy says it’s not ready yet. But of course, he and others will keep trying.

— Jim Beal

“M

y name at the time was Kate Parker. Rumor had it that I was the first female undergraduate since World War II. I was a psychology major in 1975 looking for an engineering degree when I ran into Professor Heinz in the mining and metallurgy hallway. He was the first middle-aged adult I spotted. He almost had a heart attack when I asked him to tell me about mining engineering and offered me a scholarship on the spot.

There were only three professors in mining engineering at the time, including Professor Haimson. The number of graduate students and undergraduate students was small and undergraduates took several graduate-level classes. We worked with graduate students in the research labs, which exposed me to the state-of-the-art technology of the time.

When I started in the department, some states still had laws barring women from entering underground mines. Because the last underground mine in the state closed by my second year, I organized field trips to nearby states over spring breaks so we could visit active mines. Those field trips took engineering from theoretical to real and were exciting for me.

When I started mining engineering classes, coal was king. When I graduated, there was an oil shortage and oil prices were skyrocketing along with the demand for engineers. My four geology classes and one petroleum-engineering class prepared me far better than my colleagues for my first job as a petroleum engineer in West Texas for Arco Oil and Gas (now BP).

After my first year, I transferred offshore to new field development in the Gulf of Mexico. I decided I needed to get more field experience (something that was emphasized at UW-Madison). In my third year out of college I went to work for Conoco as its first female drilling engineer. I specialized in more and more complicated exploration wells and moved into deepwater drilling well-planning fairly early in my career with different employers.

I have worked for service companies, drilling contractors, major oil companies, and independents, as well as participated in the startup of a specialized engineering consulting firm. I wrote drilling engineering software for one of the first handheld computers in the early ‘80s, because I had a programming course at UW-Madison.

I now work for a Norwegian oil company (Statoil) in the deepwater drilling group. My job is technical supervision (lots of individual training) of the 10 deepwater drilling engineers who plan and execute the 30,000-foot deep deepwater wells that the company drills in the Gulf of Mexico. Each well costs from $100 to $200 million and each engineer plans the well virtually alone. I really enjoy passing on my experience to the bright young men and women that engineering attracts now (including my own daughter who is a refinery engineer for Shell).

The training I received in geology, rock mechanics, and fluid flow has served me extremely well as a drilling engineer. The rock mechanics graduate-level work that was being done at the time at UW-Madison made it into the mainstream of drilling 15 years later, and I was lucky to help implement its early use.

I’ve also used the programming courses, chemistry classes, physics classes, mining economics and drafting that I studied at UW-Madison. I occasionally get to work with the geology students and rock mechanics PhD candidates that I studied with.

I am currently the only licensed professional engineer with a drilling job in the company. After the Macondo blowout, the government required direct oversight of well planning by a licensed engineer, so I’m finally using my stamp after almost 30 years. You never know when it will come in handy. Not to forget, the financial compensation of mining and petroleum engineering was then, and continues to be, incredible!

I owe my continuous employment and some of the highest compensation that a bachelor’s degree can provide to my mining engineering degree from UW-Madison.”

Katherine Turner (BSMineE ’79)

My path to becoming a deepwater drilling engineer
While her heart is most definitely in the world of patient care, Dr. Jacqueline Gerhart serves as a superb example of the flexibility and potential of a biomedical engineering degree from the College of Engineering.

Like many biomedical engineers, Gerhart has been captivated by medical gadgetry since her first day on the College of Engineering campus in 2000. But just being familiar with the hardware and software of the medical world wasn’t enough for her. “I realized that being in research and development of medical instruments was fascinating, but it didn’t allow me to see how the patient used the end product,” Gerhart says. “Seeing how medical devices are used in a hospital and seeing how patients benefit from them became my passion.”

Gerhart came to that epiphany during a summer internship with Kimberly-Clark Medical Systems, where she worked to develop better percutaneous endoscopic gastrostomy (PEG) feeding tubes at its Lake City, Utah location. Gerhart realized that if she wanted to follow those designs out of a lab and into the lives of actual people, she would need to consider a career in patient care. “I really became interested in the aftermath of those designs, and seeing what the device was able to do for patients long term,” says Gerhart.

She returned to campus that fall, determined to head to medical school after graduation.

A month after earning her biomedical engineering degree in May 2004, Gerhart arrived at the Mayo Medical School in Rochester, Minnesota. She finished her medical degree in 2008, interned at the Mayo Clinic in Scottsdale, Arizona, for a year, and then did a family medical residency at the Wingra Clinic in Madison through the UW Department of Family Medicine, graduating in spring 2011.

Gerhart sought the day-to-day variety of patient care, and she certainly found it in family medicine. Currently, she sees patients as a family-care physician at the UW-Health Windsor-Deforest Clinic and works at Meriter Hospital, where she does everything from delivering babies to treating serious injuries. “I see patients that are anywhere from 1 day to 100 years old, which is amazing,” she says.

And, somewhere in between the clinic and the hospital, she finds time to teach UW-Madison courses on patient relationships and how to share bad news when patients are diagnosed with cancer. She also teaches physical exam skills to medical students and writes a medical advice column for the Wisconsin State Journal. “I found myself excited and fascinated by the ability of medicine to go beyond the clinic and beyond the hospital, and tried to answer some of the questions that patients may feel either embarrassed, uncomfortable or silly asking,” Gerhart says.

In her clinic, she has started a program focused on encouraging reading as early as 6 months of age. While she no longer does research in the field of engineering, she does clinical research in family medicine and is currently a UW Primary Care faculty development fellow.

Like a handful of other engineers who have decided to transition into medicine, Gerhart believes the technical literacy that comes with her engineering degree comes in handy when a patient asks how a pacemaker functions, or what a family can expect from the placement of a feeding tube in their loved one. “I think that my background in engineering has allowed me to recognize how important these questions are and helps me to gather further research for my patients,” she says. “I notice I’m naturally interested in reviewing the newest procedures, devices and medicines to stay abreast of the ever-changing medical field and how engineering affects it.”

She doesn’t necessarily measure the impact of her time on the engineering campus in facts and figures, though. Gerhart has plenty of fond memories from her tenure as an undergraduate here, including seeing the glass walls of the Engineering Centers Building slowly taking shape. “It was really neat to see the campus grow,” she says. “That building is crazy in terms of the colors and materials being used. I remember finally having a class in the Engineering Centers Building engineering quality patient care
after having most of my classes in Engineering Hall. It was a great transition to a beautiful facility.”

She fondly recalls professors who both challenged and engaged her, particularly Biomedical Engineering Professor David Beebe and Camp Badger coordinator and Engineering Professional Development Professor Phil O’Leary. “I remember Beebe’s class being tough, but essential to my understanding of engineering for the human body,” she says.

And she calls O’Leary an amazing professor. “He was someone that I felt that I wanted to become—because not only does he have an amazing sense of research and engineering, but an amazing ability to apply it to future generations,” she says.

In addition to her professional success, her time on the engineering campus forged a lifelong bond with the university and Madison as a whole. “It’s part of the reason why I think I’m never going to leave,” says Gerhart. “I love it here.”

— Mark Riechers
Innovation. The very word evokes mental images of complex turbo-machinery, nanoscale robots and iPads. Our brains are tuned to think of people like Thomas Edison, Steve Jobs and the Wright Brothers when the word reaches our ears. Something innovative is something desired—celebrated even—in our society.

Imagine a world where the common cold is a life-threatening illness; where you actually had to be face-to-face with someone to communicate (imagine that!); where information was stored in some distant warehouse requiring a membership to gain access. It is difficult to fathom our reality without penicillin, the telephone, or the Internet. Behind these world-changing techno-breakthroughs are innovative ideas or discoveries, something that changed people’s lives for the better. Innovation seems to deserve the clout it holds within our mindset.

It is easy, therefore, to see why innovation has become a buzzword in today’s society. U.S. President Barack Obama frequently mentions initiatives to increase innovation within the United States. The corporation I currently work for is “broadening its focus on innovation” by increasing R&D resources and capital. Places like IDEO, a design and innovation consulting firm, are admired for their innovative, unorthodox methods of product creation. It is “in” to be innovative.

Even at UW-Madison, the thrust for innovative, forward-thinking students has produced the Innovation Days, Qualcomm Wireless, and Burrill business plan competitions, as well as greatly improved access to laboratories and machining facilities for engineering folks like you and me.

I believe that, in some ways, I am a product of this shift toward innovation in our society. I became interested in learning more about product design when I saw a Nightline special on how IDEO reinvented the shopping cart. I got a job at the machine shop on campus during my undergraduate days because I wanted to learn how to create and build things. I joined a corporation in the R&D department after graduation because I wanted to solve new problems. I feel that my interests within innovation have been nurtured by the societal notion that innovation is valuable and necessary. I have always been interested in building things and felt that a career in innovation would suit me well. I have enjoyed success in the Innovation Days competition on campus because I like to invent and innovate. When asked about my hobbies, I often list inventing as my favorite thing to do.

My mindset toward understanding and creating new things began at a very early age. By the time I was 8, I had amassed a 15-gallon tub full of Legos. I remember taking the gigantic tub and spilling it across the floor, picking out pieces to assemble the laser cannon mounted to the wing of the fighter jet I was making. I can vividly remember taking apart my portable CD player when I was 10: I spayed the parts across the floor,
powered it up, and watched the disc spin and the read head move back and forth. It blew my mind that the thing could still play a CD (borrowed from my brother, just in case things went awry), even with the buttons missing and the drive motor tilted at an angle on the carpeting in my bedroom. When I was 11, I decided I'd try my hand at woodworking. I assembled a cabinet with a working hinged door for the tree house my dad had built for me. I stored magazines and Pringles inside, but the mice beat me to both before my next visit.

As I grew, so did my thirst for creating things. Throughout grade school and into middle school, I participated in science fairs, with one endeavor producing a $50 savings bond that matures in 2020. I built my first guitar when I was 15. I made a working talk-box (think Peter Frampton) out of an old amplifier, a plastic jug and a sprinkler hose when I was 16. At 17, I was toying with speaker cabinet design. When I was 19, I started fixing fried LCD TVs in my spare time. And then, one day while walking through Engineering Hall, I saw a sign for the Innovation Days competition.

The Innovation Days competition forever changed my mindset about innovation. After investing hundreds of hours into each project, I found that I liked what I was doing a lot. I liked to think of ways to transport water up a tree trunk in the most efficient way possible. I liked entertaining the crazy idea of a doctor running 8 amps of current through a pin-sized wire to deploy a self-expanding stent within someone's diseased blood vessel. I liked the challenge of creating a solid bridge across a complex femur fracture. A voice inside of me said, "This isn't work. This is fun." Perhaps that is the reason I saw success within the competition: I was able to be passionate about the ideas I was incubating.

As I progress through my life, I know that I will keep learning and fueling my desire to create new things. As a development engineer at an endovascular medical device company, I am working with a team to explore treating a completely uncharted vasculature path, in hopes of providing patients with a better quality of life. As an entrepreneur, I am excited by the opportunity to help both bone fracture patients and orthopedic surgeons in the emergency room. As a future project leader, I will be able to further my team's efforts by providing insight into problems, not just managing resources.

If my experiences with the Innovation Days competition have taught me anything, it's this: Be passionate about what you do. If you can't find passion in your current position, seek out something where you can be passionate. It is the classic line given by your father, your high school advisor, and your professional mentors, but it could not have been truer in my situation.

Whether you find baseball stadiums, engine crank horsepower, weather patterns, or any multitude of the other categories that make up engineering pulling at you, go for it. I may be too young to offer time-tested advice, but I can say that so far, passionate innovation has worked out well for me.

While I will probably never invent the next Facebook or airplane, it can't hurt to have some fun and give it a shot, right?
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To discuss your legacy, contact Ann Leahy, managing senior director of development for the College of Engineering, at 608/265-6114 or ann.leahy@supportuw.org.

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