Infinity

UW-Madison engineering students do more than just study—they *live their dreams*

COLLEGE OF ENGINEERING
UNIVERSITY OF WISCONSIN-MADISON

Dear FUTURE ENGINEERS and PARENTS,

Mahatma Gandhi once said, "You must be the change you wish to see in the world."

Although Gandhi spoke those words decades ago, they still very much hold true for our prospective, current and former engineering students, who come to campus seeking not only a great education, but also opportunities to make a difference in the world.

You can find and create those opportunities here. For more than 100 years, faculty, staff and students at UW-Madison have applied their knowledge and skills to influence and improve people's lives both in Wisconsin and around the world. This "Wisconsin Idea" is rooted in a rich tradition of outreach that to this day exemplifies the university commitment to public service. (To learn more, please visit www.wisconsinidea.wisc.edu.)

Both individually and in groups, UW-Madison engineering students work to affect positive changes in our world. They join the Peace Corps. They engineer sustainable environmental solutions for entire communities in places like El Salvador, Africa and Thailand. They apply key engineering research to jobs in industry, government and national laboratories. They volunteer and teach in K-12 classrooms. They explore cultures far different from their own, and they live and learn in places across the globe. They build homes for Habitat for Humanity. They develop assistive technologies for people with disabilities. They mentor future scientists—and their own peers.

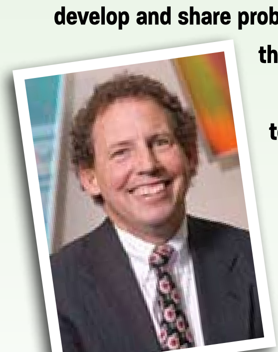
These peer-mentoring activities enable UW-Madison students to make valuable contributions right here at home. More than 800 of our students participate in College of Engineering peer-led learning activities each year. My office, Engineering General Resources, administers one of these supplemental instruction programs, which supports students enrolled in such "gateway" courses as statics, dynamics, and introductory physics.

Because of their outstanding high school academic records, students often feel like they have to tackle challenging courses without help. For them, taking advantage of supplemental instruction, tutoring and peer-led learning is a last resort, rather than their first course of action.

However, on the College of Engineering campus—and in universities around the country—peer-led learning is becoming the norm. In industry, teams brainstorm ideas and solve problems; on campus, engineering students participate in study groups—and ultimately understand difficult concepts and develop and share problem-solving strategies with their classmates.

I can't think of a better way to begin to change the world.

Regards,



Don Woolston, Assistant Dean
Engineering General Resources

International education *prepares engineering students for global workplace*

During UW-Madison materials science and engineering senior Sarah Treu's interview with GE Aviation, company recruiters noticed an extra credential on her already impressive resumé.

In addition to her engineering degree, Treu earned a certificate in international engineering. "I think they were impressed that I had thought about engineering as a global career," says Treu.

And, she got the job.

Treu was among several students who annually participate in an international engineering certificate program offered through the UW-Madison College of Engineering. Begun in 2005 after a suggestion by an advisory committee comprising industry representatives, the program helps students study the language, culture, history, geography, society or institutions of a particular country or region of the world. "The certificate underscores the importance of international experience," says Amanda Hammatt, director of international engineering studies and programs for the College of Engineering. "It acknowledges the importance UW-Madison places on that experience."

According to Hammatt, only 20 percent of U.S. citizens have a passport. In addition, citing the Institute of International Education "Open Doors" study, she says only 3 percent of engineering students nationally study abroad.

As a result, engineering students with international experience stand out. "If you can get into that niche, it opens up a lot of opportunities," says Hammatt, adding that one in six jobs in the United States has an international component.

For engineering students, learning about different cultures is especially important because engineering has become a global field, says Don Schramm, a faculty associate in the Department of Engineering Professional Development. "The standard today is to have engineers working in time zones around the world," he says.

A professor of engineering professional development who directs the College of Engineering master's and certificate programs in technical Japanese, Jim Davis says the beauty of the international engineering certificate program is its flexibility. Students take 15 credits of social science and humanities courses geared toward a country or region of the world that interests them.

The students also must work or study at least five weeks in their country or region of interest. "We want people to actually spend some time in the country or region they are studying. We want them to get to know the people, experience the culture and practice interacting," Davis says. "Significant international experience is important to make the program meaningful."

The final component of the certificate is a capstone course called *Current Issues in International Engineering.* Taught by Schramm, students write research papers and give presentations about a country or region. They also explore the culture of a company or engineering discipline.

Schramm offers plenty of personal experience to students with international ambitions. He has traveled to almost 100 countries, mostly through his work with the UW-Madison Disaster Management Center.

In addition to Schramm, students learn about working globally from myriad guest lecturers, who "attend" class virtually, via web conferencing technologies, from locations around the world. Brian Price (MS '03) is one of the course guest speakers. Currently located in the United Kingdom, Price has worked as an engineering consultant around the world.

"The advantage of teaching and learning via the web is that it fits in with a 24/7 work life. I do a lot of international travel and never know what time zone I will be in next week," says Price, who has lectured to the class from India, China, Korea and several European countries.

One certificate program alum calls *Current Issues* a "great course." Garret Fitzpatrick (BS '07) focused on Russia and now works for the NASA Johnson Space Center.

He says the most important thing he learned was to appreciate cultural differences

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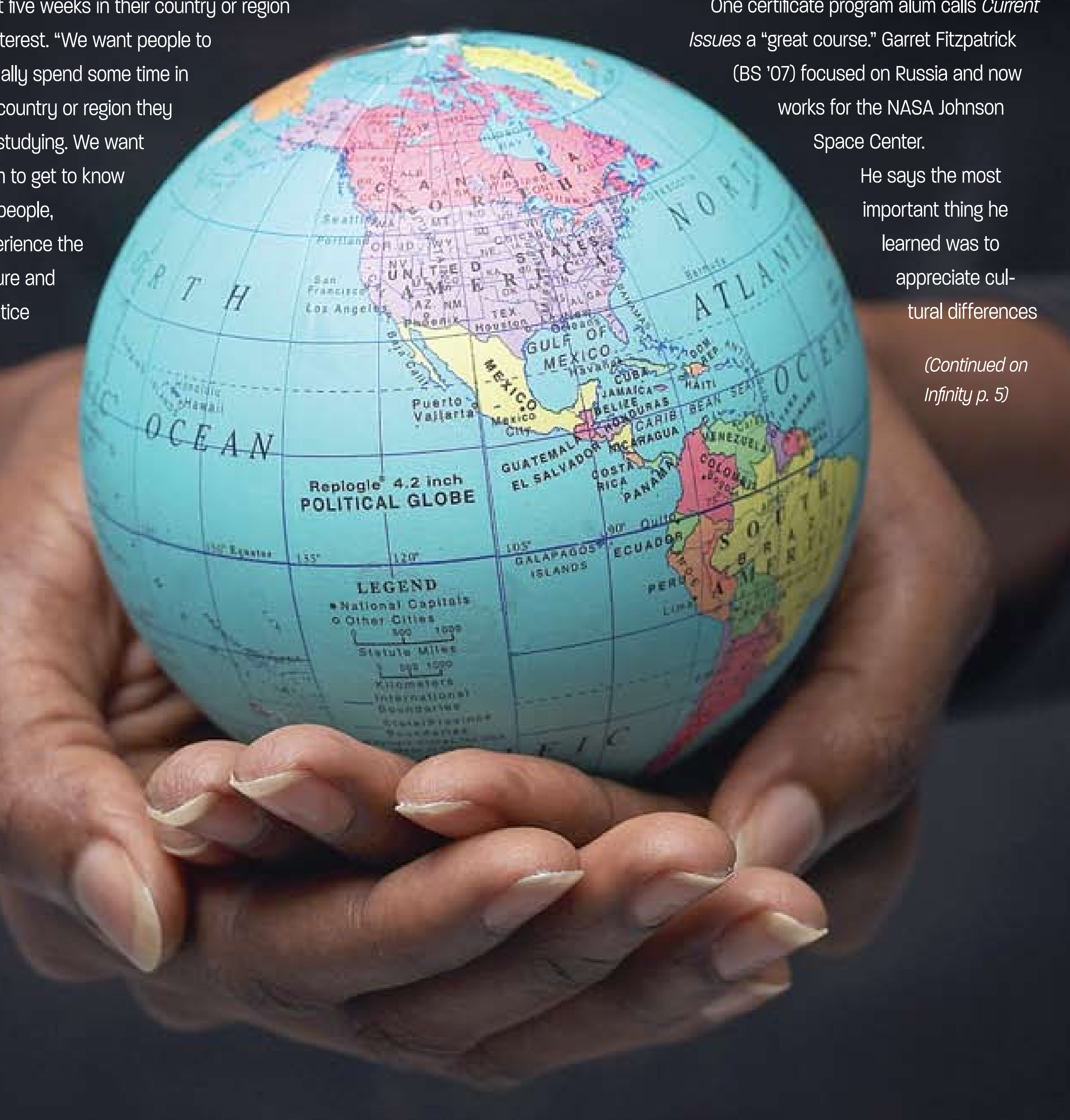
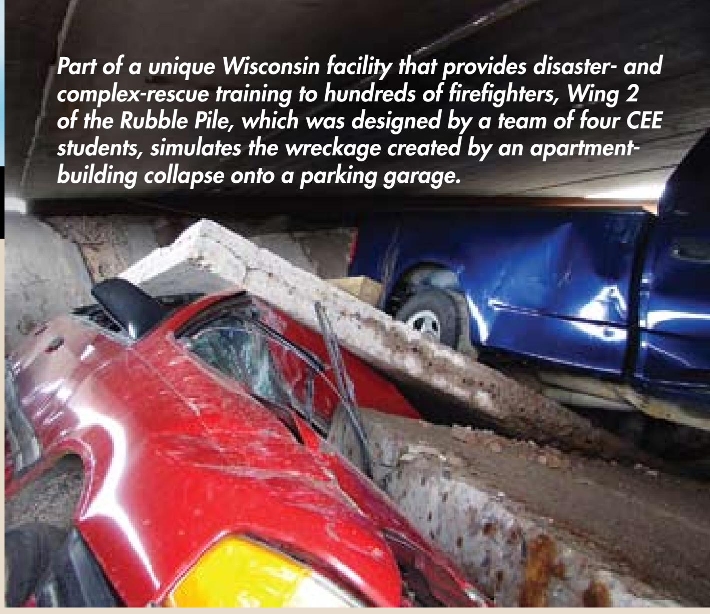




Part of a unique Wisconsin facility that provides disaster- and complex-rescue training to hundreds of firefighters, Wing 2 of the Rubble Pile, which was designed by a team of four CEE students, simulates the wreckage created by an apartment-building collapse onto a parking garage.

Students design disaster for Wisconsin rescue training facility

When students Dan Zignego, Jake Varnes, Bill Schmitz and Nick Bobinski began a design project meant to be the highlight of their educational careers, they never thought it would turn into such a disaster. Fortunately, a disaster is exactly what their client—state of Wisconsin REACT Center Director Michael Kunesh—wanted.

Operated via the Wisconsin Office of Justice Assistance and located near Camp Douglas, Wisconsin, the REACT Center provides specialized disaster- and complex-rescue training to approximately 480 state firefighters. Among its key facilities is Wing 1 of the Rubble Pile, a jumbled mass of steel, concrete, wrecked vehicles and mannequin victims that enables trainees to simulate an eight-hour-long structural-collapse rescue.

During the exercise, six teams of eight trainees—fully clad in protective gear—enter the collapsed structure at various points. Dragging heavy hydraulic saws and drills, they wiggle through crevices as small as 2 feet in diameter. They cut through steel or concrete barriers and build rakers, or braces, to stabilize portions of the collapsed structure. And they locate, assess and transport mannequin survivors or victims out of the wreckage.

Designed by civil and environmental engineering students, Wing 2 includes elements similar to the original wing. However, the students' design makes the structural-collapse rescue more realistic, more intense—and easier to clean up and "reset" after the exercise. "It's going to make trainees think more," says Kunesh. "It's going to make them use their skills better."

Before the firefighters tackle the Rubble Pile, they undergo 80 hours of training and must demonstrate proficiency in confined-spaces breaching, bracing structural walls, cutting metal, and navigating a challenging obstacle course.

A 30-year veteran firefighter who previously was homeland security program manger for the state of Wisconsin, Kunesh says the REACT Center grew out of training requests from firefighters across the state. He and his colleagues created Wing 1 of the Rubble Pile and, while it was both safe and effective as a training tool, the design needed some improvements. "We knew what we wanted," says Kunesh. "We just didn't know how to build it."

Enter the engineering students, who chose the "transportation" category of potential design challenges in Professor Jeffrey Russell's senior capstone design course, CEE 578. At first, they were less than excited about the project they received. "You could sign up for general building, transportation or environmental for the senior design project," says Zignego. "We all signed up for transportation, thinking we were going to get a road to design. When we saw this thing, it was like, 'Come on—this is a piece of junk. We want a road.'"

The students discarded their dream of creating a traditional civil engineering design, however, after they explored the Rubble Pile. "They left—and you could tell they were very excited," says Kunesh. "They saw it inside and out, and they understood it. They met with our lead instructor and talked about the curriculum and what we're trying to accomplish with the training."

Back in Madison, the students set to work on a 40-by-160-foot design that simulates the rubble created by an apartment-building collapse onto a parking garage.

With advice from industry mentor Finn Hubbard, state of Wisconsin bridge engineer, they conducted a soil analysis and specified a six-inch compacted-gravel pad, topped in critical areas with a strong material called hollow core, to alleviate settlement and load-distribution issues. They chose such common construction materials as jersey barriers, concrete pipe and manholes—not only to ensure their design was safe, but also to enable workers to remove rubble and replace barriers more efficiently. To make the new wing simpler to build, the students laid their design out on a grid system with dimensions down to tenths of a foot.

Varnes also spent hours creating an intricate 3-D model. "I think every design for a road I've ever seen is in 2-D, because you know how the parts are going to fit together, you know the road is just going to be right on top of the ground," he says. "For this, we were thinking that if we didn't do a 3-D model, we would have pipes running into each other and going through places they shouldn't be going. We kind of started it just to make sure everything made sense, but in the end, I think it worked out really well—just for demonstration of what it's going to look like."

The project forced the students to think outside the civil engineering box. "There was nothing standard," says Schmitz. "You couldn't just go to a manual and it'd tell you to design any of this stuff. You just needed to think and use your engineering judgment."

Not only was designing "junk" a valuable educational experience for the students—it also landed Schmitz, Varnes and Bobinski jobs as project managers at the REACT Center. "Their job was to come out and make sure we're building it right," says Kunesh.

Now that Wing 2 is finished, Kunesh will be able to schedule more training sessions because workers can clear and reset the wing more quickly. In addition, the new wing will provide greater challenges for trainees. "Before, it was mostly move forward and cut, move forward and cut," he says. "Now, it's move forward, cut, enter a void—which you can't enter until you brace it—and work their way through that."

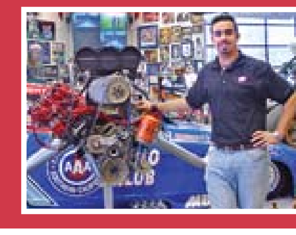
In addition, trainees now will spend an intense 24 hours—rather than eight—working their way through the Rubble Pile. "They will rotate shifts. So, they'll work six hours, sleep six hours, and so on," says Kunesh. "And they will rotate the crews just like in a real disaster. The old wing never would have gotten us through 24 hours. And the old one exhausted the firefighters physically."

Kunesh calls working with the UW-Madison students a great partnership. Recently, he collaborated with another student team to produce a Rubble Pile Wing 3. "It's always going to be constantly rebuilt," says Kunesh.

From left: Students Nick Bobinski, Jake Varnes and Bill Schmitz; Gary Whited, of the UW-Madison Construction & Materials Support Center; and Michael Kunesh, REACT Center director, at Wing 2 of the Rubble Pile at the REACT Center near Camp Douglas, Wisconsin. The students, with Dan Zignego (not pictured), designed Wing 2 for their capstone design course.







Gianluca Mantovano:

Face of prospective student tours has a drive to succeed

Gianluca Mantovano's favorite part of the tours he gives prospective students is what he calls the "grand finale." It's a look at the Myers Student Automotive Center in the Engineering Centers Building—home to the six University of Wisconsin-Madison vehicle teams and a major part of Mantovano's daily life.

"This is the team I'm on," the mechanical engineering student tells nine high school students and their families, gesturing at the Formula SAE car engine Mantovano tests.

A couple of the high school students hover around the 2007 world-champion formula car, and their interest in the vehicle is reminiscent of Mantovano's high school days. The Chicago, Illinois, native spent a lot of time in his school auto shop and even started a high-mileage vehicle club to design and build a fuel-efficient car. "I really wanted to continue that type of extracurricular activity in college, so that's how I started looking at different universities," Mantovano says.

During Mantovano's senior year in high school, the UW-Madison Formula SAE team ranked third in the world, and Mantovano was impressed. After touring the auto shop and meeting some of the students, he thought UW-Madison was the place for him.

As a freshman, Mantovano joined the Formula SAE team; student members design, build and race a formula-style car for a collegiate competition sponsored by the Society of Automotive Engineers.

In May 2007, Mantovano's sophomore year, the team traveled to Romeo, Michigan, and claimed the world championship for the first time in UW-Madison history. Afterward, team membership skyrocketed to more than 100 students, and Mantovano, who had been the group leader's "right-hand man," found himself mentoring newer members. During the 2007-2008 school year, Mantovano was the powertrain group leader. He says the team has evolved substantially since his freshman year: Team leaders are more focused on training new members, and Mantovano says their self-sufficiency lets him focus on designing the powertrain system and testing engine parts.

Team dedication is evident in the amount of time members spend in the shop. "It's like a job," Mantovano says.

In the fall semester, he works on the car 20 hours a week; the time commitment jumps to almost 50 hours a week in the spring months before competition. "People don't understand how I do it. I work twice a week, take four or five classes, and I'm at the gym right when it opens—I'm always running around," says Mantovano with a laugh. "It's worth it—it definitely pays off," he adds. "You get what you put into the team. The more time you put in, the more you get out of it."

Mantovano credits his family for the discipline it takes to balance all of his responsibilities. Both of his parents are originally from Italy, and Mantovano speaks fluent Italian. "They grew up pretty disciplined themselves, and some of that rubbed off on me," he says.

His family is also the source of his passion for all things automotive. "When I was 5 years old, we used to go to Florida to visit my uncle. He'd have a few Ferrari model cars running around, so I'd play with them and take them apart, but try not to crash them because they're kind of expensive," Mantovano says.

His father, an avionics technician who originally aspired to be an engineer, taught Mantovano how to be hands-on around the house and in the garage. The result, Mantovano says, is that he's a "fixer."

His experience has led to several internships. In summer 2007, he worked at Goodyear in Akron, Ohio, on massive off-road tires that stand 12 feet tall. In summer 2008, he moved to Iowa to work for John Deere on powertrains and engine control. In fall 2008, he switched tracks and worked on jet engine turbines for GE Aviation.

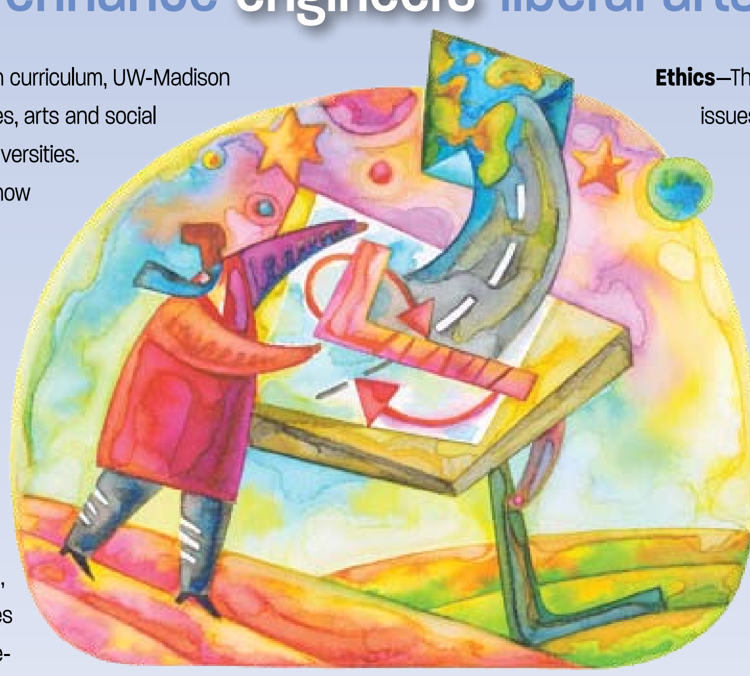
In the future, Mantovano says he would like to own his own company. He's earning a business certificate at UW-Madison with that goal in mind. "If I could work for Ferrari, that'd be my dream job," he adds.

In addition to his vehicle experiences, Mantovano has helped Assistant Dean for Engineering General Resources Don Woolston give presentations to prospective engineering students. After the presentations, Mantovano leads the students and their families on a tour of the engineering campus.

"I show them the shop as the last part because a lot of students want to see the hands-on stuff and the shop is an easy way to give them a good representation of what they can get involved in here," he says.

Involvement, in the end, is what Mantovano stresses to prospective students. "When you come to college, no matter what you do, get involved. Do something you love," he says. "If it weren't for my involvement in the organizations I'm in, I wouldn't be where I'm at today."

Certificate program to enhance engineers' liberal arts education



With both the physical distance and differences in curriculum, UW-Madison engineering students and those in the humanities, arts and social sciences might feel like they attend different universities.

But in fall 2009, a few UW-Madison professors hope to show engineering students that they have a bigger place in the non-engineering parts of campus. The team has created a certificate program that will enable engineering students to fulfill their humanities breadth requirements via a series of related courses.

The **Certificate in Integrated Studies in Science, Engineering and Society (ISSuES)** is a new program offered by the Robert F. and Jean E. Holtz Center for Science and Technology Studies. Not only will ISSuES help engineering students fulfill their liberal arts requirements, it also will give them coherent exposure to the social sciences and humanities in a way that emphasizes the relationship between science, technology, engineering and society. "Instead of taking these courses in smorgasbord fashion, we are being more intentional in terms of getting students to think about what courses may mean in a coherent group and then how they can build on each other," says Civil and Environmental Engineering Professor Jeffrey Russell, one of three certificate coordinators.

Students enrolled in ISSuES will:

- Use their required electives to gain the interdisciplinary skills necessary to become creative and effective engineers in a rapidly changing environment.
- Think critically about the connection between science, technology and society.
- Have one-on-one contact with leading faculty from across campus.
- Get help creating a plan of study that fulfills their College of Engineering liberal arts requirements while achieving their individual educational goals.
- Interact with students and faculty interested in the broader impacts of social, political and ethical concerns related to engineering.

The program enables engineering students to be selective with their electives and still stay on track.

Initially, ISSuES students take *Where Science Meets Society* (STS 201), a three-credit course that can give them the tools and language to approach the relationship between science, engineering and society in an integrated and interdisciplinary fashion. Students then complete 12 additional credits (typically four courses) chosen from one of four focus clusters:

Ethics—This cluster aims to give students the tools to consider ethical issues that surround engineering and science research and commercialization of the products of that research.

Leadership—This cluster concentrates on public policy issues that relate to science and engineering work and the widespread use of new technologies.

Design—This cluster aims to expose students to the aesthetic and social issues raised in engineering practice.

General—This broad cluster enables students to create their own emphasis in approaching the relationship between science, engineering and society.

Students in ISSuES choose a certificate advisor who will help them select courses that simultaneously fulfill both the liberal elective requirements of their engineering majors and the Integrated Studies in Science, Engineering and Society certificate requirements.

Russell says the program is valuable because today's challenges require solutions that combine the knowledge of several fields and disciplines. "The role of science and technology is much different than it was 25 years ago, because if you look at the scale of the problems we have: Looking forward, they are very significant," Russell says, adding that the energy crisis, sustainability and water are some of the biggest issues. "That's what we're about. We educate leaders who are going to go beyond the boundaries of this institution and this state and actually make a difference in the world."

Student entrepreneur aims to reduce carbon emissions by selling laptop energy credits

Ted Durkee

The average laptop uses enough energy over the course of its lifetime to power an American home for a month. If Ted Durkee has his way, all that energy will be produced by wind turbines.

Mechanical engineering student Durkee and recent UW-Madison business school graduate Brandon Gador have started a company that sells renewable energy credits (RECs) for laptops. They hope their company, Powered Green, will reduce carbon emissions in the United States by hundreds of thousands, if not millions, of pounds.

To offset the energy used by their laptops, Powered Green customers can purchase an Energy Seal—a sleekly designed emblem that adheres to a laptop—for $16. Purchasing an Energy Seal means 690 kilowatt hours of wind energy will be produced to offset the amount of carbon energy required to run a laptop for seven years. Currently, Energy Seals purchase RECs for the Hollow Horse Wind Farm near Abilene, Texas, which is the world's largest wind farm.

Energy Seals also are intended to be a public statement for the environmentally conscious consumer. "There are few opportunities for people to show they're green beyond using re-usable grocery bags or driving a Prius," says Durkee. "This is a cool way for someone sitting down with their laptop at a library or coffee shop to show off in a visually appealing way that they support green energy and sustainability."

The seals are the size of a Band-Aid and come in either black, silver or white. The seals, along with the envelopes and packaging they are mailed in, are made from recycled materials.

There's an added bonus to purchasing a seal from Powered Green instead of other REC sellers: Durkee and Gador will donate 10 percent of their profits to land conservation charities.

"We think the two most important ways to alleviate the exponential growth in consumption going on in societies around the world right now are renewable energy and land conservation, says Durkee.

Powered Green is the result of seven months of research and design. Durkee attended school part-time in spring 2008 in order to devote 60 hours of work to the company each week. "This is what I'm passionate about," he says. "I want to spend the rest of my life working on endeavors and projects that make an impact on the environment."

Durkee's passion from the environment stems from his interest in outdoor hobbies. He is an avid backpacker, canoeist and hiker.

In college, Durkee was motivated to act on his interests after taking two engineering courses. He was a student in the late Civil and Environmental Engineering Professor Peter Bosscher's final sustainable engineering course before Bosscher died from kidney cancer in November 2007. Durkee was inspired by Bosscher's dedication to improving the environment, and after taking another course with CEE Professor Michael Oliva, he wanted to start a business that supported wind energy.

He and Gador purchased 1 million Green-e certified RECs for the Hollow Horse farm, equivalent to 1,000 RECs. "When we came across this idea, we were excited not only for the effect on the environment, which will be quite significant, but because it is one of first environmental products that provides customers with an opportunity to express themselves," says Durkee.

People can vote on Energy Seal designs on the company website—www.poweredgreen.com—as well as participate in an online energy blog.

Overall, the experience of starting and running a company has been a roller coaster, Durkee says. "We will find out soon if people embrace this, but either way, the experience has been worth the work."

West meets East

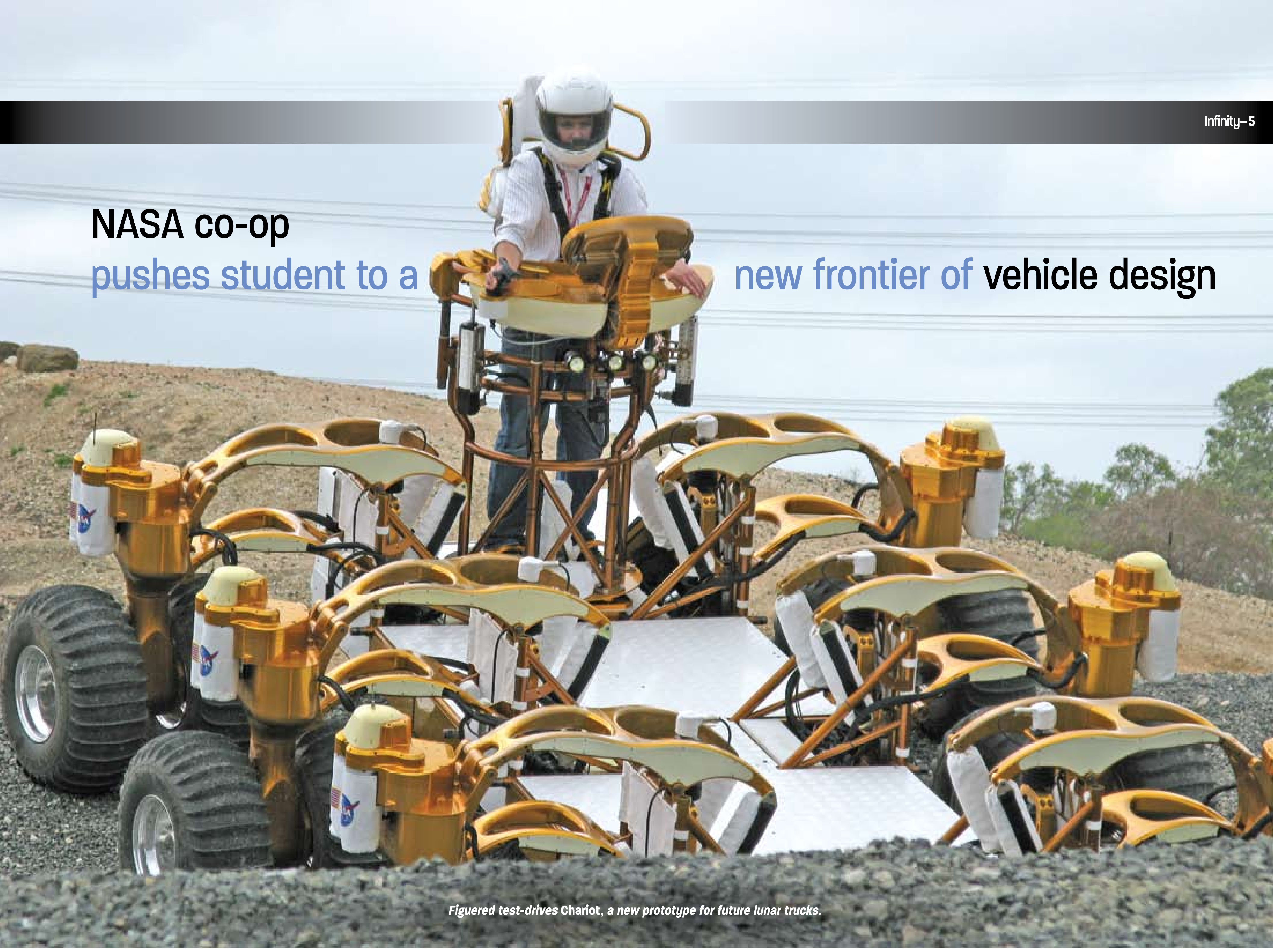
Students take part in China Summer Program

Students in Mechanical Engineering and Engineering Physics Professor John Pfotenhauer's summer section of *Thermodynamics* (ME 361) have taken learning out of the box—and all the way to Hangzhou, China.

As part of the China Summer Progam, students receive six credits of engineering coursework (ME 361 and EPD 397, *Technical Communication*), taught by UW-Madison faculty at Zhejiang University. Students spend four days a week in class alongside Chinese students who chose to audit the classes to improve their English language skills. In addition to their coursework, the students live on campus, interact with students from other universities around the globe, view presentations on Chinese culture and navigate the city by using body language and a few gleaned words of Mandarin.

The UW-Madison students have been able to share some American culture with the students at Zhejiang, from helping them with their English to giving presentations about life in the United States and Madison, Wisconsin. The cultural exchange even permeated recreation: A game of Frisbee among the students drew a crowd of onlookers. "Over the course of the two hours or so, I would say around 30 people stopped to watch and take a picture at some point," says sophomore Val Maharaj. "It probably is rare to see Americans playing Frisbee in front of a 40-foot-tall Mao statue."

NASA co-op pushes student to a new frontier of vehicle design



Figured test-drives **Chariot**, *a new prototype for future lunar trucks.*

Lunar dust is sharp stuff. Created when micro-meteorites hit the moon's surface and shatter into razor-blade-like bits of melted glass, the abrasive dust can cause a multitude of problems for astronauts and machinery.

Within a decade, NASA plans to begin building a permanent lunar colony to serve as an outpost en route to Mars.

So, the lunar dust needs to be cleared—and one mechanical engineering student is helping to develop the robotic equipment needed for the task. Joshua Figuered works on part of the latest NASA lunar rover project.

Figuered is a NASA co-op student, working for the robotics systems technology branch of the NASA Johnson Space Center in Houston, Texas.

"It's something I've always been super-interested in," he says of NASA. "As a co-op, it's amazing because they really try to put you through all the processes of engineering. It's a cool opportunity."

Mechanical engineering student Joshua Figuered works on part of the latest NASA lunar rover project.

Figuered is no stranger to the design and manufacturing processes. Originally from a farm in Bloomington, Indiana, Figuered spent his high school years working as late as 3 a.m. on cars and bikes for the school solar racing team. The hard work paid off, rewarding Figuered and his teammates with multiple trips to Japan to claim world championship victories.

When he started college at Georgia Institute of Technology in Atlanta, Georgia, Figuered continued working for the institute Baja team.

However, he soon focused his skills on vehicles of a different sort. As a sophomore, he began working for NASA as a co-op student. He transferred to UW-Madison in time for the spring 2007 semester.

After spending a semester adjusting to UW-Madison, Figuered followed his pattern of alternating his semesters between school and work. He again piled his belongings into his car and moved back to Houston. "It was January the first time I went down. I left my house and it was 14 degrees," Figuered recalls. "I drove down there, got out of the car and it was 70 degrees. That's a perk."

A bigger perk is the chance to work on a new major project each year. In 2007, he designed the transmission for the *Chariot* lunar rover, a prototype that includes several advanced vehicle concepts and is the first step in a new era of lunar rovers. *Chariot* was designed, manufactured, assembled and tested in 11 months—an intense pace, Figuered says.

"What we've done with Chariot is design a concept in advanced mobility," says Figuered.

In 2008, the robotics branch tackled another rover, which builds on some of the elements developed for *Chariot*.

Figuered sees his work at NASA as beneficial to earthlings as much as to astronauts. "The technologies that were developed in order to get to the moon originally really benefited mankind in a variety of ways," he says. "To set up a sustained colony, you face a lot of huge problems that have solutions that can really be used to benefit people."

Many of his co-workers, who come from a variety of engineering and non-engineering backgrounds, also are college students on co-op. (NASA takes approximately 50 co-ops per semester.)

"It's almost like a college campus in a way," he says of the NASA facilities and co-op culture. "It's similar—except you don't have homework and you're paid to be there!"

International education

(Continued from Infinity p. 1)

when approaching engineering. "Different cultures have different attitudes toward work, professional etiquette, communications, cordiality, and so on. It is important to understand all these aspects, especially when approaching a challenging multi-disciplinary international engineering problem," Fitzpatrick says. "Engineers are becoming increasingly global and soon I think it will be difficult to compete for jobs without having the international experience."

Since students take *Current Issues* after going abroad, they are able to learn from each other in addition to Schramm and the speakers.

A biomedical engineering student, Jack Ho concentrated on Hong Kong and the opportunities to work in the biomedical engineering industry there. In addition to Hong Kong, Ho has traveled to Cambodia, China, Great Britain and Germany.

Like Treu, Ho hopes the certificate program will set him apart after graduation. "I think the certificate will allow employers to see I'm not your average engineer, and I can be comfortable in various situations and can be sent to their various branches around the globe," he says.

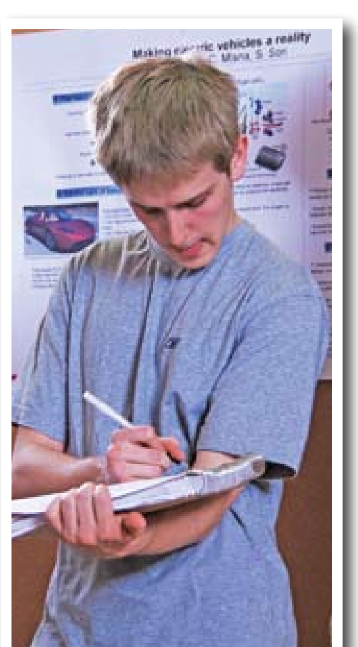
Freshman course teaches students how engineering benefits society

Grand CHALLENGES

Tokyo sits on a tectonic plate boundary, making it particularly vulnerable to earthquakes. So, for the capital and largest city of Japan, a seismic monitoring system to predict earthquakes is critical. However, current technology can give residents only a few tens of seconds of warning that an earthquake is about to strike.

More than 6,000 miles away from Tokyo, UW-Madison engineering students are discussing technologies for better prediction systems—and how engineers from different disciplines could collaborate to find a solution.

The Tokyo case study is only one example of the humanitarian applications of engineering that students investigated in the inaugural semester of the course, *Introduction to Society's Engineering Grand Challenges.*



Based on challenges outlined by the National Academy of Engineering (NAE), the UW-Madison class aims to inspire students to become engineers to improve the quality of life around the world. In spring 2008, 98 first-year students tackled five themes that encompass a variety of challenges facing society today.

Susan Hagness, a professor of electrical and computer engineering, conceived of the course as a way to show students the bigger picture of what engineers do for society. "The course is a combination of the NAE project and an inclination I've had for a while that there are students out there who would make wonderful engineers who need to know more about the important impact engineering has in the world," says Hagness. "It's not about making cool high-tech gadgets. It's more than that."

The course reaches out to students early in their engineering education because studies suggest that students who see the role of engineering in society are more likely to stay with the field, Hagness says.

Mike Lucas was one of the first-year students in *Grand Challenges.* Lucas says he entered UW-Madison confident he would be an engineer, but partway through the first semester of classes, he was unsure he wanted to continue. "I was just not exposed to much engineering," he says.

His adviser, Assistant Dean for Engineering General Resources Donald Woolston, encouraged Lucas to try the Grand Challenges course. The class helped. "It gives you a good idea of what engineers do and the specifics of what the different disciplines do," Lucas says. He says studying engineering now feels like a concrete decision and plans to pursue a degree in engineering mechanics.

The course also makes an effort to reach out to women—nearly a quarter of the enrolled students were female. Samantha Kamin was one of them. A first-year student, Kamin was interested in engineering before taking the course, but it helped her pinpoint biomedical engineering as the discipline she would study.

The course structure offers students a taste of different engineering disciplines while enabling them to examine broad engineering issues, says Hagness. "Instead of structuring the themes based on specific NAE grand challenges, we came up with societal themes based on scale, starting with engineering challenges at the personal level and getting larger and larger," she says.

Course sections rely on a team of faculty members who each present a theme and case studies to students, who work with two of the themes over the course of the semester. Mechanical Engineering Associate Professor Nicola Ferrier teaches students about engineering challenges that impact individuals, such as privacy, biometrics, rehabilitation engineering and assistive technologies. Civil and Environmental Engineering Associate Professor Trina McMahon and Professor Jeffrey Russell discuss sustainable engineering solutions for challenges facing the developing world, including clean water, housing and healthcare.

Hagness teaches the third theme, which is engineering for the "megacity" and tackles challenges such as pollution, transportation, security, energy, and natural disasters in cities with populations above 10 million; Chemical and Biological Engineering Professor Daniel Klingenberg looks at global engineering challenges focused on environmental issues like climate change and conservation. And finally, Biomedical Engineering Assistant Professor Kristyn Masters expands the course horizons beyond Earth to investigate space travel, inhabiting space and deflecting near-Earth objects like asteroids.

Within each course section, students work in teams to develop oral and poster presentations. In the "megacity" group, for example, projects have included underground high-speed transportation to reduce congestion in cities and turning megacities into self-sufficient eco-cities. "This course helped me decide to get the additional Technical Communication Certificate (in engineering) because it helped me realize that I really enjoy the presentation and communication aspect of this field," says Kamin.

Class activities also challenge students to consider more than just technical issues when developing solutions to engineering problems. "Engineering is fundamentally a design process with both technical and nontechnical constraints," says Hagness. "We're trying to emphasize the importance of a broad perspective: Engineering solutions are influenced by political, environmental, ethical, legal and social constraints. That perspective will help students in all of their future coursework here as well as wherever their career takes them."

The course is funded by the College of Engineering 2010 Initiative, which seeks to increase cross-disciplinary research and education on campus to respond to changes in the engineering field, such as technological advancements and global competition. "The long-term vision is to expand the offering of this course to students from all over campus," says Hagness. "Having a more diverse environment in the classroom would help the engineering students because ultimately, they are going to be working on technologies that have to be embraced by the public."

That message resonates with Kamin. "The most valuable thing I learned in this course is that the communication of information is just as important as obtaining that information in the first place," she says. "Without being able to communicate your research or the effect it will have on society, it is impossible to get people excited about your work."

Engineering students partner with Red Cliff reservation to improve community infrastructure

"Hello, or as they say around here, boozhoo!" called out Tim Funk, tribal planner for the Red Cliff Band of Lake Superior Chippewa, to four engineering students from the UW-Madison chapter of Engineers Without Borders (EWB).

The students waved back across the tribal office parking lot and headed inside to discuss the details of their first long-term domestic project. Until now, the UW-Madison EWB chapter has focused on international projects in Rwanda, El Salvador, Haiti and Kenya.

EWB is a nonprofit organization that designs and implements sustainable engineering projects for communities, the vast majority of which are in foreign countries. "Working closely with a Wisconsin community is as important as working in an exotic foreign location," says civil and environmental engineering graduate student Alison Sanders *(above)*, who is project co-manager with CEE undergrad Matthew McLaughlin. "We're also getting a valuable experience in learning federal engineering design codes as well as learning the reservation's own laws."

Sanders and McLaughlin, along with mechanical engineering undergraduate Gavin Weir *(right)*, CEE graduate student David Blodgett and CEE Professor Ken Potter, met with Funk and tribal members from August 1-4 to begin three projects related to flooding and stormwater infrastructure. The projects are long term, since EWB requires its chapters to commit to a community for at least five years.

The Red Cliff reservation wraps around 14 miles of the northernmost peninsula of mainland Wisconsin. The shoreline has a view of the Apostle Islands National Lakeshore and the clear waters of Lake Superior, known as Anishanaabeg-gichigami in the Ojibwe language (Chippewa is the anglicized term for Ojibwe).

Unfortunately, the scenic setting has not translated into economic prosperity for Red Cliff residents. The modest homes and community buildings on the reservation, which is home to approximately 1,500 people, stand in contrast with those in nearby Bayfield, Wisconsin.

"Many Native American communities were decades behind comparably sized non-Indian communities in terms of basic water and sewer infrastructure," says Funk. "Generally, quality of life in some parts of the reservation is not as good as it could be, and we hope EWB can help the tribe develop creative, low-cost solutions."

One task for the UW-Madison EWB will be to find a practical way to prevent flooding in a new community cemetery, which is located downhill of a wetland. Dry land suitable for development is often scarce on reservations in northern Wisconsin, and the tribe has discussed options for years. EWB members will evaluate the current plans to direct water away from the site and try to turn those plans into a practical solution.

The students spent a hot and sunny afternoon surveying the cemetery with surveying equipment borrowed from the civil and environmental engineering department. They also toured a subdivision plagued by seasonal flooding and the future site of another housing project that currently consists of a bumpy dirt road cutting through a thick patch of forest. Funk hopes the students can design a stormwater management system for the new development, and the students plan to return in the fall to survey the site after the leaves have fallen.

Connecting with the community was also a trip priority. Students spoke with a tribal elder, who explained the tribe's history and the relationship between the Ojibwe tribes and the United States. Sanders and Blodgett met with the tribal council on the final evening of the trip and were featured on the local television station.

"We are really excited to be working with the Red Cliff Tribe," says Sanders. "Not only is it a great learning experience for student engineers to apply their knowledge to real-world problems, but this collaboration provides a unique personal experience and cultural awareness."

Red Cliff is not the only tribal community that will benefit from UW-Madison EWB efforts. Throughout spring 2008, Sanders and McLaughlin were in touch with multiple Lake Superior Chippewa communities. They selected Red Cliff as the UW-Madison project, but they didn't neglect the others: Sanders and McLaughlin coordinated with the EWB chapters at UW-Platteville and Indiana University-Purdue University, Indianapolis, which will work with Lac Vieux Desert. Michigan Technological Institute will pick up projects with Keweenaw Bay.

"I'm very appreciative of the effort and attitude of the group," Funk says. "Beyond the practical help, I'm looking forward to the energy, enthusiasm and inspiration of the UW-Madison EWB chapter."

Text and animations help students master statics

With a wide grin, Engineering Physics Professor Mike Plesha proudly holds up a thick softcover textbook. Inside, the wide margins, neatly formatted text and myriad figures evoke the idea of engaging, understandable information. Together, design and content fill an important role: helping students master statics, the study and analysis of structural equilibrium.

Published via McGraw-Hill, *Engineering Mechanics: Statics* (and its companion, *Engineering Mechanics: Dynamics*) is the result of an eight-year collaboration among Plesha and Francesco Costanzo and Gary Gray of the Penn State University Department of Engineering Science & Mechanics.

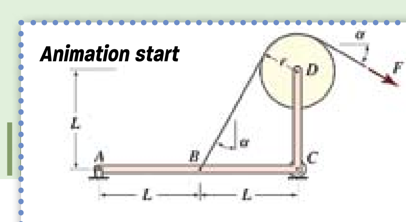
Statics is a required course for nearly two-thirds of UW-Madison engineering undergraduate student body. In addition to presenting real-life design challenges, the new statics text lays out straightforward problem-solving approaches that include modeling, idealizations, governing equations, computations and discussion of the results.

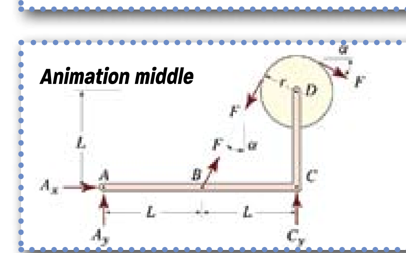
For Plesha, however, the textbook is only the first step in his unique approach to teaching this difficult-to-master subject. With funding through the College of Engineering 2010 initiative, Plesha and engineering physics PhD student Jonathan Fleischmann are developing animations of free-body diagram construction—and other difficult concepts—that enable statics students to visualize the phenomena they study. "This course is a course in which the math isn't challenging," says Plesha. "It's the visualization—taking a real-life problem and replacing it with a mathematical idealization. That's where they struggle."

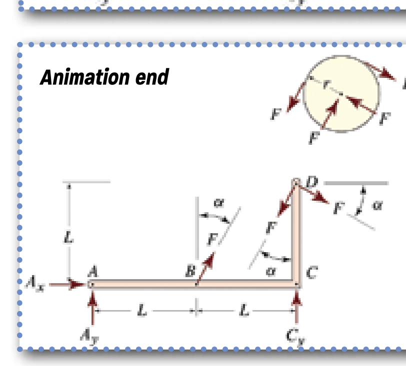
Students draw free-body diagrams to help them analyze the forces acting on a free body—a structure removed from its environment. Vectors in their drawings show the direction and magnitude of forces, such as contact, friction, weight due to gravity and others, that act on the structure. Based on their free-body diagrams, students then write, solve and interpret the results of equations that govern the structure's equilibrium. "The ability to draw free-body diagrams—this is something that they'll do in a good number of their courses after this," says Plesha. "It's an essential skill, and if they don't develop that skill, it'll adversely affect them in a lot of coursework to follow—and in their professional practice."

Some free-body diagrams are relatively straightforward; others create more confusion. The animations, which last about a minute, demonstrate the process for drawing a free-body diagram and help students ensure they don't miss—or misinterpret—forces.

One animated structure has a pin at one point, a roller at another point, and includes a pulley and cable. Because it includes multiple components, says Plesha, it is the kind of problem that's difficult for students. The animation begins by taking a cut that separates the structure from its environment; next, arrows glide into place to indicate the forces. Then, the roller goes away and the force-vectors for it appear. Next, the cable is cut and the pulley drifts away, while arrows move in to show the forces at those locations. Future animations will show force reactions for various structure supports, behavior of springs, mechanisms in truss structures, and others.







Chris Holland, a statics student who intends to major in chemical engineering, calls the animations incredibly helpful, particularly as the structures he studies become increasingly more complex. "They allow for a much simpler visualization of the problem you are looking at," he says.

While the animations are important to students' understanding of free-body diagrams, they also are key instructional tools, says Plesha. "This subject will be taught in increasingly larger courses, without blackboard and chalk," he says. "It'll be whiteboard and a place to plug in a computer. Effective lecture materials are kind of a challenge—and also an opportunity—because there are some things that are hard for students to visualize and hard for instructors to convey."

So far, Plesha and Fleishmann mainly have used Adobe Illustrator and Apple QuickTime Pro, but hope to use Mathematica and Working Model in future animations. The two aim to develop 20 animations that instructors can incorporate into statics courses in technology-rich classrooms and lecture halls. Plesha also envisions an additional benefit to students. "Longer range, I would like to see the animations be a resource for students on a class website that they can consult independently of the lectures," he says.

Already, Holland appreciates the value of having the animations at his fingertips. His message to Plesha: "Keep using them and developing them. They will be of incredible use in statics and dynamics classes in the future."

For three years, mechanical engineering graduate student Chris Meyer has combated such challenges as rust, lime, broken pipes, crab apples, and powerful jets of water that send his glasses flying.

It's all in a day's work for one of the "keepers of the fountain," as Meyer refers to the members of Enlight, a small student organization interested in computer and electronic technologies. Enlight members take care of the iconic 18-foot-high sculpture, Māquina (Spanish for machine), on Engineering Mall.

Thanks to a gift in 2008 from National Instruments, his job has gotten easier. National Instruments donated a $9,000 CompactRIO programmable automation controller that, when combined with the National Instruments LabVIEW graphical programming language, allows Enlight members to program the fountain to perform a variety of special effects. "The fountain is a perfect application for what we do, and we're really excited about the different possibilities," says National Instruments Applications Engineering Manager Casey Weltzin (BSECE '06). "The fountain is something everyone on campus is going to look at and learn from."

The fountain was installed in the Engineering Mall in 1999. Designed by St. Louis artist and UW-Madison alumnus William Conrad Severson, Māquina is intended to be an interactive experience with air and water in all forms.

Water shoots out of alternating valves on the fountain, then flows down the base of the sculpture into a spillway that stretches to a pool at the northern end. There, compressed air forces water and bubbles up a 22-foot-high clear column; at its top, water runs out and spills back into the pool.

Enlight adopted the fountain in 2003, shortly after the organization's formation. Though maintaining it is not Enlight members' sole focus, it is their most time-intensive effort.

Enlight members are making full use of the fountain's interactive potential. They have programmed the infrared proximity sensors inside the stainless steel poles in front of Māquina along Engineering Drive. The sensors can change the pattern of the valves when the sensor is covered by a hand. When activated, the bollards can trigger intense jets of water or even shut the fountain off entirely.

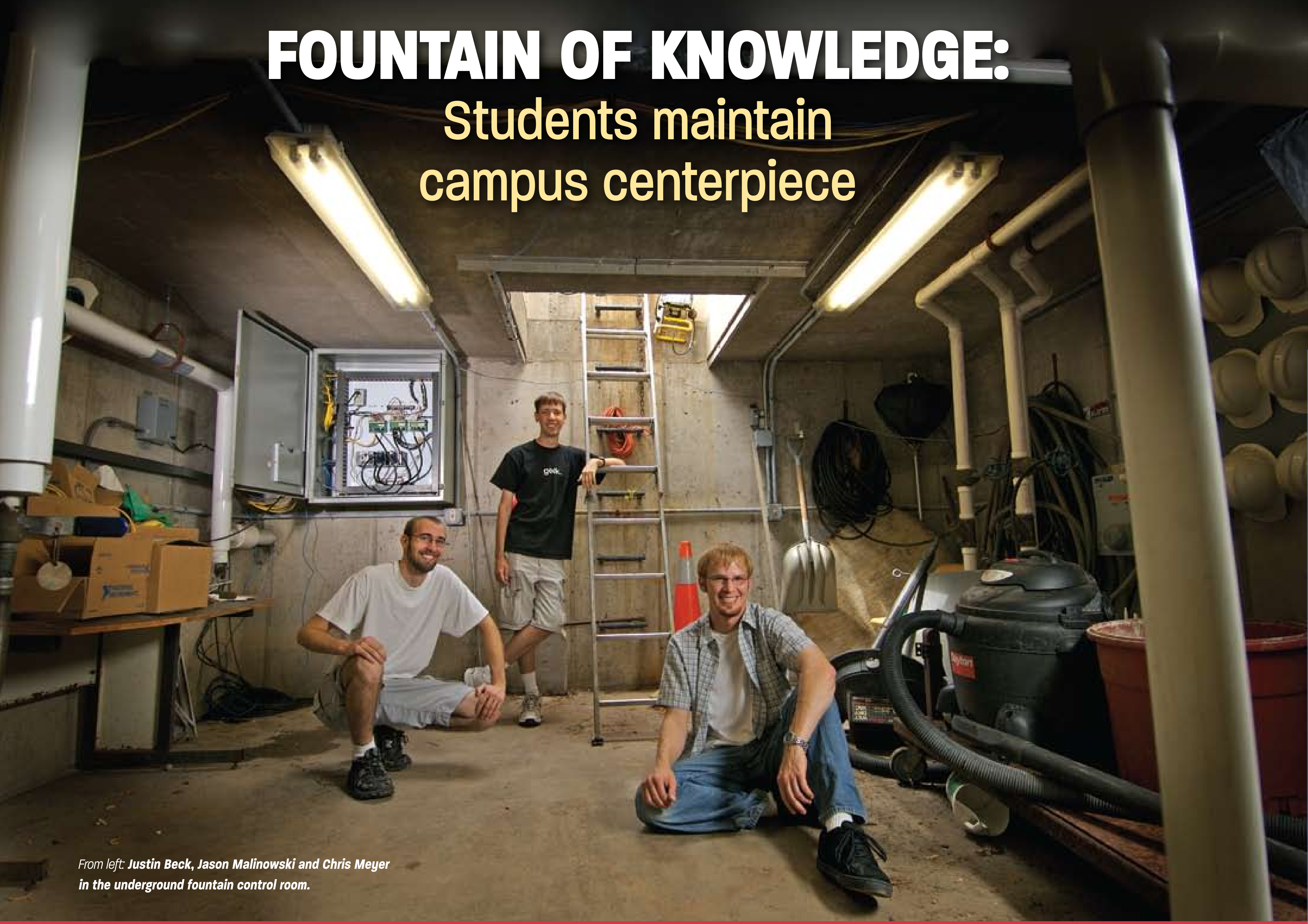
To allow for even more customization, Enlight members have installed a kiosk in Engineering Hall that enables fountain-watchers to control the individual valves via a liquid crystal display touchscreen. Viewers can turn specific valves on and off to create original patterns in the water.

In the future, group members plan to add additional temperature and wind sensors to better determine when to turn on the winter mist caps, which create columns of ice. They also have discussed running light-emitting diode lights into the fountain and connecting Dance Dance Revolution pads to allow viewers to control the fountain with their feet.

Running the fountain isn't merely play. Meyer and several fellow students clean and maintain it. They climb down a ladder into a nearby manhole to reach the fountain control room, where they've battled floods and the seasonal plague of crab apples that clog the fountain.

At the end of the day, though, the effort is worth it. "You're working on something people see everyday," says Meyer. "It's fun because it's a centerpiece of campus, yet no one realizes it's student-run."

FOUNTAIN OF KNOWLEDGE:
Students maintain campus centerpiece



From left: ***Justin Beck, Jason Malinowski and Chris Meyer in the underground fountain control room.***

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