12-2015

Creating Tomorrow, Fall 2015

College of Engineering

CREATING Tomorrow

COLLEGE OF ENGINEERING
engineering.usu.edu
FALL 2015

Learning Outside the Classroom | Special Year of Water Edition

UtahStateUniversity

A Note from
Dean Christine Hailey...

Learning Outside the Classroom

Less than a week before the beginning of the fall semester, faculty, students and friends of the College gathered to celebrate the continued support of two of our most generous benefactors. Longtime Cache Valley residents and fellow Aggies, Richard and Moonyeen Anderson, have made a financial commitment that will impact future engineering students for many years to come and one that secures their names as part of our history.

Through their accumulated gifts totaling $5 million – both in direct contributions and in-kind donations from Hewlett-Packard, where Mr. Anderson served as a vice president for many years – we are privileged to name our flagship classroom building in their honor. Their latest gift will ensure the long-term success of the Richard and Moonyeen Anderson Scholarship fund which has helped approximately 100 undergraduate students complete their engineering degrees. And their support doesn't end there. Mr. Anderson is part of Gov. Gary Herbert's Technology Initiative Advisory Board where he's responsible for allocating $3 million in legislative funding into multiple engineering and computer science programs across Utah and right here at USU.

I believe I speak for our faculty, advisory board members and our student body in saying thank you to the Anderson family and others who have given back to this institution. Their far-reaching gifts are helping us prepare the next generation of top engineering leaders. Our newly-named classroom building has been and will continue to be the keystone of this great college, while our labs and research centers give students the hands-on experience beyond the classroom they can't get anywhere else.

From our world-renowned Utah Water Research Lab, to the Center for Space Engineering, Utah Transportation Center and more, USU engineering students truly have a unique opportunity to learn outside the classroom. Our environmental engineering students are leading innovative water quality research around the state; civil engineering students are exploring the giant foundations of what was the Teton Dam; and our mechanical engineering students are learning the latest in fluid mechanics – and getting a little wet – in our newest research center, the Splash Lab. In addition, our Engineers Without Borders student teams recently returned home from service expeditions in Mexico and Peru. Students and faculty have been working for several years to improve water quality in a community near Mexico City; and in Peru, students constructed mobile shelters designed to protect young alpacas from extreme weather. These are just a few of the exciting things happening at the College of Engineering.

As you explore this year's alumni magazine, you'll see a series of articles about water. 2015 is the Year of Water – a university-wide campaign highlighting the 50th anniversary of the completion of the Water Lab and a tribute to the research and people who have made USU a source of water expertise. From guest speakers to musical performances and the Common Literature Experience, it's all about water. We've even established a Water Legacy Scholarship fund to support some of our most promising students pursuing environmental, civil and other water resource engineering areas.

These exciting programs are helping us do more for our students and strengthening our mission to empower tomorrow's leaders who will design the technologies and services that build our economy and sustain the environment.

Christine E Hailey

PUBLISHER
Christine Hailey, Dean and Professor

ENGINEERING ADVISORY BOARD
Richard Anderson
Mark Bowen
Ronald H. Campbell
Mike Goodwin
Von Hansen
George Humbert
Kent L. Jones
William Luce
Ruth Moser
Eva Nieminski
Jim Nottingham
Scott Nowlin
Jerry Olds
Ward Parkinson
Fred M. Perkins
Mark Ripke
Steve Rowlan
Janine Rush-Byers
Mel Torrie
RaNae Webster
Gene Weckler

MANAGING EDITOR
Matt Jensen

CONTRIBUTING WRITER
Natalie Humpherys

ART DIRECTOR
Arie Stucki

GRAPHIC DESIGNER
Natalie Humpherys

PHOTOGRAPHY
Donna Barry, University Photographer
Andrew McCallister
Matt Jensen

COPY EDITOR
Maren Aller

CONTENTS

PLUS

On the Cover: Dr. Tadd Truscott, assistant professor of Mechanical and Aerospace Engineering, and Ph.D. student Nathan Speirs conduct a high-speed camera test in a water tank at the Splash Lab. **Back Cover:** The west façade of the main engineering building now features the names of Richard and Moonyeen Anderson for whom the building was named on Aug. 25.

iGEM vs the Cheese Killer

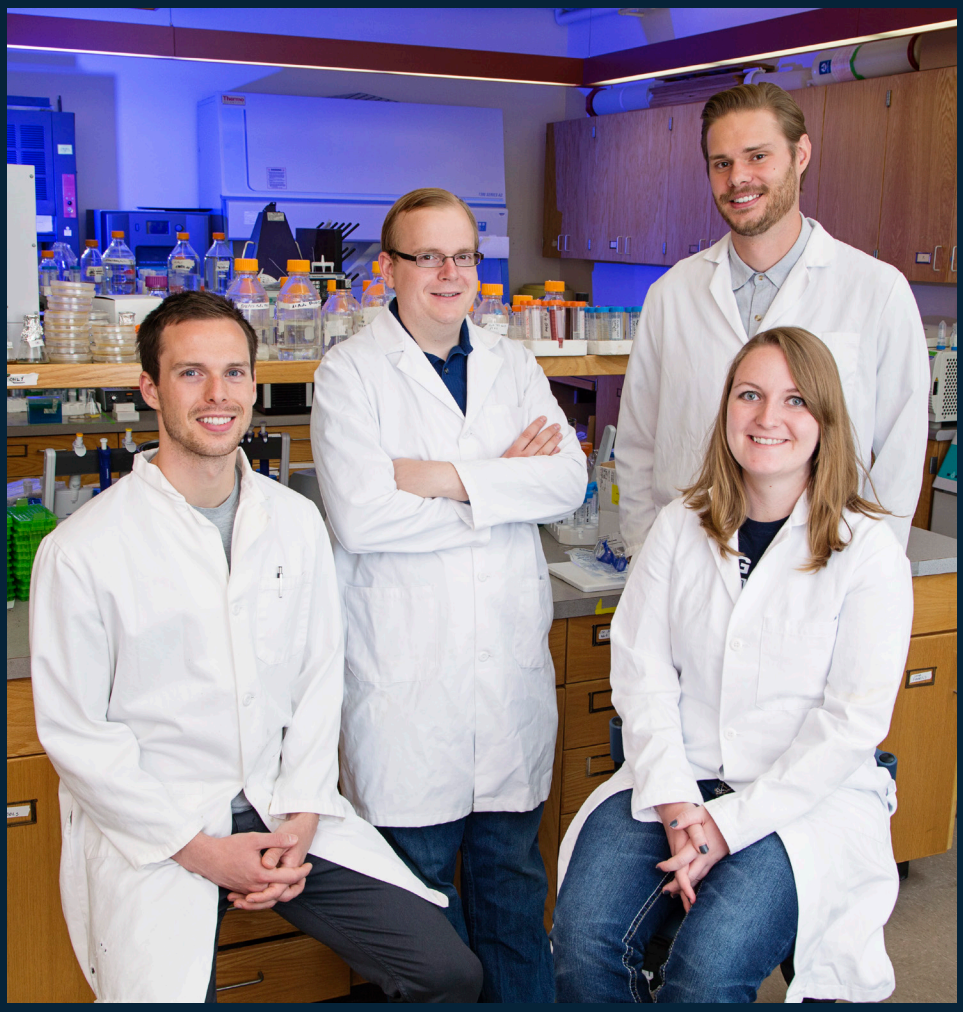
Cheese manufacturing is under attack by a type of virus called bacteriophages. The viruses infect bacteria used in the dairy fermentation process that yields our beloved cheese and yoghurt. Utah State's 2015 International Genetically Engineered Machines, or iGEM, team has been researching ways to fight back against the virus. The iGEM event is a competition that promotes student involvement in real world synthetic biology research.

Led by Dr. Charles Miller, the team is using synthetic biology to attempt to create a strain of phage-resistant lactic acid bacteria. The new strain will be capable of detecting the presence of the virus by activating a genetic switch. If the virus is found, the bacteria will turn red or green alerting technicians of infection. The iGEM team is also developing a different method, which they've dubbed the 'suicide system,' that works by causing the bacteria to die before the virus fully forms. Miller says the system will hopefully stop further spreading, preventing additional contamination throughout the culture.

Student team members say it's exciting to be part of an innovative research project with a practical application.

"It's a chance to hone my skills in working with synthetic biology, to practice leadership roles and to develop my ability to present information in multiple formats," said Chad Nielsen.

This year's team is preparing to compete against more than 280 teams from across the world at the 11th annual iGEM competition in Boston, Mass. This will be the eighth iGEM competition for the USU team, something Miller says is a unique experience for biological engineering students.



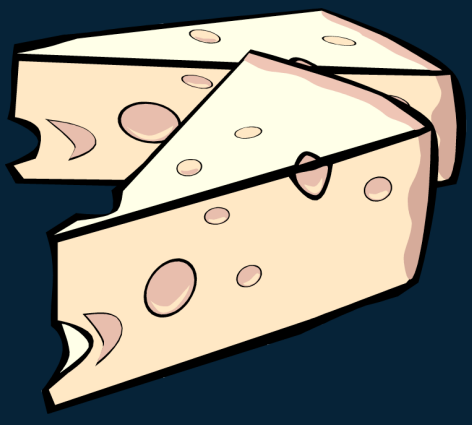
Students, from left; Ryan Putman, Tom Overbeck, Chad Nielsen and Sara Gertsch will compete at this year's iGEM event with their research on combating viral infections that can affect cheese manufacturing.

"I think each student is taking away something different from their iGEM experience, said Miller, who has been the iGEM faculty advisor since its start. "Several of the students have never worked in a biological engineering laboratory, so they're learning skills that are not duplicated elsewhere."

Competing in iGEM also gives students unique training they don't get inside the classroom.

"It's a great opportunity for individuals to gain valuable experience working together as a team," said Tom Overbeck.

iGEM 2015 takes place Sept 24-28.



BIOINNOVATION: Turning Sawdust into Plastic

USTAR-endowed professor Dr. Foster Agblevor is running at full pace on multiple projects aimed at making the world a healthier place.

Last fall, the biological engineering professor won a grant from the National Science Foundation to support his ongoing work in turning organic plant material into bio-based plastics and oil. This exciting research centers on a collaboration with Egyptian experts and local farmers. At many of Egypt's rice, cotton and banana farms, plant residues including leaves and stems are burned in the fields – a practice that contributes to a growing air quality problem that impacts the nation's public health and threatens to deteriorate its ancient monuments.

The goal is to create a new low-cost catalyst that breaks plant material down into oils or sugars that can be used to make plastic, foam, insulation, adhesives and other products. The result would be cleaner air and reduced dependency on petroleum for everyday goods. This and other biomass conversion research has earned him a J. William Fulbright Foreign Scholarship Award.

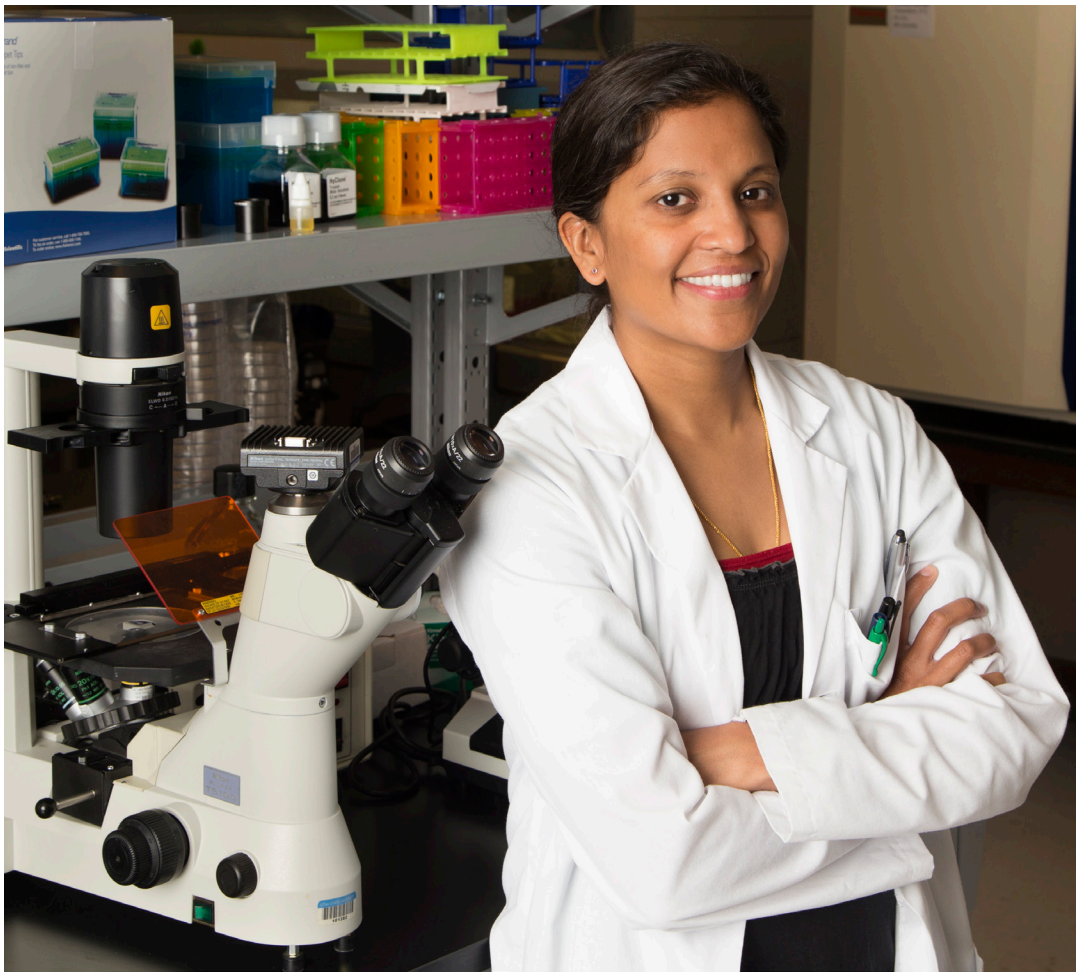
In a separate project, he and his student researchers are working with biomedical experts to extract the heath-promoting compounds of Korean red ginseng to fight cancer, diabetes and other disease. The properties of the extracts will be evaluated in combined radiotherapy and chemotherapy treatments in clinical trials at the SORAM Bio-Medicine Institute in Seoul.

VISION: An Engineer's Tool in the Fight Against Eye Disease

If you've seen the latest news headlines about Dr. Elizabeth Vargis, you'd think she was an ophthalmologist – a medical expert on vision-related disease and treatment. But Vargis is no physician. She's an engineer – pure and simple.

Hired in 2013, Vargis is the newest assistant professor to join the Biological Engineering Department. She and her team of student researchers are using nanoscale engineering tools to better understand biological phenomena and leading a new study to combat eye disease.

In one study, Vargis is building nano-scale models of retinal disease to explore how age-related macular degeneration affects eye tissue. Unlike normal cell behavior, cells impacted by macular degeneration start a domino sequence that causes neighboring cells to die. The size of the diseased areas can affect how powerful this chain reaction is. By controlling the exact size and location of cells within her in vitro disease models, Vargis can evaluate cell behavior and possibly identify a method to reverse the disease or prevent its escalation.



"As an engineer, we have the tools and expertise to really change how biological and biomedical problems are solved," she said. "I'm thrilled that we will be using our methods to better understand retinal disease."

Elizabeth Vargis, right, and Ph.D. student Cindy Hanson are leading innovative studies in eye disease research and Raman Spectroscopy.

The Vargis Lab is using similar technology to model an often blinding eye disorder found in premature infants. Retinopathy of prematurity usually develops in both eyes and can lead to lifelong vision problems and blindness. This exciting research has support from the Knights Templar Eye Foundation which contributed $60,000 to help Vargis fund the next stage of research in her ongoing work to combat vision-related disorders.

Vision health isn't the only line of work at Vargis' Lab. Ph.D. student Cindy Hanson, is implementing USU's Raman microscopy system for biological detection. Her work involves detecting and identifying bacteria using Raman spectroscopy in conjunction with dielectrophoresis. For her commitment to the field of biological and optical engineering, Hanson was awarded a 2015 Optics and Photonics Education Scholarship by SPIE, the international society for optics and photonics.

Tackling Salinity in the Colorado River

One Ion at a Time

It's one of the most overtaxed waterways on the planet, and its shrinking flow is only part of the problem.

The Colorado River travels 1,500 miles through seven U.S. states before reaching the Gulf of California. Throughout its long journey the river supplies water for approximately 40 million people and is used to irrigate more than five million acres of land in the Western U.S. and Mexico.

But along its journey, the Colorado picks up and transports millions of tons of salt left over from geologic sediments and agricultural runoff. By the time it reaches the lower basin, salinity concentrations can be high enough to ruin crops and damage soil. The U.S. spends millions of dollars each year to combat salinity, and entire government programs are dedicated to improving farming practices that reduce how much salt leaches into the river.

Associate professor of biological engineering Dr. Anhong Zhou has developed an innovative method to measure the concentration of specific salt compounds in water. He and his team patented an inexpensive, reusable handheld device that can detect the concentration of sulfate ions. Measuring sulfate and other salt compounds, and identifying their sources, is the first step at improving salinity control.

"There are dozens of ions in the water but only a few of them contribute significantly to the salinity problem," said Zhou. "The current probe to detect salinity is based on conductivity measurements, but that only indicates an overall presence of salt. It doesn't tell you what ions and at what concentration."

Because much of the salt in the Colorado gets picked up in the river's upper basin, researchers want to know what ions are present in the river in regions of Eastern Utah.

"We've invested almost as much as we can to control salts coming from irrigated lands," says Utah Water Research Laboratory Director Mac McKee. "There's almost no opportunity left to reduce salts coming from irrigated lands, and yet we still have salty water."

He and other experts agree: identifying sources of these ions – including sulfate – in the upper basin will help researchers better understand how to manage the total salt load in the Colorado River.

"We're looking at several hundred million dollars a year in quantified damages to lower basin users," said Don Barnett, executive director of the Colorado River Basin Salinity Control Forum. "The effects include decreases in productivity in irrigated agriculture; in industry it increases costs to use water; in the public sector it degrades pipes and leads to corrosion and scaling problems."

Zhou says several companies are showing interest in the device and a similar technology he developed that can detect microorganisms in water including cryptosporidium.

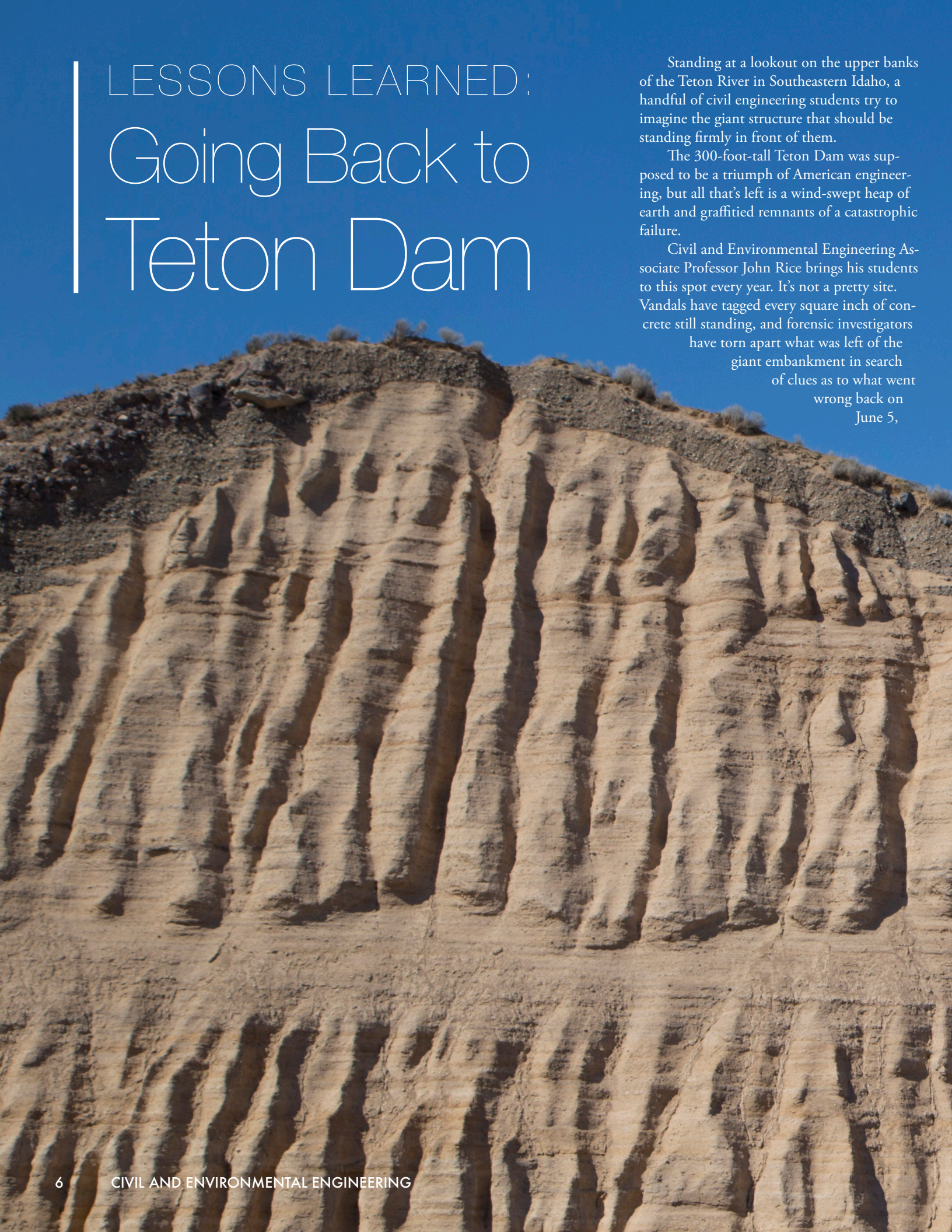
LESSONS LEARNED:

Going Back to Teton Dam

Standing at a lookout on the upper banks of the Teton River in Southeastern Idaho, a handful of civil engineering students try to imagine the giant structure that should be standing firmly in front of them.

The 300-foot-tall Teton Dam was supposed to be a triumph of American engineering, but all that's left is a wind-swept heap of earth and graffitied remnants of a catastrophic failure.

Civil and Environmental Engineering Associate Professor John Rice brings his students to this spot every year. It's not a pretty site. Vandals have tagged every square inch of concrete still standing, and forensic investigators have torn apart what was left of the giant embankment in search of clues as to what went wrong back on June 5,



1976. The location is an outdoor classroom, a laboratory, where Rice – pen and portable white board in hand – illustrates the complexities of dam construction and geotechnical engineering.

"The Teton Dam site is probably the best site in the country, if not the world, where students can come and see all of the elements of earth dam construction exposed for observation and discussion," said Rice. "It also provides a great setting for discussing the design and construction mistakes that were made at Teton. All of this reinforces the concepts we discuss in class."

Rice leads the group to the dam's foundation where he points to cracks deep in the rock that he and other experts say should have been grouted during construction to reduce seepage. His students scurry up the loose grade to inspect the formations. At every turn Rice and his colleague, Professor Emeritus Loren Anderson, see an opportunity to educate these future engineers.

"The site really impresses on the students the responsibility they have as civil engineers," said Rice. "Whether they are building a bridge, a building, or a dam the safety and well-being of others is genuinely affected by the job they do."

Dam construction in the U.S. has undergone a major shift in recent years. In the 1950s, '60s and '70s, engineers were erecting dams as fast as they could. The era was a heyday of civil engineering feats, and nearly all dams – even those built similarly to Teton – continue to serve their intended purpose. However, our understanding of dam design has evolved significantly.

The focus in dam engineering has shifted away from new construction and onto risk assessment and maintenance. In fact, the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation – the U.S. agencies responsible for Teton Dam and hundreds more – are getting out of the dam construction business; concentrating on maintaining and upgrading existing inventories.

Projects to improve the safety and functionality of dams dot the globe, and civil engineering students from USU are among the top experts who are leading the cause.

One of Rice's students, Lourdes Polanco-Boulware, is one such future leader. In April, she received the $10,000 scholarship awarded annually by the United States Society on Dams for her research on analyzing underseepage in levees. This innovative work is critical to the safety of levees across the U.S. – especially in regions of Central California and Mississippi where many of these types of levees are in need of evaluation and improvements.

"In our program we strive to produce geotechnical engineers who are able to apply the principal geotechnical concepts they are taught to a wide variety of situations," said Rice. "Gone are the days where a standard 'cookbook' approach is acceptable."

The Teton Dam site gives students a chance to see how well-intended engineers made critical errors by not completely understanding the conditions they were dealing with.

"It teaches them that they will be the ones responsible for understanding the conditions they'll work in," said Rice. Today's engineers need to be able to assess a wide variety of site conditions and determine the appropriate analyses to use in their design. It's been said that if we don't learn from our history we are doomed to repeat it."

ENGINEERS WITHOUT BORDERS

PERU

Team Peru has been working with a group of communities in Southern Peru over several years. In the community of La Union the main income comes from raising alpacas for their fur and meat. But every year about 50 percent of newborn alpacas are lost to harsh winter exposure. Students sought to design and implement durable, portable alpaca shelters to help protect the animals and the residents' income.

Students went through a year of trial and error during the design process. Not only did the alpaca shelters have to be sturdy enough to withstand high winds and heavy snowfall, they needed to be portable since farmers move their herds throughout the year. The biggest challenge students faced was the limited resources and knowledge of availability of materials in Peru. Knowing they must be prepared, students walked from shop to shop in Juliaca, an industrial trade center of Peru, bartering for materials they needed. The team learned to be adaptable as supplies were limited.

MEXICO

Members of the Engineers Without Borders Team Mexico have been working with residents in the community of La Salitrera, Mexico for several years to help eliminate arsenic from water supplies using an improved design on a classic tool – the bio-sand water filter.

In May 2015 the team traveled back to Mexico to assess their existing filters and build more. The main goal was to make sure residents understood how to use the filters correctly and teach them how to construct the filters. The trip provided students with hands-on experience in engineering and design. Most importantly, said team leader Nathan Stacey, students learned first-hand that no matter how good an idea is, it's useless unless it can be effectively communicated to others.

"Before they could start the project, students had to write reports to convince EWB of their plans for

With the materials found, the team was able to make a high quality prototype. The group had succeeded with a design that met all of the farmers' criteria and more were implemented. Team leader Jared Madsen said, "The most incredible part of the trip was seeing how excited the farmers were to finally have something to protect their alpaca. It was an unforgettable experience to be able to use the skills we have learned from school and other life experiences to make a difference."

La Salitrera and why the bio-sand filters would make a positive impact on the community," he said. "Once in Mexico it was critical that the students communicated clearly about how the filters work."

Five additional bio-sand filters were built during the trip. Stacey said residents were taught the importance of the project through a workshop and by students visiting families one by one. One member of the community, who was willing to help others build their own filter, was named an expert through his involvement in every step of the construction process. Families that did not receive a filter this trip have access to materials to build their own with help of the local expert. EWB plans on returning to monitor performance and take on other humanitarian projects.

A Map for the Road Ahead

As transportation continues to play a big role in society, the need for civil engineering experts will continue to grow, and USU's state-of-the-art Time Lab will continue to be a training ground for future transportation leaders. USU's Dr. Ziqi Song is a transportation researcher exploring new themes in transportation including economics and modeling, highway maintenance and asset management, traffic operations, safety and sustainable transportation development.

Dr. Song and his student researchers are rolling out several innovative ideas in transportation engineering. The team has funding from UDOT to design and test a new aerial LiDAR system that can capture more information about Utah's roads and highways with lower costs. The initiative is part of a new federal mandate that calls on state transportation agencies to modernize their asset management systems.

"Transportation systems essentially follow the same supply-and-demand theory as other sectors do," says Song. "When roads become congested, transportation engineers recommended a traditional remedy like building more roads, hoping to solve the problem from the supply side. However, stringent budgets and environmental concerns make it harder to construct new infrastructure."

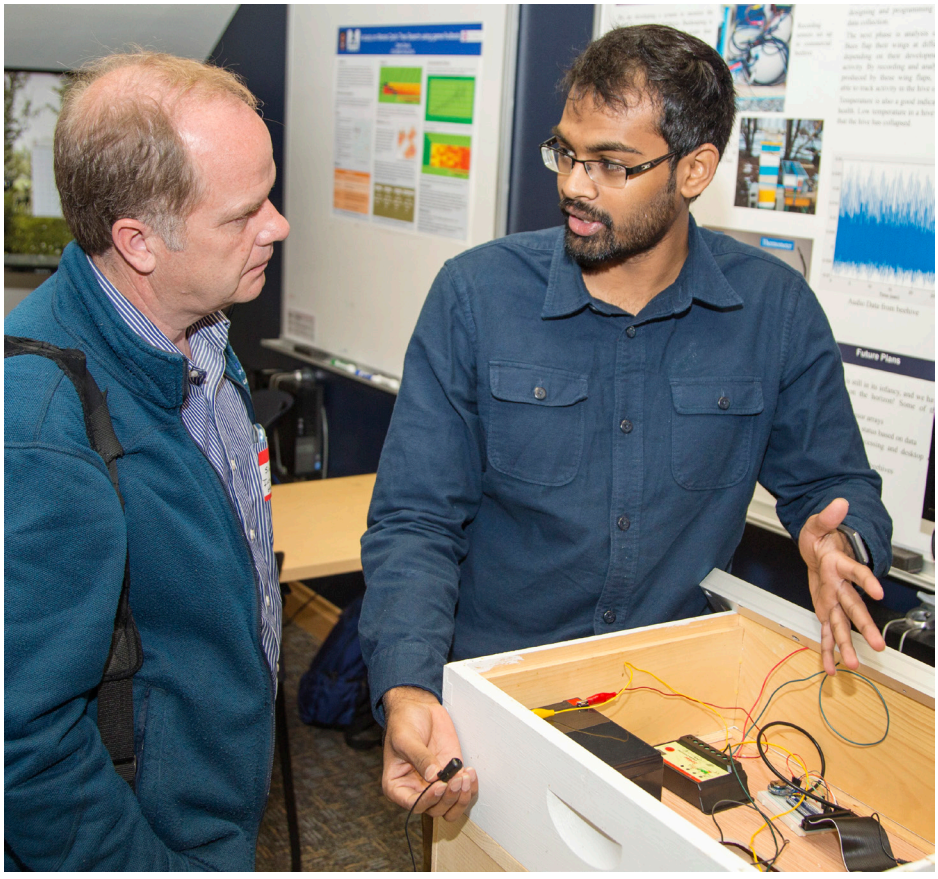
The Time Lab team is also working on ways to improve traffic congestion modeling and a new study exploring the safety of diverging diamond interchanges, or DDIs.

"Utah currently has six DDIs – the most in the nation," said Song. "Innovative geometric designs are often considered a solution to increased traffic, however the safety impact of these designs is often ignored."

Graduate student Holly Lloyd and Assistant Professor Dr. Ziqi Song discuss LIDAR data at the Time Lab.

OUT of the GATE

Aggie Computer Science Grads Filling Top Jobs



Graduate student Sarat Kiran Andhavarapu discusses his work on remote beehive monitoring during the Computer Science Industry Day.

Do an Internet search for engineering jobs nationwide and the results might look something like this:

civil engineering: 15K jobs
biological engineering: 1K jobs
electrical engineering: 47K jobs
mechanical engineering: 52K jobs
software engineering: **135K jobs**

In Utah, the numbers tell an even more exciting story. In the last decade, the region has become a high-tech hub with names like Adobe, Domo and XactWare dotting our communities.

These growing firms are hiring computer science graduates – a group of young professionals poised to earn more out of the gate than nearly all other undergraduate majors.

"Students realize that a large part of the growth in Utah and elsewhere will be in the software industry," said USU Computer Science Department Head Dr. Dan Watson. "Everybody's looking for computer scientists; students are looking for quality programs they can be a part of, and USU is just shining."

Undergraduate enrollment at USU has increased 78 percent since 2008 – something Watson says reflects the quality of faculty and instruction in his department.

"We're experiencing tremendous growth in terms of undergraduate enrollment, and we're getting higher percentages of women who are interested in the degree which is a good sign."

The CS department has also expanded its industry connections with partners around the Intermountain West and implemented a unique pro-

Employment status for USU CS Graduates (2013-2014 data)

gram with the Space Dynamics Laboratory that gives students hands-on programming experience.

Watson says CS students at USU are getting the best of both worlds from established faculty and newly-hired assistant professors who are at the cutting-edge of computer science theory and technology. In addition to strong job prospects, he says a CS degree can open a lot of doors.

"Having a CS degree is more than just the paycheck," he said. "It gives people a tremendous amount of flexibility in their careers whether they want to work in a big company or create their own."

Nationwide, CS jobs are available at a rate roughly equal to the number of jobs in all other engineering disciplines combined. Here at home, the numbers are even bigger.

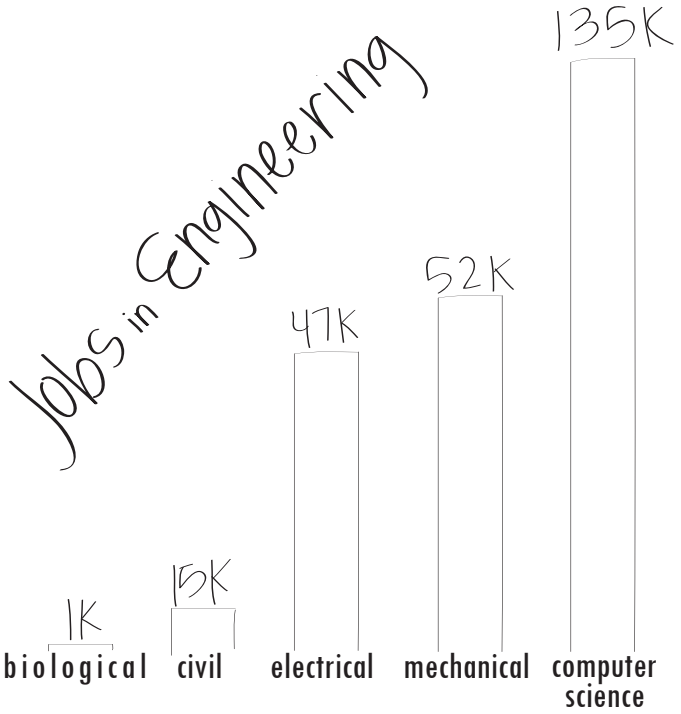
"In Utah, CS jobs are available at a rate equal to about twice the number of jobs in all other engineering disciplines combined," he added. "We are moving quickly in Utah to becoming a software mecca."

Average Starting Salary for USU CS Graduates (2013-2014 data)

Bs 60,929

Ms 64,750

PhD 119,000



Inside the Life of Computer Science Aggie: Nicky Gertman

It's no secret that computer science is a male dominated field, last year Utah State had 461 computer science undergrads and only 45 of those students were women. One of those women was Nicky Gertman.

Gertman started out college as a math major but by the end of her first semester she decided to find her true passion. She registered for a variety of classes to find what she was interested in, one of these classes was an introductory course to computer science. She loved the way computer science constantly challenged her intelligence, she had found her passion and decided this field would be what she would want to do for the rest of her life.

"It can be one of the most frustrating and maddening things to do," she says, "but at the same time one of the most rewarding."

Being a woman, Gertman feels is an advantage in the field. Her gender gives her a different perspective on how to solve problems.

"I think it is a great advantage for me," she said, "men and women think in different ways from one another, and I feel that my gender means that I approach problems differently. Sometimes my approach is better, and sometimes it is worse. But, I feel that the more different approaches we have to fixing a problem, the better."

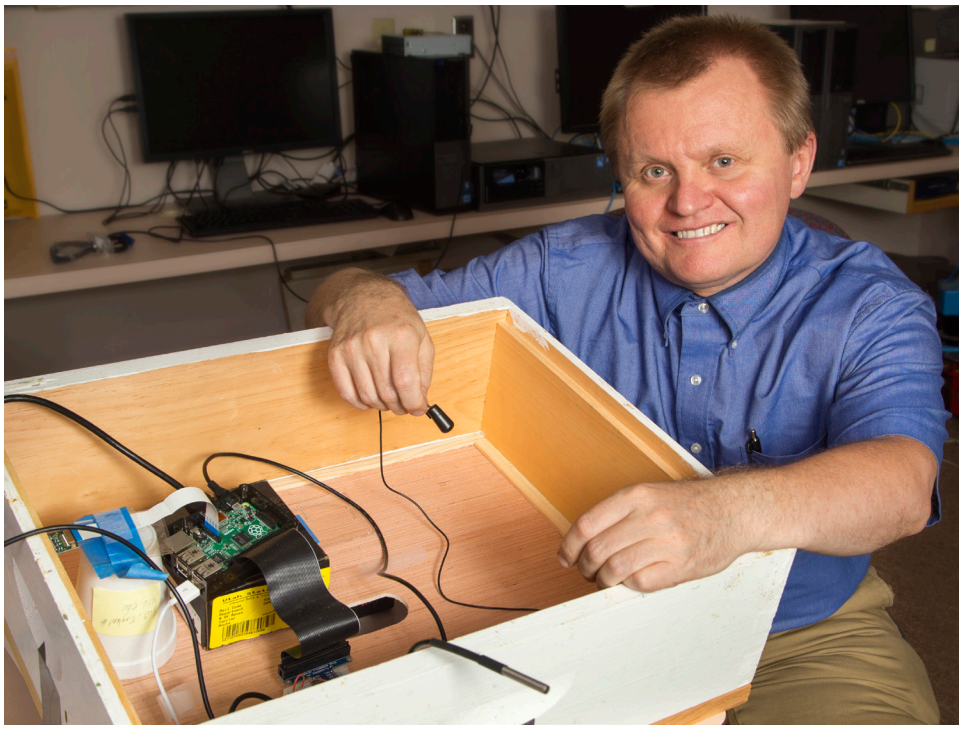
Over the 2014-2015 school year, Gertman was president of the Association of Computing Machinery for Women giving her experience in leadership. She was able to pass her knowledge by being an assistant teacher for a beginning class. Over the summer she interned for GE Oil and Gas, working mainly with the visual aspect of computer applications.

Her favorite project she worked on was focused on hungry USU students and faculty members called USUEats. The app has menus from all of the restaurants on campus. Users choose which restaurant they wish to eat at and how much they are willing to spend. The app then generates three options of meals within the price range given. Gertman has been excited about this project and hopes to get it to the app stores soon.

Gertman has a bright future ahead of her with travel plans and offers to be a programmer at GE. For now she is keeping her options open until she graduates this December. She plans on applying for many different companies post-graduation. She is excited for her prospective opportunities and is grateful for what Utah State has offered her and how it has prepared her for her career.

All About the BUZZ

On a warm spring day at the USU Organic Farm, computer science professor Dr. Vladimir Kulyukin delivers a few puffs of sweet-smelling pine cone smoke into one of his beehives and gently opens the top. Everything appears normal but it's not your average backyard beekeeping setup. Kulyukin's hives are equipped with electronics that monitor temperature, audio and video – all powered by solar energy and controlled by a credit-card-sized Raspberry Pi computer.



The purpose of today's visit, however, is not to collect honey or pose for a picture. Kulyukin and computer science graduate student Sarat Kiran Andhavarapu need to swap out one of the SD cards onboard the computer that's been collecting data for two weeks.

It's a routine chore for Kulyukin – a seasoned beekeeper who skips wearing the full-body suit and gloves – but a first-time experience for Sarat who until now has never been this close to a swarm of busy bees.

Kulyukin has been interested in beekeeping for about five years, but the motivation to look closer at what's affecting global bee populations came from a 2013 cover story in Time magazine about the mysterious collapse of bee colonies around the world.

He proposed a simple system to collect data from beehives with the goal of creating a method for both small and large-scale beekeepers to keep better track of changes in the hive. If the audio profile inside the hive changes significantly from one day to the next, the beekeeper could be notified by email and have time to investigate.

"The camera, microphone and temperature probe capture intermittent snapshots," said Kulyukin. "These snapshots are used to estimate the amount of bee traffic in and out of the hive. The audio files will be analyzed to identify significant events in the hive. For example, are there buzzing patterns that indicate the queen is beginning to fail?"

Temperature readings tell Kulyukin if the hives are in good repair. A rapid decline may point to external damage to the body of the hive. With funding from the Micron Corporation, Kulyukin set out to construct three beehive monitoring systems at the USU Organic Farm in North Logan and another system in Garland, Utah. Each beehive system, which the researchers dubbed "BeePI," is made up of a miniature camera, solar panel, temperature sensor, battery, hardware clock, solar charge controller, and, of course, the Pi computer. A future addition of a Wi-Fi card, Kulyukin explains, will allow beekeepers to extract data without manually removing SD cards.

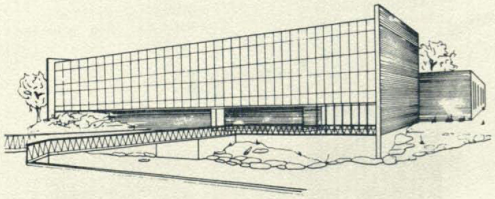
Remote beehive monitoring isn't new. Fellow researchers have been exploring ways to better understand hive conditions for several years, but there are still a lot of unanswered questions. Kulyukin's research is focused on creating a reliable solar energy and battery storage system for the monitors and developing inexpensive ways to construct the units with commonly available off-the-shelf supplies.

"A major objective of our project is to

transform standard bee yards into distributed solar-powered multi-sensor data clusters that collect and analyze large volumes of live data in real time," he explained. "This type of monitoring system will also enable researchers and practitioners to collect objective data on different bee races and different hive designs."

Kulyukin's research also gives his computer science students a practical application for their skill set.

"Recruiting and retaining excellent undergraduate CS majors is challenging," he said. "Students enrolled in CS courses often complain that many covered topics lack practical significance. This project demonstrates that CS is not only practical, but also highly relevant to areas that seemingly have little to do with computation such as beekeeping, entomology, and environmental science."

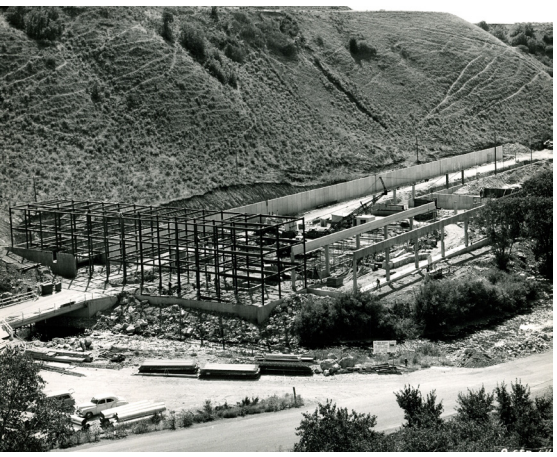


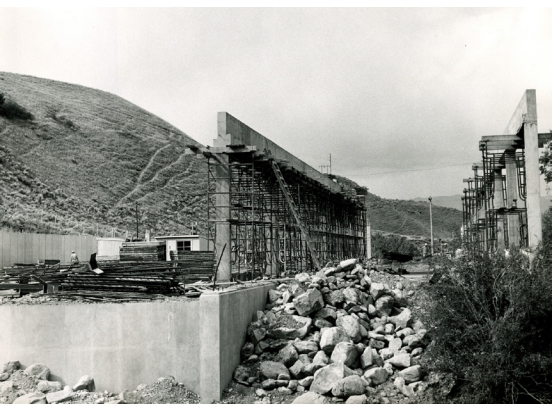
2015 THE YEAR OF WATER

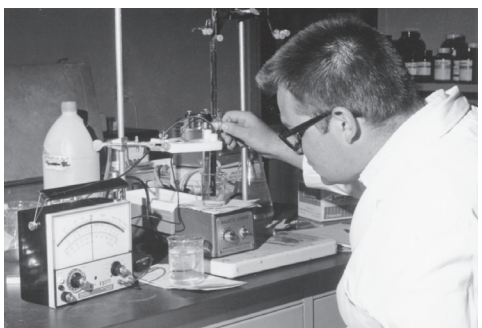
UtahStateUniversity

WATER EXPERTISE **AT ITS SOURCE**

The Utah Water Research Lab is the oldest and one of the largest university-based water research facilities in the United States and is considered one of the most well-respected facilities of its kind. Our cutting-edge research facility and expert water faculty attract students from around the world, many of whom move on to become the next generation of water experts in their own countries. While our diverse research program, which is directed at solving interdisciplinary water-related problems in Utah and around the globe, has gained an international reputation, our focus is primarily on Utah's unique water challenges. In 2014 alone, we conducted over 250 projects that will yield future benefits in each of Utah's 29 counties. Some projects are relatively small, while others involve interdisciplinary teams in collaboration with multiple agencies and the private sector. As we celebrate 50 years of water research, education and value to Utah and the world, we acknowledge the dedicated people and innovative ideas that have made these achievements possible.

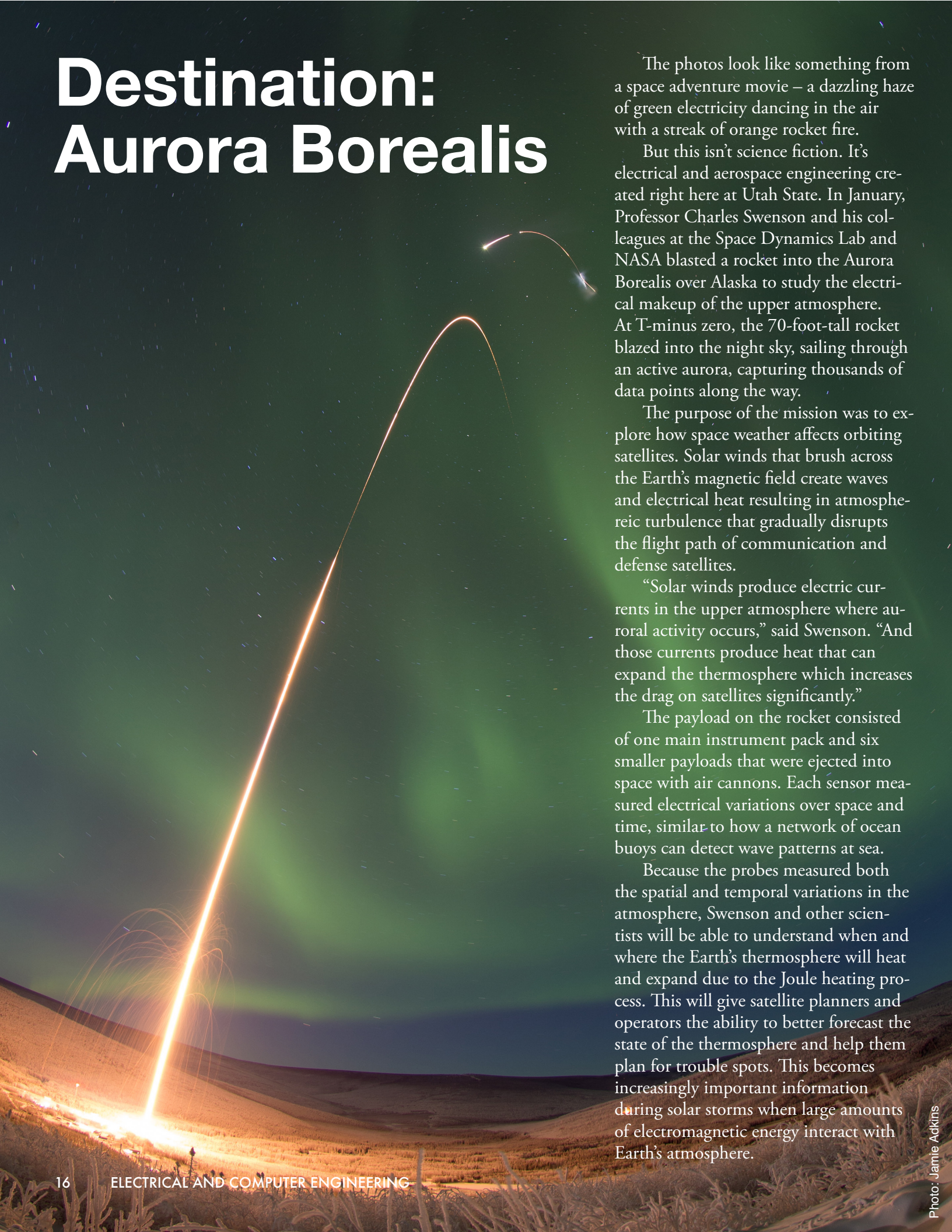







UTAH
WATER RESEARCH
LABORATORY
GEORGE D CLYDE
BUILDING

Destination: Aurora Borealis



The photos look like something from a space adventure movie – a dazzling haze of green electricity dancing in the air with a streak of orange rocket fire.

But this isn't science fiction. It's electrical and aerospace engineering created right here at Utah State. In January, Professor Charles Swenson and his colleagues at the Space Dynamics Lab and NASA blasted a rocket into the Aurora Borealis over Alaska to study the electrical makeup of the upper atmosphere. At T-minus zero, the 70-foot-tall rocket blazed into the night sky, sailing through an active aurora, capturing thousands of data points along the way.

The purpose of the mission was to explore how space weather affects orbiting satellites. Solar winds that brush across the Earth's magnetic field create waves and electrical heat resulting in atmospheric turbulence that gradually disrupts the flight path of communication and defense satellites.

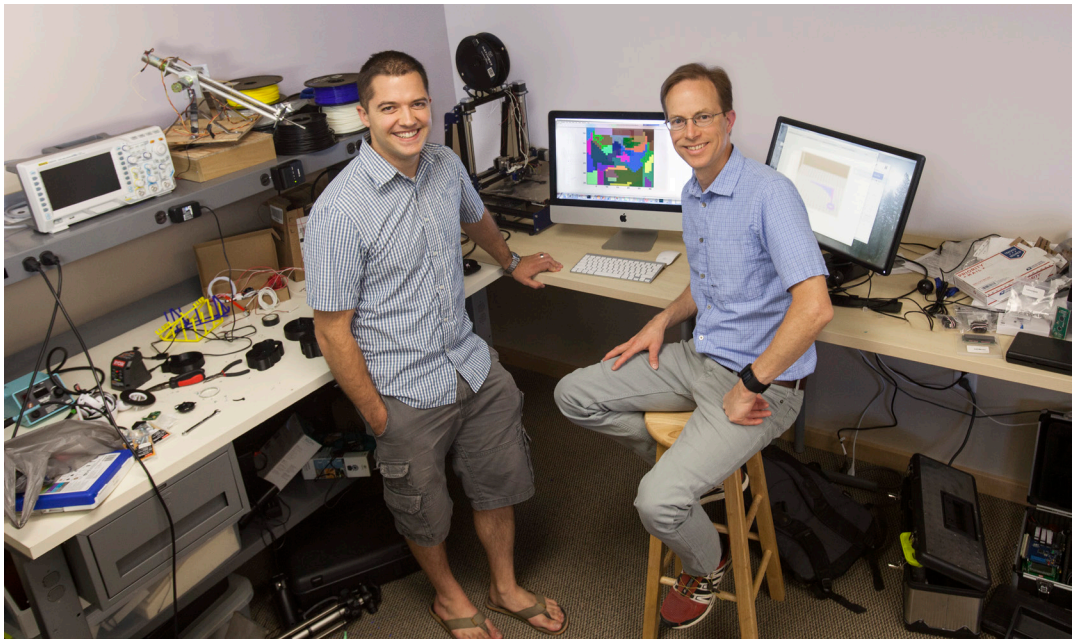
"Solar winds produce electric currents in the upper atmosphere where auroral activity occurs," said Swenson. "And those currents produce heat that can expand the thermosphere which increases the drag on satellites significantly."

The payload on the rocket consisted of one main instrument pack and six smaller payloads that were ejected into space with air cannons. Each sensor measured electrical variations over space and time, similar to how a network of ocean buoys can detect wave patterns at sea.

Because the probes measured both the spatial and temporal variations in the atmosphere, Swenson and other scientists will be able to understand when and where the Earth's thermosphere will heat and expand due to the Joule heating process. This will give satellite planners and operators the ability to better forecast the state of the thermosphere and help them plan for trouble spots. This becomes increasingly important information during solar storms when large amounts of electromagnetic energy interact with Earth's atmosphere.

Photo: Jamie Adkins

A Smarter Baby Monitor:
Student Project Spurs New Business Venture



Nate Ruben, left, and Professor Jake Gunther have started a new biometric processing company called Photorithm, Inc. Pictured below: Nate Ruben and his son Hyrum play on a slide. Ruben is developing a new heartbeat sensing technology that could be used in baby monitors.

Nate Ruben and Professor of Electrical and Computer Engineering Dr. Jake Gunther can see something on the surface that most people can't. The two are developing a new technology that uses a video camera to detect a person's heartbeat. It's not the first time engineers have tried to remotely measure a heartbeat signal. Medical technology experts have been at it for years with different designs that tether a child or his bedding to an electronic device that alerts parents to the possibility of Sudden Infant Death Syndrome, or SIDS.

But Gunther and Ruben's system is different. Instead of direct contact to an electrical sensor, a video camera is used to capture images of a person's face, neck and cheeks. Though it's invisible to the naked eye, a pumping heart actually changes the colors under your skin.

"When your heart beats and circulates blood through your arteries and veins, the color in your skin changes ever so slightly," says Gunther. "You and I don't see it with our eyes and we don't see it through the camera lens either, but our system can detect those subtle differences."

Digital cameras record images in specific values of red, green and blue. One might think the red channel captures the color of blood, and that the blue channel detects hues in our arteries and veins. But that's not the case. Gunther says the system actually uses green values – 256 of them to be precise.

"There is a certain response in the green light that we're looking for," he explained. "We process that color data and take an average over regions of the face, neck or cheek."

It's a simple system, but there's a major obstacle. Sleeping infants don't hold exactly still during sleep, meaning the camera captures a lot of competing signals. Ruben and Gunther, however, say they've developed a way to extract only the signal they need.

"We have a technique that allows us to separate those fine details," said Gunther. "We've done this, we've pulled it off."

This contact-less monitoring system could revolutionize some consumer products like baby monitors, exercise gear and medical equipment. A future version of their design could even replace some hospital tools used to monitor blood pressure and blood oxygenation levels.

"Our system is similar to how a pulse oximeter works," said Ruben. "But instead of looking at the light coming through the tissue, we're looking at the light being reflected off a person's face."

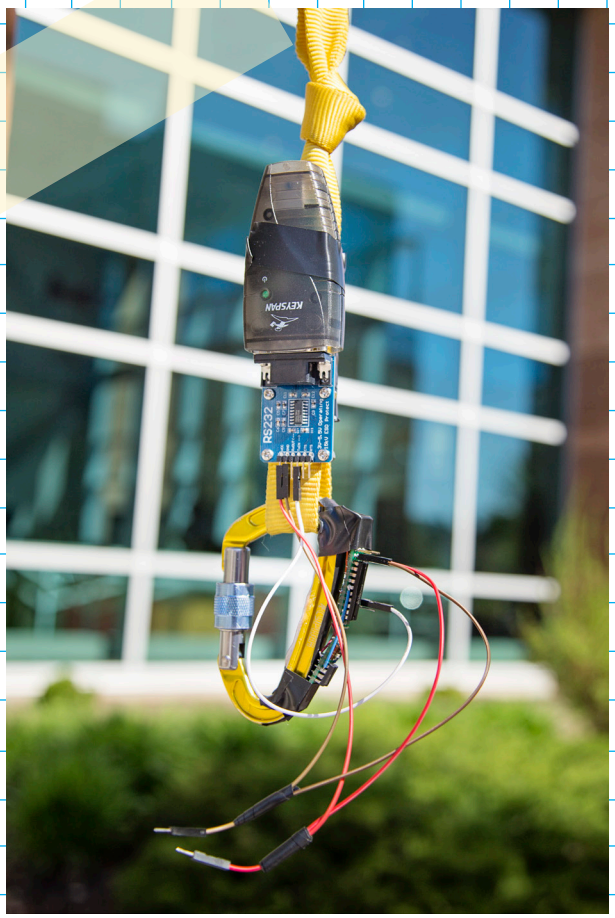
The idea for the new technology came when Ruben and his wife had their first child in 2012. Like most new mothers, Ruben's wife consistently checked in on the child as he slept to make sure he was well. All those trips gave Ruben an idea: how to make a better baby monitor. At the time, he and another professor had been experimenting with an app that used simple webcams to show heartbeat, but the technology still had a long way to go. That fall, Ruben built a prototype of his new system and submitted it for his senior design project.

"That first monitor did show some heart rate information but it wasn't very accurate," he said. "I worked on it with Dr. Gunther for a year and a half during my master's degree. In 2014 we were approached by an investor who saw the potential for this to be put in consumer products like treadmills and baby monitors."

The two have since created their own company, Photorithm. Inc., which specializes in computer vision and biometric processing. They say the company will become a launch pad for this and other breakthrough technologies.

Engineering Answers:

Elegant Solutions Start with Simple Ideas



Smart Carabineer

ECE students Jeff Lunt and Craig Manning created an electronic carabineer that tracks stats during a climb. The unit can be plugged into a computer afterward to display information about loads and more.

Solar-Powered Backpack

Courtney Richards was inspired to create her solar-powered backpack while working as a report writer for a paleontologist. While on long surveys both her camera and GPS would often run out of power making it impossible to do her job properly. She realized the problem could be solved with a portable power supply system which she created for her senior project.

The backpack uses solar cells to convert sunlight to electrical DC power that charges an internal battery. It then converts the energy into a steady five volts delivered to a USB port. The system was also designed to boost and transform the five volt signal to power a 120-volt AC outlet.

Richards said the biggest challenge during the project was time. To meet the deadline she simplified her design and put the AC outlet on hold for a future iteration. She says she hopes to make the system produce the full 120 volts for the AC outlet, bringing her vision to life.

"I hope to better my design to make it a more reliable system," she said. "I have a few ideas I want to implement during the next year or so to make the Solar-Powered Backpack even better."

Knock Detecting Lock System

After years of being involved with his parents' door hardware business, Connor George was always fascinated with different locking systems. For his senior design project he created a door that unlocks with a knocking sequence. He calls it the Knock Detecting Lock System. It detects a correct knocking passcode to unlock the door's deadbolt.

The system is broken down into two parts: the software and hardware design. When an input is detected, the software times the intervals between knocks. If the correct pattern is detected, the door will unlock. The hardware is a circuit system that electrically opens the lock. George says the best part of his design is that unlike most locking systems, it requires no hardware on the door's exterior. This helps conceal the locking system from a potential intruder and makes it harder to break in whereas traditional locks can be picked and keypads can be removed or bypassed.

Aside from enhanced security, they system has a more aesthetic appeal since the lock mechanisms and electronics are inside the door. Though it was a success, George would like to add a user-controlled delay before the door locks itself, a variable sensitivity control and other modifications to make the system smaller.

Robotic Hand

Quinn Thomas had always wanted to build a robotic hand and Ryan Lamoreaux has always had an interest in image processing. Together with Amber McDougal and Chris Green, the team built the Visual Servo Robotic Hand. The four team members built a hand that can imitate a user's right hand in three ways: closed, open and a two finger point. The device uses Microsoft's Kinect v2 to mimic hand motion. The team also programmed the robotic hand to "feel" and hold objects with force-sensing resistors on its fingertips. When the sensors detect a certain level of force it will stop the hand from closing.

The hand isn't the only part that moves. The wrist is able to move up to 90 degrees and the forearm can move at an angle from zero to 180 degrees. The hand was built with a 3D printer. Team members say the physical design proved to be the biggest challenge as most of them are electrical engineering students. Visual Servo is unique to other robotic hands because it is truly controlled visually. During their master's programs two of the team members plan to increase its abilities and plan to use it to learn more about control systems.

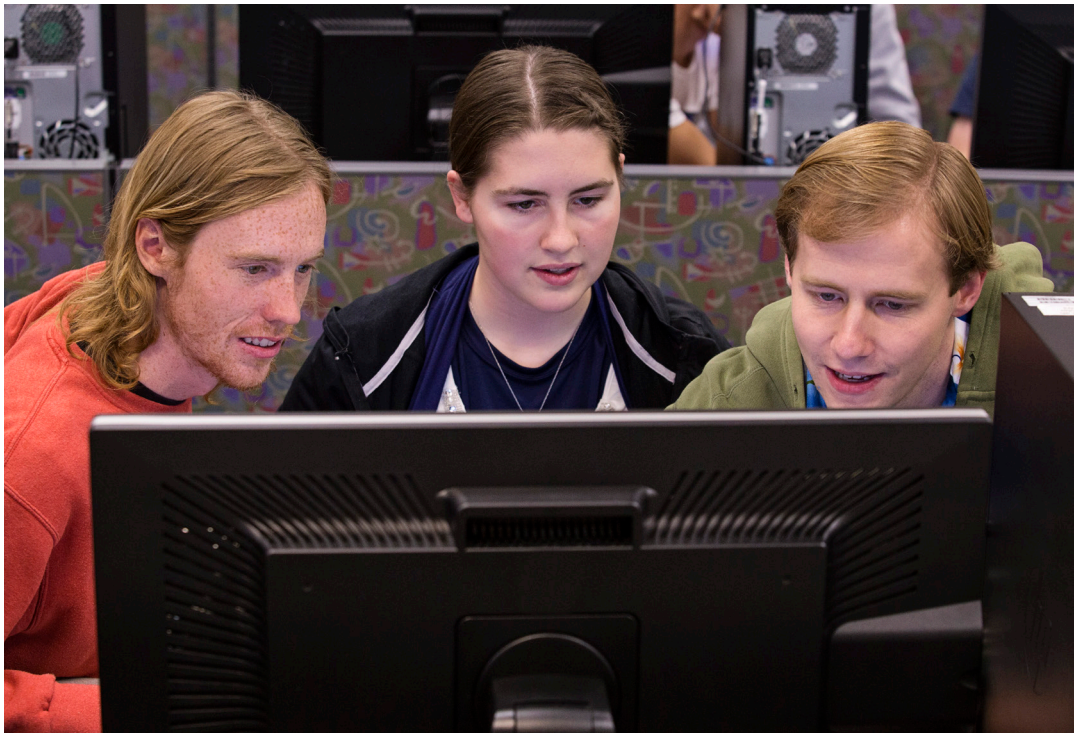
Toward a Continuum of Engineering

Education Experts are Rethinking Their Classroom and Curriculum

You can't watch the evening news or attend a school board meeting without hearing the latest in the ongoing push to get more kids interested in science, technology, engineering and math, or STEM. It's arguably the most prominent conversation in secondary education in this country: we need more young people interested in engineering and computer science degrees right now.

But there's a catch. Simply matriculating more students in STEM degrees doesn't mean we get more STEM graduates four years later. In fact, retention rates in engineering programs, can dip to lower than 50 percent at some institutions. Even for the most accomplished undergraduate, pursuing an engineering degree can be an overwhelming task.

In the growing field of engineering education, researchers are working to identify why students quit or change majors halfway through. Dr. Idalis Villanueva, Assistant Professor of Engineering Education, is part of a research team that's looking for answers.



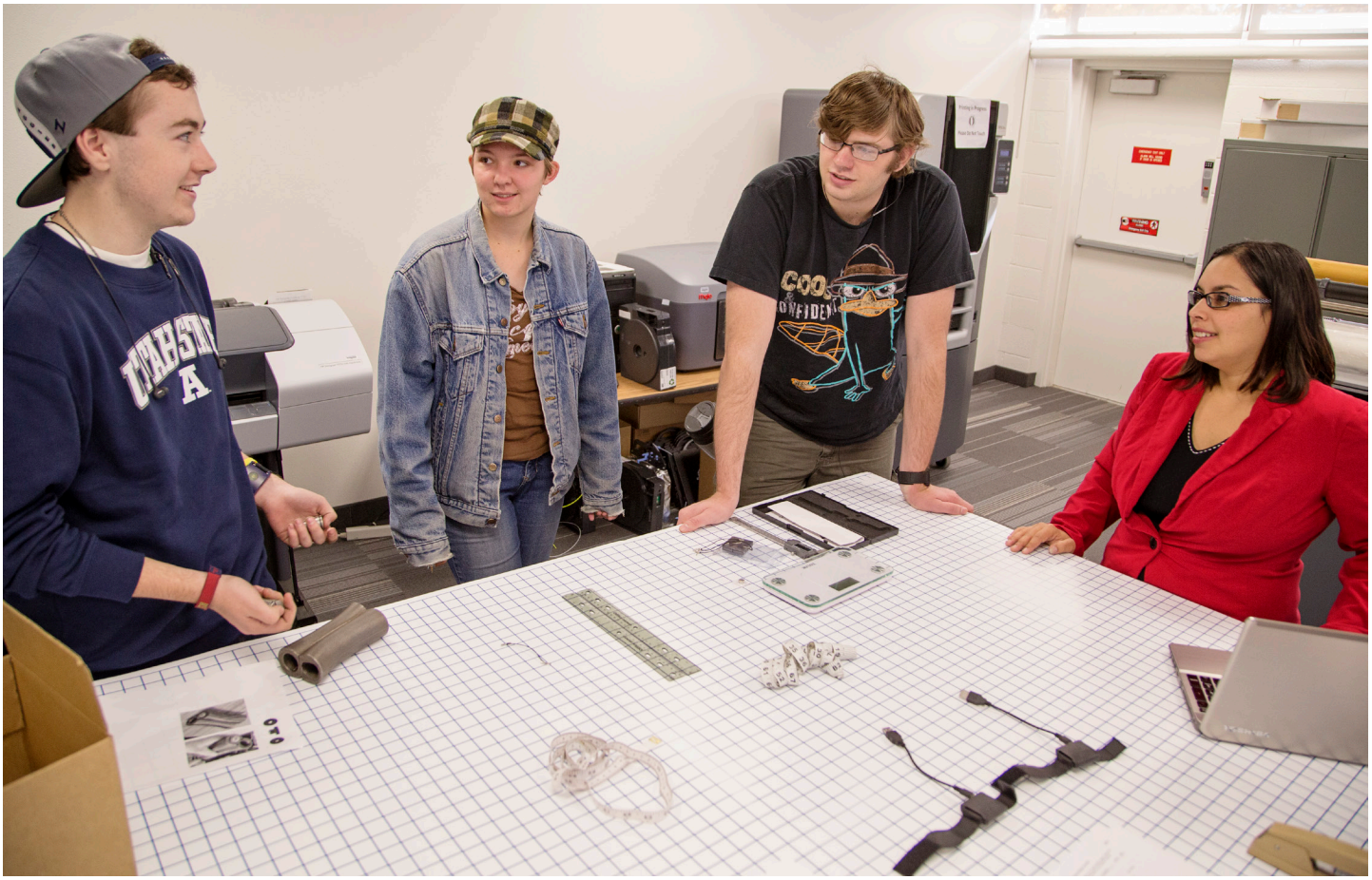
Pictured from left to right: Kyler Albrechtsen, Nicole Peterson and Benjamin Russon take part in an engineering graphics exercise.

"Part of the problem is that we have students entering engineering programs who get overwhelmed because they've never been exposed to engineering concepts," she said. "In high school there are not enough classes that cover engineering."

Villanueva says some students have limited tools to cope with failure, manage change and, in some cases, work effectively in groups – three common elements of any engineering classroom. She identifies three ways engineering teaching can be improved, and it all starts with making fewer assumptions about how prepared engineering students are.

"The first step is to diagnose the problem," she said. "We need to identify where the stumbling blocks are, and from the literature we know calculus and statics can be a problem for students.

"The next step is to understand the assumptions instructors are making when they design their courses. Oftentimes educators assume that students know how to survive engineering courses yet we overlook the context of students' former knowledge, culture and mental and emotional state of being. We're making assumptions that everyone fits the mold, and



Pictured from left to right: Jesse Chadwick, Suzanne Rhodes, Nathaniel Christian work in teams in many of their undergraduate engineering courses. Right: Researchers are using electronic wrist sensors to understand how different classroom activities can induce stress or emotional changes in students.

that's simply not true."

Villanueva says there's a broad assumption in higher education that students know how to work well in teams – an everyday exercise in engineering courses and a standard practice in industry.

"Teamwork is essential in engineering," she said. "Yet as educators we don't present students with the tools needed to cope with difficulties while working in a team."

A third step is to understand how students handle their emotions in the classroom. Villanueva is leading a new study that explores how emotion plays a role in a student's success. In her research lab, volunteers can be outfitted with wrist sensors that record emotional arousal in real time. The sensors help researchers observe how students respond to lectures and group exercises. Heart rate, sweat secretion, body temperature and blood oxygenation levels are recorded to show how emotions fluctuate with different course activities. Oral interviews and self-reflective reports are also used to provide a broader picture about the students' experience.

"Academics are important, but there are other factors at play, such as peer interactions, the way the instructor presents him or herself and more," she said. "These are stressors that are not related to a course but that are equally important."

Preliminary data show that some activities provoke a broader range of emotions than others. Villanueva says the ultimate goal with the study is to identify the most common experiences that cause students high levels of stresses and identify how sustained levels of academic stress can lead to attrition and dropout. She hopes one day to provide tools and strategies for engineering educators to help them incorporate stress management practices in their engineering courses.

"As engineering educators of the 21st century, we are in the crux of great changes both in academia and in industry," she said. "It's our duty to help our engineering students manage these changes successfully and sustainably in their careers."

Cracking the Egg on Engineering Thinking

Assistant Professor Wade Goodridge and student Alexis Houghton discuss how brain waves can be analyzed to learn more about engineering thinking.

It's no surprise: engineering courses are tough. Professors assign complex homework problems that can take hours to solve, and for some the experience feels like drinking from a fire hose.

Most engineering programs begin with a handful of rigorous courses in statics and dynamics that can be stumbling blocks for some. This has engineering education experts looking for retention solutions and rethinking how these difficult courses are taught.

Dr. Wade Goodridge, assistant professor of engineering education, says part of the solution will come from a more thorough understanding of spatial thinking – specifically spatial ability.

"Spatial ability means being able to visualize an object in different orientations," said Goodridge. "For example, choose an item on your desk and mentally pick it up and rotate it. Or take the object and mentally slice it in half. Are you able to visualize the pieces in this new perspective?"

Spatial ability, sometimes referred to as spatial cognition, is a crucial skill for many hands-on professionals including dentists, airline pilots and engineers. Experts have shown that spatial thinking is highly correlated to success in engineering majors and success in an engineering career. Experts also say spatial ability can be taught and improved.

What's unclear, says Goodridge, is how much spatial ability a student has when he or she shows up for their first lecture and how much impact that has on their ability to succeed in a course.

"We know that people have different levels of spatial ability," he said. "In statics we look at a lot of force interaction type problems. Most students can easily visualize a two-dimensional problem, but when we move to 3-D problems it gets more complex."

Goodridge suspects that some students struggle with more challenging concepts because it can be difficult to mentally construct the many components in a force interaction exercise. To learn more, he's conducting new research aimed at analyzing brain activity as it relates to how students solve these types of complex mechanics problems.

"We use an electroencephalogram, or EEG, headset to look at the neural activity in research subjects," he said. "What we discovered is that the mental cutting test takes more neural involvement than other commonly used spatial visualization tests."

In fact, the classic mental cutting test, developed in 1930s, is so difficult, Goodridge rarely sees a perfect score among his students. The interesting connection is that the homework problems he assigns in his statics course require a similar level of neural engagement.

"So if statics is a stumbling block, are there ways to teach it that are more spatially involved?" Says Goodridge. "Can we design an intervention within the curriculum for those students who aren't as spatially adept to better understand the material?"

Through his ongoing research, Goodridge is trying to do exactly that. He'll present on his findings and on the importance of spatial thinking to a group of researchers at Northwestern University this fall.

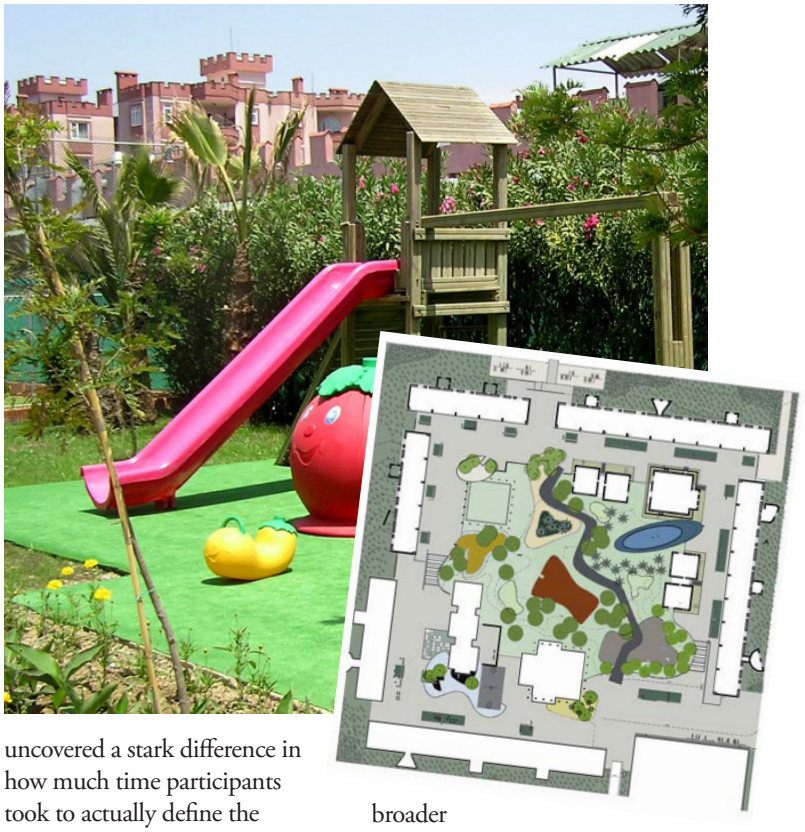
Engineering a Playground: How experts and novices see problems differently

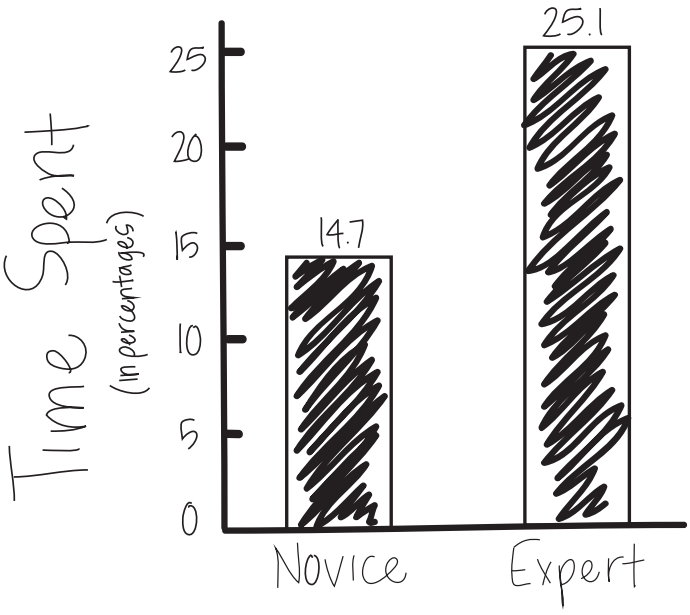
When pilots begin training in small single-engine aircraft, they're told not to fixate on any one particular cockpit instrument like the airspeed indicator or altimeter. Focusing on a single piece of information is a natural but dangerous habit that must be broken early on.

Engineering students have the same innate tendency to fixate on individual parts of a problem. It's an obstacle at the core of engineering education: how do we teach future engineers the thinking and design skills needed to solve complex, big-picture problems?

Professor of Engineering Education Dr. Kurt Becker is an expert in engineering design learning and thinking. In one of his most recent studies, Becker identified some key differences in how inexperienced engineering students approach problems compared to professional engineers with years of training.

He and his colleagues designed an experiment to track the differences in how experts and novices solve problems and how much time they spend on each step of the engineering design process. A group of young engineers in training and a group of experienced engineering experts were used in the study. One by one, participants sat down with a researcher and were given a unique challenge: design a playground in the middle of a city that is safe for kids, comfortable for parents, accessible to persons with limited mobility and a number of other criteria. The results uncovered a stark difference in how much time participants took to actually define the problem.





Becker's research shows expert engineers spend more time defining or 'scoping' the problem before they begin designing solutions.

"High school and college students jumped right to the first solution they saw," said Becker. "They didn't spend time like the professional engineers do to go through a whole iteration of possibilities and comparing alternatives."

The research study showed that high school-aged participates spent about 14 percent of their time scoping – or defining – the problem, whereas experts spent 25 percent of their time. Becker said that's a significant difference between the two groups.

The findings highlight a major gap in how engineering students mentally map their way through a problem. It also demonstrates a need to redesign certain elements of engineering curricula to help students better understand the importance of human-centered engineering design – a term used to describe the broader goals of an engineering task, not just its individual parts.

"It's all about curriculum development," added Becker. "So if we know that people fixate, what tools can we develop for students to overcome that tendency?"

Becker says part of the solution may be to give engineering students more design experience in more classes. Another is to help young people better understand the problem scoping phase.

"Early on in the curriculum, we need to give students more design problems where they can work together in teams to address the problem scoping gap between a novice and expert designers," he said. "Right now, students get the bulk of their design experience in a senior design program, but they really should start much earlier."

Becker's research will be published in the October issue of the Journal of Engineering Education.

New Engineering Research Lab Making a SPLASH

WARNING: You will get wet.

The mechanical engineering students who work inside one of Utah State's newest research centers don't mind getting the occasional work-related soak. The whole lab is one giant splash zone and the creative workshop of newly-hired assistant professor of mechanical engineering Dr. Tadd Truscott.

Truscott built the first Splash Lab at Brigham Young University before coming to USU. The facility might look like a tinkerer's paradise, but behind all the toys and tanks is serious business – high tech research with funding from the U.S. Navy and other high profile interest groups.

"The purpose of the lab is to improve our understanding of physical phenomena – typically in fluids – through visualization, observation and modeling and then to disseminate the information in a way that inspires people."

Truscott is an MIT graduate and a top expert in fluid mechanics. In one of his most recent projects, he and his team demonstrated how a spinning sphere in a shallow bath of fluid can act like a pump. The concept is nothing fancy. He boils an egg, spills some milk on the kitchen counter and with a twist of the wrist sends the egg spinning through the puddle. What happens next is a simple principle of fluid dynamics, but it had never been fully explained in the scientific community until Truscott came along.

"As the egg spins through the milk, the fluid is drawn up the sides of the egg and then ejected at a point near the equator," he explained. "This phenomenon occurs when any partially submerged object whose radius increases upward from beneath the fluid surface spins in a liquid bath."

An image of the egg and its beautiful radial jets of blue-colored milk was captured with a high-speed camera. The mesmerizing photo along with Truscott's findings captured the attention of other scientists and media and was featured on the cover of Physics of Fluids earlier this year. Through additional research, Truscott says the concept of the spinning sphere could be used to design and build a more efficient pump capable of moving viscous fluids at high rates.

The egg project is just one of many Splash Lab studies on how objects move through fluids and how a better understanding of fluid mechanics can help engineers develop smarter technology.

"There are so many applications for this type of research," says Truscott. "The Navy, for example, is interested in how projectiles travel through water, the kind of sounds they make as they enter the water surface and even ways to alter the forces on the surface of impacting bodies like ships. Understanding why splashing occurs can help produce safer laboratories and even more hygienic restrooms. The possibilities seem endless."

Another exciting development for Truscott involves the unlikely combination of schools of fish and a pack of Tour de France riders. Truscott was recently named a Department of The Navy Young Investigator for his research on how groups of animals (or bicycle riders) move together in synchronization – better known as swarming. Mimicking the patterns and precision displayed in swarming could lead to safer and more efficient use of autonomous vehicles.

"Developing these forms of swarming algorithms from the ground up would be daunting," said Truscott, "But nature has already figured out how autonomous creatures can move together with striking efficiency in, for example, a shoal of herring

Above: from left: Ben Lovett, Nathan Speirs, Tadd Truscott and Andrew Merritt demonstrate how an elastic ball bounces out of the water when shot from a low pressure air cannon. Truscott and his team are unraveling the physics of how elastic spheres can bounce along the surface of the water. The research has both recreational and naval relevance. Below: A spinning sphere in a bath of liquid can pull fluid up its sides like a pump.

or a murmuration of starlings."

Truscott's research will focus on how an animal's individual sensory inputs and movements lead to the behavior of a larger group. A better understanding of swarming behavior has big implications for our modern world.

"Recently, there has been increased interest in using collective groups of autonomous vehicles to perform coordinated surveillance, search and rescue, environmental hazards modeling or coordinated evasion operations," said Truscott. "Our observation techniques focus on kinematics and sensory cues. From that, we'll develop models of the animals' behavior and attempt to mimic them by implementing our models in swarms of small table robots."

Truscott's team will use a multi-camera array to capture high resolution images of insects, birds and small fish. This data will then be analyzed and incorporated into 3D models. The effectiveness of the resulting swarm behavior models will be evaluated using virtual simulations and live implementation using a group of tabletop robots.

TANDEMONIUM

Side-by-Side Cycle Helps Opportunities Roll

Jay Lindstrom's love for biking and Laura Birkhold's enthusiasm for a hands-on project made designing a side-by-side quadricycle perfect for their senior design project. Along with their team members and representatives from Common Ground Outdoor Adventures and Icon Health & Fitness, the group of mechanical engineering students set out to build a unique tandem cycle they dubbed 'Tandemonium.'

Common Ground provides outdoor activities for persons with disabilities. Tandemonium was built to provide a safe and enjoyable riding experience for their clients. Icon Health & Fitness helped fund the project and offered expert mentoring and manufacturing support along the way.

In designing the bike, students chose four main goals to implement: safety, accessibility, durability and portability. Safety aspects included turning radius, braking distance and visibility. The team wanted Tandemonium to be easily accessible for all body types and to be strong enough to ensure durability. In addition, it needed to be lightweight enough to make it easy to transport.

"It was so easy to get tunnel vision and just design your part," said Birkhold, adding that even when there were problems throughout the project, she enjoyed working with her team members. "Everyone brought different experience and expertise to the table, without which we wouldn't have been able to build the bike."

Tandemonium taught the senior design team how to effectively communicate, work together and overcome problems, an invaluable experience for their future careers. They learned how to work together even when difficult challenges came up.

Gage Salerno, left, and Chris Trumbull take Tandemonium for a spin. Right: The team. Pictured from left to right are Jaden Eldredge, Jay Lindstrom, Jake Forsyth, Laura Birkhold, Matt Larsen, Alex Moser, and Jason Parrish. Not pictured: Austin Stott and Mike Emery.

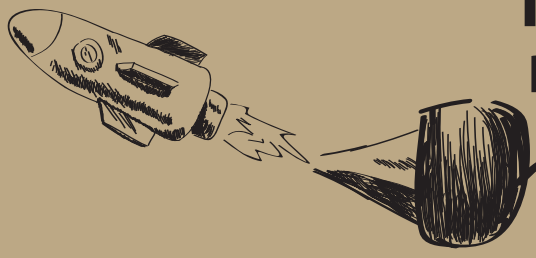
"My favorite part was seeing it all come together in the end," added Birkhold. "For so long the bike was just a model on a computer screen or a list of parts we had to source. Seeing it actually in front of me and getting to ride it was the most rewarding experience of the whole project."

Lindstrom said the project taught him the importance of a thorough design process.

"I was surprised by the number of iterations required to get the final design down," he said. "With a minor change in one system, it could change the requirements for another system. It was kind of a balancing act."

The Tandemonium team is working with advisors Rees Fulmer and Dixon Nielson to finalize the cycle and deliver it to Common Ground.

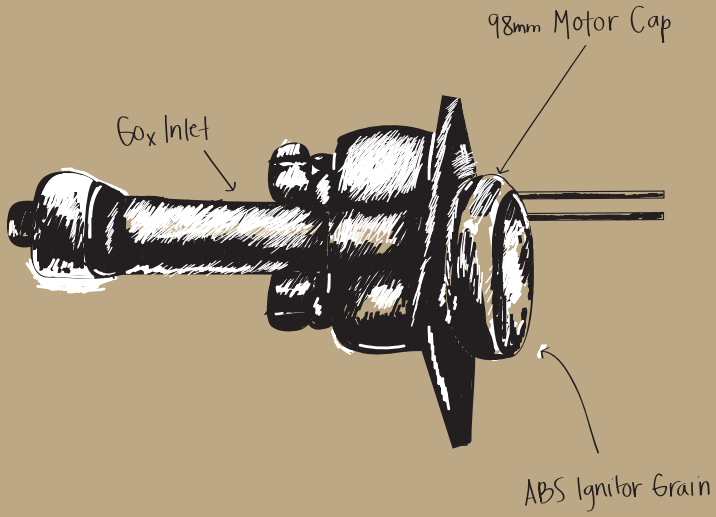
unwinding the FUTURE of ROCKET MOTORS

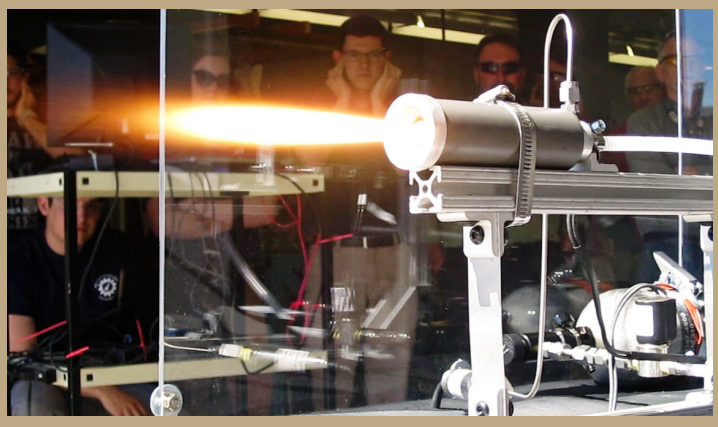


Hydrazine is an unstable, flammable liquid that has been used as a propellant in small space crafts for decades. The cost of hydrazine, its transport, storage, servicing, and cleanup of accidental releases are too high, making it impossible for the commercial space industry to expand. Finding a green alternative is imperative for safe future space travel.

Utah State University professor of mechanical and aerospace engineering Stephen Whitmore, Ph.D., and USU graduate, Zachary Peterson took on the challenge to investigate possible replacements for hydrazine as rocket fuel. What they found was that hybrid rocket motors with use of additively-manufactured Acrylonitrile Butadiene Styrene (ABS) a moldable plastic material, is a promising alternative. Hybrid rocket motors can be safely stored and operated without risk of explosion or detonation, and since ABS does not have a true melting point, it's a better candidate for additive manufacturing known as Fused Deposition Modeling (FDM) which supports high production rates, improvement of hybrid fuel grain quality, consistency and performance with lower costs. When fully developed, FDM manufacturing overcomes development problems usually associated with hybrid rocket systems. FDM can offer a wide variety of space propulsion applications that can replace existing hydrazine-based systems.

The discovery of ABS's unique electrical breakdown prompted Whitmore to invent an ignition system that takes advantage of hydrocarbon seeding. Two fundamental generations of prototypes were built and tested. The first was designed as an external "strap-on" ignitor for existing 98mm diameter hybrid motors that would replace pyrotechnic charges. The second reconfigured the "strap-on" ignitor to move inside of the combustion chamber with the ignitor fuel grain section-and essential part of the main motor fuel grain. In order to lower cost, an existing 98mm motor cap was adapted to fit into a short 10.2 cm hybrid motor section, this smaller adaptation became the Micro Joe.





"The long term commercial potential for this technology is almost limitless. If successful, this project introduces a "game-changing" technology," Whitmore stated. So what is next for the Micro Joe? In the short run after an upgrade, the team can do larger scale research funding. Eventually leading to space flight demos. Long run potential rises as demand for communications grow and available bandwidth shrinks. The proposed technology can provide a solution enabling inexpensive space-based communication network to support growth. The partners could be at the beginning of a potentially multi-billion-dollar commercial, civilian, and military communications market.

Water Lab Helps Las Vegas Community Solve Supply Problem

The community of Las Vegas, Nevada, is acting to assure a reliable water supply by building new intake facilities at Lake Mead. After a series of drought years dropped Lake Mead levels to historic lows, the Southern Nevada Water Authority is moving forward with an ambitious project to keep the water flowing, and they're turning to the Utah Water Research Lab to help do it right.

The Las Vegas Valley gets 90 percent of its water from Lake Mead – the manmade reservoir on the Colorado River that's

Research Associate Professor Steve Barfuss and his team constructed a scale model of a new low lake level pump station designed to keep water supplies in Las Vegas flowing.

inching to lower and lower levels. Two existing pump stations can pull water from the lake if its level is above 1,050 feet in elevation for one pumping station and above 1,000 feet for the other. But there's a realistic chance levels could drop even further – meaning one or both of the intake pumping stations could become inoperable, and the water supply for Southern Nevada put at risk.

Community planners and water customers say that's not an option. So crews have begun work on a new $650 million Low Lake Level Pumping Station that can lift water from the lowest depths of Mead even if it drops to an unprecedented 875 feet – a parched capacity at which Hoover Dam stops releasing water downstream.

At the Utah Water Research Lab, Research Associate Professor of Civil and Environmental Engineering Steve Barfuss is working to help understand exactly how this proposed new pump station will operate. He and his crew were asked to construct a 1:9 scale physical model of the station to evaluate the hydraulics of the proposed design. The model was designed in such a way that Barfuss and his graduate students were able to accurately measure how the water will flow throughout the structure.

Lake water will enter the pump station through an existing tunnel system, fill a large underground forebay and then be pumped upward through 34 well shafts to the surface where it will flow to two water treatment plants. When it's built, the station will be able to pump 900 million gallons of water each day. Barfuss' mission is to examine flow conditions for the specialized submersible pumps inside the well shafts.

"What we're trying to do is protect the longevity of the pumps," he said. "You can actually destroy a pump very quickly if it's put in an extreme environment it wasn't designed for."

Engineers are designing the system to ensure that water entering the pumps flows at a consistent velocity and with very little turbulence. If the velocity of the approaching water varies or if the flow rotates significantly, the pumps won't operate as efficiently and may ultimately burn

Research Engineer Andy Lee helped build the pump station scale model inside the UWRL's Hydraulics Modeling Lab.

out – a risk the Southern Nevada Water Authority can't take.

"To operate the way they were designed, these pumps need to have uniform flow approaching them so that their impeller blades do not cavitate and vibrate and so they can operate at their optimal location on the pump curve," said Barfuss. "If you have weird things happening in the shaft, the pump starts vibrating, pumping costs go up and the pump wears out quicker than it would otherwise."

To measure what's happening inside the well shafts, Barfuss installed rotometers inside the model's 8-inch acrylic tubes. If the rotometer spins too quickly as water flows through it, the team will know there's too much swirl in the shaft and the design will need to be changed.

"If the water is perfectly uniform and streamlined, the rotometer won't turn," said Barfuss. "In a perfect world, the rotometer is perfectly still. In this case, the pumping station was designed well enough that we see only very small rotations – which is acceptable."

Other measurements including velocity profiles and separation zones were measured using a green laser and a specialized camera that captures enormous detail and information.

But simply pointing the camera at the acrylic tubes didn't return the clear picture Barfuss and his team were hoping for. It's a problem we're all familiar with – an object behind rounded glass or plastic looks different than the same object behind flat glass.

"It's just like viewing an object in a glass of water," said Barfuss. "The rounded tube distorts what we're trying to see in the well shaft."

To fix the problem, some of the well shafts were equipped with a section of square clear tubing. The flat surface allows the laser and camera system to capture a clear picture and give Barfuss and his research team the data they need to improve the design.

After several weeks of testing, preliminary data indicate that the design is acceptable without any significant modifications to the structure's geometry.

The project has been a seven-year-long undertaking for Barfuss. An earlier design was modified when SNWA officials recognized the possibility that Mead could drop to never-before-seen levels. Barfuss says projects like the new Lake Mead pumping station and dozens more around the world illustrate the growing need of the Utah Water Research Lab and its experts.

Engineers from all over the world come to the Water Lab for help in solving hydrologic, environmental and hydraulic water-related problems, and the professional expertise available at the UWRL keeps bringing these same people back again and again.

"In hydraulics, it's normally about hydraulic efficiency, safety and cost," said Barfuss. "With these physical models, we're able to help engineers around the world design their water structures so that they operate at an optimal level, so that they are safe and so construction costs are minimized. It's very enjoyable to be part of this engineering process."

How Plants Can Make Stormwater Cleaner

Ever wondered what happens to the surge of stormwater you see racing down your street?

In cities across the West, precipitation is collected in urban centers by gutters and drains, channeled outside city limits and, in some cases, piped into irrigation canals or natural waterways. This system has been around for decades, but it's under increasing scrutiny in light of new research that shows stormwater in urban areas carries harmful pollutants to downstream rivers and lakes.

Researchers in the College of Engineering and Utah Water Research Lab are working to change that. Margie Rycewicz-Borecki, a Ph.D. candidate in the department of Civil and Environmental Engineering, is approaching the issue with a unique perspective thanks to her background in landscape architecture. She and her adviser, Dr. Ryan Dupont, are wrapping up a long-term study on how vegetation can be used to remove heavy metals and unwanted nutrients from stormwater.

"More and more, we're realizing that stormwater pollution is a big deal," she said. "We know that vegetation improves stormwater quality. Now we're asking if the species of plant makes a difference and if so, how much?"

To test the theory, she and her colleagues built a test site where runoff from a nearby subdivision is collected in a retention system that's divided into 24 treatment bays. The bays were planted with one of three species commonly found in stormwater bio-retention systems – cattail, sedge and sunflower.

Experts know the plants can remove metals and nutrients from the soil, but they want to know if adding citric acid to the bays stimulates the plants to take up even more. Citric acid increases metal solubility and facilitates uptake by the plants.

After the treatment cells were planted, researchers went back twice a year to harvest the vegetation and analyze it at the Water Lab. Sunflower was found to be good at taking up zinc and copper; while sedges were effective at taking up phosphorus and nitrogen. Dupont says the results will demonstrate that using this enhanced method of phyto-extraction can increase metal uptake by plants, which can then be harvested and removed from the site.

"With the application of this low-tech, plant-based treatment approach," he explained, "the surge of stormwater generated from storms in our urban environments can safely be released back to the environment free of hazardous metals and polluting nutrients in a low-cost, environmentally sustainable way."

Student Darianne Willey, front, clips vegetation with Ph.D. candidate Margie Rycewicz-Borecki. The team is working to determine if plants can play a more active role in remediating heavy metal buildup in stormwater retention areas. Left: Ph.D. student Trixie Wolf analyzes soil samples at the Environmental Quality Lab.

Alumni Highlights

Nare Hayrapetyan

Computer Science
2012, Master of Computer Science
2010, B.S., Computer Science, Math minor

Current job title: Software Development Engineer II at Amazon

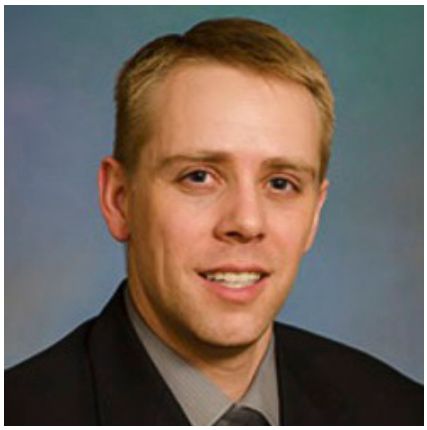
Area of expertise: Software development and cloud computing. Currently developing backend services for Amazon Web Services (AWS)

Lives in: Seattle, Wash.

Favorite part of life at USU: "I really enjoyed the campus experience and having a friendly and approachable faculty."

What Memory Stands Out? "I got an award for always being late to class :D"

Latest Accomplishment: I recently launched a new AWS service called CodePipeline



Brian Crookston

Civil & Environmental Engineering
2010, Ph.D., Water Resources Engineering
2008, M.S., Hydraulics
2008, B.S., Civil Engineering

Current job title: Project Engineer at Schnabel Engineering

Area of expertise: Advanced hydraulic modeling of rivers, hydraulic structures, and pipelines, labyrinth weir design

Lives in: West Grove, Pa.

What Student Experience Left an Impact? "I was team captain for the USU Steel Bridge team that was the ASCE/AISC Student Steel Bridge Rocky Mountain Regional Competition Champions.

Latest Accomplishment: Brian was recently named Young Engineer of the Year by the Engineers' Club of Philadelphia.

Work Hard, Run Hard: Brian founded the Schnabel Running Club where he enjoys participating in local charity running events.

‘Where I Ought to Be’ Dean Emeritus Reflects on Lifetime of Work

For Bruce Bishop, a cozy retirement is still a ways off. On his last official day of work in June, the former dean and professor of civil engineering was waist deep in activities at the Water Lab and taking on a new project to showcase the College of Engineering across South America.

And despite his active involvement across the university, the Dean Emeritus says it’s time to make a quiet exit. Dr. Bishop served as dean for 20 years

– from 1982 to 2002, during which he improved industry connections to the college, broke ground for a new four-story classroom building and pioneered new recruiting efforts to get more young women interested in engineering programs.

Bishop wasn't always sure he wanted to be an engineer. As a student, he did well in school especially in math, physics and chemistry, and he'd thought about a career in science. But his exposure to civil engineering at an early age tipped the balance. Bishop's father, a civil engineer who grew up on a farm in Delta, Utah, had been engineering water projects around the west before joining the civil and irrigation engineering faculty at what was then the Utah State Agricultural College. From the time he was about 8, it wasn't uncommon to see young Bruce on campus or in the field tagging along with dad. At the time, there weren't many engineers in Cache Valley so during summers and weekends, Bishop's father and other professors would take on some of the engineering work that needed to be done in and around Cache Valley. By the time he was 12, Bishop's dad put him to work.

"He'd go out and do some surveying for a project, so he'd pack up his surveying gear and I was his rod man," said Bishop with a chuckle. "I'd be hiking around the hillsides carrying surveying rods while he took the measurements."

The work came naturally to the budding engineer, who by his senior year of high school, had been hired by engineer and Professor Emeritus Reynold K. Watkins to work on a new study in buried pipe design and culverts. He didn't know it at the time, but Bishop was taking part in a new area of engineering research that would set standards for years to come. That next fall, Bishop started his freshman year at Utah State, and engineering was not his ultimate goal.

"I thought, 'I can't be an engineer. Dad's an engineer,'" he quipped. "But after I got started I realized engineering is where I ought to be, and it just kind of happened from there."

The coursework came easy to Bishop who sailed through much of his undergraduate experience. At the start of his junior year things were going smoothly and he could see his master's program right around the corner. However, the war in Vietnam was heating up and Bishop suspected he might have to be a part of it.

"I didn't want to risk being enlisted so I signed up for ROTC that fall and was commissioned as an officer in the Army Corps of Engineers at the time of graduation," he said.

Bishop postponed active duty long enough to complete a Ph.D. at Stanford where he studied systems analysis and economic planning in engineering – a discipline that would define much of his professional career and the next chapter of his life.

"Immediately after finishing my Ph.D., I was right off to the Army Corps of Engineers. That took the next two years of my life, and during that time you were going to spend a year in Vietnam whether you supported the war or not."

Bishop spent a year working on projects related to flood control, dams and river navigation. The following year was spent in Vietnam where he served on a joint services task force assigned to study ways for the U.S. to end its involvement in Vietnam.

"Our analysis showed there was no withdrawal scenario that could preserve a stable South Vietnam," he recalled. "Unfortunately, our military interventions in other parts of the world since then have only proved we didn't learn a thing from Vietnam."

After about a year, Bishop returned to Utah in 1971 to join the engineering faculty at USU. Since then he's also served as an executive director of the New York State Energy Research and Development Authority, as an engineering expert for the US Forest Service, Oak Ridge National Laboratory, Los Alamos Scientific Laboratory, various Utah State agencies, and on international project in Brazil, Africa, India and Thailand.

Looking back on his 44 years of service at Utah State, Bishop shared these words of advice for incoming freshmen and graduating seniors.

For Freshmen: There's going to be a lot of hard work ahead. Don't come in thinking it's going to be easy. Instead, come into it thinking it's going to be fun. Engineering – more than any other career – helps you understand the science and technology of how things work in our world, and how that impacts people's lives and society in general.

For Seniors: You've got a good degree and lots of options. Engineering can take you a lot of different directions. A broad spectrum of companies and agencies need engineers to design and implement projects and products, and to manage technology; or it can be a launching pad for other degrees in engineering, medicine or business. Or you can start your own company. Whatever ways you choose to practice engineering, our goal should always be to improving the quality of life for our fellow human beings and the sustainability of the environment.

A Legacy of *Gratitude...*

College of Engineering Names Classroom Building in Honor of Richard and Moonyeen Anderson

It was standing room only at an Aug. 25 special event where the College of Engineering honored two fellow Aggies and longtime supporters who are helping more young people graduate with a degree in engineering.

Faculty, students and university officials gathered to celebrate the ongoing support of Richard and Moonyeen Anderson of Wellsville, Utah. At the special ceremony, Mr. Anderson and USU President Stan Albrecht pulled the cords on a 30-foot-wide veil, uncovering the new name of the 12-year-old engineering classroom building.

The newly-named Richard and Moonyeen Anderson Engineering Building is home to approximately 2,680 undergraduate and graduate students who represent six academic departments. The take-home message from the event was 'gratitude.' College of Engineering Dean Christine Hailey jokingly told the crowd that she got the last word at the ceremony, saying she wanted those in attendance to walk away with a sense of thankfulness.

The Andersons' lifetime giving and most recent financial commitment total more than $5 million – a level of support that will ensure the long-term success of the Richard and Moonyeen Anderson Scholarship fund.

The Andersons have maintained a strong relationship with Utah State University throughout their nearly 40-year career at Hewlett-Packard. Val Potter, executive director of development for the college, said through their involvement with USU, the Andersons have recognized an opportunity to expand student scholarship funding and provide support for faculty research and facility improvements.

"Many years ago, the Andersons made a decision to give back to USU and established a scholarship fund for incoming freshman from high schools in Cache and Box Elder counties in Utah," said Potter. "What a great incentive for high school students to excel in their studies knowing that a scholarship in engineering is available to them. Through this scholarship fund nearly 100 students from Northern Utah have graduated from USU with degrees in engineering. Richard and Moonyeen have ensured that this scholarship fund will continue to offer assistance to engineering students for years to come. This is a legacy that will live on forever in the lives of our successful engineering graduates."

Potter said the Anderson scholars he has known over the year have expressed a deep sense of gratitude for the help they

Richard and Moonyeen Anderson pause for a photo with four of their six children (left to right) Tina Rosenthal, Deborah Justeen, Michael Anderson and Suzette Eickman. Left: Ryan Martineau, a recipient of the Anderson Scholarship, speaks about his experience getting to know the Anderson family.

received in paying for their education.

"It allows them to focus on maintaining their grades and college pursuits without the worry of excessive outside debt," he added. "The College of Engineering is a much better institution thanks to the support from generous people like Richard and Moonyeen."

Prior to the naming event, the Andersons spoke with Potter about their motivation for giving.

"There are so many young, wonderful people in the world today who just need a little help, a little boost and a little understanding of the opportunities that are out there," said Mr. Anderson. "And for those of us who have enjoyed some success, we would be derelict in our responsibilities if we didn't share and give something back."

Mrs. Anderson has also played an active role at USU. She's been a strong advocate for the scholarship fund, and in 2005 she and her husband received the university's Distinguished Service Award.

"I fully support Richard on this because when I was school, I went all four years on a scholarship," she said. "Without it, I probably wouldn't have had that opportunity."

The College of Engineering is honored to name our flagship classroom building after the Andersons. Their example, generosity and kindness are a lasting legacy for the many students who will walk these halls and aspire to the many opportunities an engineering degree can bring.

The Andersons say providing the scholarship fund has been a joy, knowing their assistance is helping Aggies complete their engineering degree.

"I promise you from personal experience that that which you give with a spirit of love and thanksgiving for what you have, you'll never miss," said Mr. Anderson. "You'll never miss it at all."

COLLEGE *of*
ENGINEERING

UtahStateUniversity

4100 Old Main Hill
Logan, Utah 84322-4100