Celebrating the Capstone

Also inside:
Engaging students in the Land O’Lakes Global Food Challenge
Partner with Students!

It was a great honor to be with so many members at the Annual International Meeting in Orlando in July and to share my thoughts on the upcoming year for ASABE and my presidency. It was especially exciting to see the number of student members and those in the early years of their professional careers attending the meeting—over 40%. Many attended to actively engage in one of the ten student competitions featured at the meeting or to present results of project work they had been involved in.

I’ve chosen Stewardship as an overarching theme of my presidency. Stewardship is central to much of what we do as agricultural and biological engineers. I suggest that it is basic to all of our professional activities: providing better nutrition, safe water to drink, a clean and sustainable environment, and a higher standard of living for the world’s population with the goal of ensuring the same for future generations. As professionals applying the science of engineering to the essentials of life, we can take credit for some incredible achievements in the past few decades.

While we have had remarkable successes, the challenges that lie ahead will require even more exceptional achievements to meet the Grand Challenges that face us as the world population grows from the current 7.5 billion to a projected 9.5 billion by 2050—all in the space we currently occupy. ASABE and its members will play a key role in meeting these challenges. The task requires foresight and dedication to the vision for the long term. ASABE leadership has been working for some time to formulate strategies to help our Society focus on this endeavor, and earlier this year, leadership adopted a five-point set of supportive Goals and Strategies (www.asabe.org/about-us/governance/strategic-priorities.aspx). To achieve these objectives, we must give priority to activities that:

- Provide value to employers supporting employee membership and involvement.
- Provide value to our members who participate in Section and Society activities.
- Meet the needs of preprofessionals and young professionals, engaging them in Society activities and technical communities.
- Enhance our digital footprint to meet expectations of the current generation of engineers and beyond, communicating our message more effectively.
- Reach out to those working in the ABE fields who have not discovered the benefits of participating in ASABE activities, helping them realize the value of membership and participation in our Society.
- Proactively engage organizations around the world that share the engineering space related to agricultural and biological systems, partnering our combined efforts and expertise to solve the Grand Challenges of our planet.
- Take a responsible role in sharing scientific information relevant to our profession with the public and with policy makers, enabling all to make better decisions for the future.

I look forward to the coming year, promoting our Society’s efforts to implement the Goals and Strategies that will strengthen our society, and making us a greater force in the future. Please feel free to share your thoughts and suggestions with me at mherron@myasabe.org.

Maynard Herron, P.E.

From the President

ASABE Conferences and International Meetings
To receive more information about ASABE conferences and meetings, call ASABE at (800) 371-2723 or e-mail mtgs@asabe.org.

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Events Calendar

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2016
- Sept 6-9: 10th International Drainage Symposium, Minneapolis, Minn., USA
- Oct. 24-27: Engineering and Technology Innovation for Global Food Security, Cape Town Stellenbosch, South Africa
- Dec. 3-9: 21st Century Watershed Technology Conference and Workshop, Quito, Ecuador

2017
- July 16-19: ASABE Annual International Meeting, Spokane, Wash., USA

2018
- July 29-Aug. 1: ASABE Annual International Meeting, Detroit, Mich., USA

ASABE Endorsed Events

2016
- Oct. 11-14: Improving Irrigation Water Management, Fort Collins, Colo., USA

2017
- Feb. 21-24: 45th International Symposium Actual Tasks on Agricultural Engineering, Grand Hotel Adriatic, Opatija, Croatia
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Welcome to the first-ever Capstone issue of Resource! I should have known that a suggestion for a Capstone issue would be instantly welcomed by ASABE’s terrific publication. In addition, as we spread the word about the plans for this special issue, we expected an outpouring of support from our contributing institutions, and that’s what we got. It’s been uplifting and exciting to read about the dedicated, hard-working students, faculty, alumni, and industry leaders who are creating meaningful real-world experiences.

As you read through this issue, you’ll be amazed at the diversity of Capstone projects and the breadth of how the projects were selected, staffed, and conducted. Even the geographic focus was global. Here at the University of Illinois, we are fond of saying that our students work on the land, in the air, and in space. We are not alone!

In talking to my colleagues and through my work as an ABET Program Evaluator, it’s been my experience that Capstone is a serious component of an engineering program’s accreditation efforts. It’s the perfect demonstration that the graduates have had major design experience within reasonable constraints, including consideration of standards, economics, ethics, professionalism, and a global context.

The quality of the tools that are available to students is so high that it is shaking some traditional beliefs about what a design project should entail. I graduated back in the 20th century. Today, students can routinely generate everything on paper or on line, run a finite element analysis, and even skip the usual prototype phase. Thankfully, although that kind of abstract engineering is possible, I believe that my colleagues, on balance, don’t want their students to miss out on the experience of building, testing, breaking, redesigning, and seeing their work deployed. In fact, projects that start out as purely paper studies are practically passé. What counts is work that can be handed over to the sponsoring entity for further development. That’s what happens in the real world!

An old expression says that business is easy until people are involved. How true this could be for Capstone teams as well. Students from a variety of backgrounds, geographic areas, native languages, and other circumstances must come together for sixteen or more grueling weeks, while juggling other coursework, family, and outside work responsibilities. For many, it’s the first time they’ve been involved in a team-based, open-ended, and possibly industry-linked project. And, for the most part, they handle it very well. My predecessor told me of the time when he had to defuse a fistfight between team members in the tractor lab. We didn’t ask for any such anecdotes from our contributors, nor were any offered, but I know that Capstone is a high-stress undertaking.

None of the projects featured in this issue were easy or routine. Nothing important ever is. You will get a sense that the students believe in engineering as their calling, and their Capstone projects were a learning experience that they will remember and use for a lifetime. Many engineering lessons, and life lessons, were exchanged among the students. The faculty advisors donated time that they could have used for other responsibilities, and each sponsor dedicated a high-value working engineer, often two, to guide the students and evaluate the projects. Many of the participating students received, and accepted, job offers from their clients.

The Resource staff and I started out believing that the ASABE family would be interested in what is happening with Capstone in member institutions. I think you will agree that the family is “playing nice” and that we can all be proud of the dedicated people involved. There are a lot of moving parts and motivations in Capstone, and the stories in this issue prove that the concept is in good hands. The engineer’s drive toward continuous improvement will see to that.
The BSE Comprehensive Design Project is a two-semester, real-world team experience for seniors. In 2015-2016, we had 49 students in 14 teams developing designs across two focus areas: biomolecular engineering and watershed science and engineering—as well as food, bio-processing, and health-related engineering. Ten design projects were developed with industry clients, three were related to faculty-derived ideas, and one was fully developed by the student team. The locations of the designs were local (on campus and in town), regional (the cities of Roanoke and Salem), eastern Virginia (Saluda), and international (Malawi). For the first time, we had two teams working on the same design problem and, given that we have 70 seniors in the 2016-2017 class, we will be moving toward having more teams developing alternative designs for the same client. Designs were developed for nonprofit groups (the Lick Run Farm and Community Development Center, Lick Run Watershed Association, and Impact+Amplify), for-profit groups or companies (Afri-Nut Ltd., Cardinal Mechatronics, Cell Free Bioinnovations, and Novozymes), government agencies (City of Roanoke, Virginia Department of Corrections, and Virginia Tech Dining Services), and a local apartment complex.

Some of the best experiences were with very energetic nonprofits, particularly Lick Run Farm and Community Development Center and Impact+Amplify in Roanoke. These groups are led by high-energy individuals working to revitalize low-income neighborhoods and promote sustainable, healthy communities. As one student commented, “Working on a real project for a real client with a real need enhanced our sense of purpose as a team. The reward was far greater than the typical satisfaction felt from a completed test or assignment.” Similarly, another student stated that working with a nonprofit was “both challenging and rewarding” and felt their project “was contributing toward a higher cause.”

“one of the major constraints I placed on the compost facility design was minimizing the use of fossil fuels for aerating the feedstock. I was interested in deliberate technological simplification and creative design to amplify human muscle power in making compost. I had my own ideas, which I shared, but the students came up with their own creative solutions that were quite different from my thinking. They let themselves be guided by my constraints without being constrained by my guidance. Very impressive.”

—Rick Williams
Founder, Lick Run Farm and Community Development Center

Team members Joseph Kleiner and Sara Gokturk survey a pond inlet channel. The final design resulted in a two-stage channel lined with native vegetation for reducing sediment and nutrient inputs to the pond, which had severe algae bloom problems. Photo by Kyle Jacobs.
HELP villages in a developing country share water resources among people, livestock, and crops? “You bet!” was the response of Rebecca Mattson, Noah Slocum, Nathan Senger, and Sara Bossenbroek, seniors in the BBE 4502W Senior Capstone course. “Culminating four BBE years with a humanitarian water supply project is the best outcome imaginable,” said Bossenbroek. Senger was excited to work with the client, Somali Green Initiatives and Technology, Ltd. (SOMGIT), because “they’re interested in lasting solutions for the community, not just completing design objectives.” Mattson agreed: “It has been a unique, fulfilling opportunity that directly improves the quality of life for an entire community.”

The Somali villages of Danica Baloow are being assisted by SOMGIT from its offices in Mogadishu and near Dallas, Texas. SOMGIT has created an R&D site to test practices for supplying potable and agricultural water. Drip irrigation methods have been tested, and specific crops have been recommended. Using components provided by SOMGIT, the BBE team designed the entire water system for Danica Baloow. The project became a design-build process in which components were built in Africa as fast as the team could design them.

The main objective was to provide a water distribution system that is sustainable, innovative, and economical. While the BBE team pursued this, a Senior Capstone team in civil engineering designed a water tower. The team also designed a unique watering trough that discourages animals from stepping into it and uses different access sizes for cattle versus goats and sheep. The faculty advisor, Bruce Wilson, met weekly with the BBE team. “Even under limiting conditions,” he said, “The students were able to complete their designs using basic engineering principles.”

Further objectives were to reduce waterborne disease among humans and reduce the spread of disease among animals that share the watering facilities. World Health Organization guidelines were applied as a standard quality measure, and water test results showed no need for water treatment for agricultural use. Disinfection methods are not likely to be sustainable due to lack of funding for operation and maintenance and lack of access to a reliable source of chlorine.

The team’s professional mentor, Walter Eshenaur, said, “The students’ attention to detail and probing questions gave them the background to design a unique, high-quality, appropriate solution for Danica Baloow.” Eshenaur indicated that SOMGIT approached cautiously at first. However, countless e-mails and numerous Skype calls helped everyone stay on track. “Because the students were highly motivated and maintained good communication, important decisions were made quickly and easily.”

SOMGIT soon realized that working with students and their mentors offered unique benefits. The students were very curious about Somalia and asked important questions that helped SOMGIT expand its understanding of appropriate technologies and practices. Thinking “outside the box” helped SOMGIT provide an efficient and profitable water system. With the cash crops produced by irrigation, the construction cost of the entire system will be recouped within two years.

The BBE Senior Capstone course involves a team of faculty, with the goal that each student team has a faculty advisor and an industry advisor. We’re especially grateful to have an active industry advisory council—including alumni, employers of our graduates, and other interested companies and agencies—that proposes projects and provides advisors and mentors. Enrollment in the Senior Capstone course produced five teams in 2014, ten teams in 2015, and nine teams in 2016, with an emphasis in environmental, ecological, bioproducts, and food engineering. Previous projects have included work with a local distillery on malting processes, a drying system to increase production of a healthy nut flour in Guatemala, design of water management features at a new state park, compost and fuel options for cabbage waste from egg roll manufacturing, and development of a dryer for small parts at a window manufacturer.
At the University of Manitoba, all engineering students complete a common preliminary year and then spend the remaining three years of their degree program in a specific department. As of May 2016, undergraduate enrollment in the biosystems engineering department was approximately 125, and student numbers are expected to increase in September 2016. Our biosystems engineering department is growing, and we’re committed to providing an exceptional student experience.

The department has a long history of innovative teaching in engineering design. About 15 years ago, we introduced three design courses to the core of the program to provide a dedicated design experience each year. In the original conception, students were to experience three industry design projects with increasing expectations in each year, essentially providing an opportunity for mastery learning of the engineering design process. Technical communication was integrated into these courses to teach students the importance of communication skills when interacting with industry clients.

In 2010, the last two design courses were re-configured into a two-semester, year-long Capstone course to enable teams of four or five students to prepare a conceptual design and then fabricate a prototype as a means of validating the conceptual design. Students are provided with basic training in fabrication processes, including welding, woodworking, copper pipe soldering, and sheet metal, so that they can fabricate their prototypes under the supervision and guidance of the shop technicians and instructor. In the fall term, each student works from a set of drawings to make the parts and assemble a small project that includes all of the skills mentioned above. Students are typically amazed by how much their designs change from the conceptual design prepared at the end of the fall semester to the prototype that’s constructed by the end of the winter semester.

A recent project came to us from McCain Foods’ French fry production facility in Portage la Prairie, Manitoba. McCain asked for assistance with a dumping station for potatoes and fries that fall off the line. The design involved ergonomic considerations, mechanical systems, and had to be easy to clean. McCain is now implementing the students’ design. An additional project was an inspection station that required our students to evaluate ergonomic aspects and design an improved station that reduced worker fatigue. Beginning in the 2016-2017 academic year, a fourth core design course is being introduced into the curriculum. In Design 1, students are introduced to fundamentals of safety engineering and human factors engineering so they learn to consider these principles from the beginning in every design problem. In Design 2, we introduce reverse engineering as a tool to deduce design features from previously designed products or systems. Considerations such as design for sustainability and design for disassembly are introduced. In Design 3, students prepare a preliminary design for an industry client based on a real industry problem. Finally, in Design 4, students have the opportunity to validate their conceptual solution through prototype fabrication and testing.

Our core design courses play a prominent role in developing several graduate attributes mandated by the Canadian Engineering Accreditation Board, including design experience, teamwork, and communication skills.

“The entire McCain management team was very impressed with the final outcomes. Both projects are being implemented in our Portage facility, as they address all of our issues. I highly recommend this program to all businesses looking to solve any process issues. The value for the industry partner and for the students involved is enormous.”

— Eric Durand, P.Eng.
Engineering Manager, McCain Foods
Biosystems Engineering Design I and II, commonly referred to as Senior Design, is a two-semester Capstone series that provides real-world experience with discipline-specific design projects for seniors in biosystems engineering. In recent years, 10 to 30 students have been enrolled in Senior Design. The students are assigned to teams of three or four based on their area of interest. Teams are assigned a faculty mentor and, in many cases, a client who has requested engineering support to solve a real-world problem.

The projects typically fall into one of four disciplines within BAE: bioenvironmental, food and bioprocessing, machine systems, and pre-biomedical. The teams are required to formulate a problem statement, determine the motivating economics, produce a preliminary design, report on their design, consult with advisors and the client, produce a final design, and then fabricate and test the end product. Throughout the year, the teams are also given formal lectures on ethics, economics, statistics, drafting, and written and oral communication to make sure they have all of the tools needed to successfully complete their project and effectively present the results.

A notable project during the 2012-2013 academic year was proposed by Robert Klingensfus, owner and operator of Harvest Home Dairy in Oldham County, Kentucky. Mr. Klingensfus had recently converted his 110-cow freestall barn to a compost bedded pack (CBP) barn. CBP barns replace the individual stalls found in freestall barns with a large open bedding area, where manure is composted in place rather than being removed daily. Controlling moisture is crucial for proper operation. Excessively high moisture impedes aerobic decomposition, which causes CBP barns to fill up faster and produce greenhouse gases (e.g., NH$_3$ and CH$_4$) at a higher rate. Regular aeration and incorporation of a carbon source (typically wood shavings) are key management practices to ensure thorough composting and a dry bedding environment for the cows.

Mr. Klingensfus was particularly concerned about the need to aerate the CBP. Unlike windrow composting, the CBP must be mixed in situ, which limits the types of tractors and implements that can be used inside the facility. In Kentucky, many producers use older model tractors of 44 to 60 kW with rototillers or cultivators to aerate CPBs. Rototillers, while providing an excellent surface finish, do not aerate and mix the material below 20 cm. Cultivators tend to leave large clumps of material on the surface, which limits the drying rate. Both tools result in a partially composted system in which only a portion of the CBP is actually aerobically decomposing. Other available tools, such as rotary spaders, require more power than is typically available. This concern led Mr. Klingensfus to inquire about developing a custom tillage tool that would provide a good surface finish while digging deeper, to increase the depth at which aerobic decomposition could occur.

It was a great opportunity for undergraduates in need of their first comprehensive design project. John Evans, Jeff Clark, and Stephanie Hunt were given the task. The team ultimately settled on a hybrid tillage system that included a traditional rototiller coupled with an adjustable-depth deep-shank tillage tool. Designing the custom tillage tool required applying the engineering principles they had learned in tillage, traction, mechanics, and hydraulics to a real-world problem for which many of the parameters and constraints were unknown or difficult to predict. The team worked alongside staff engineers and machinists at the Agricultural Machinery Research Laboratory (aka “The Shop”) to fabricate the system, and they ultimately tested it at Mr. Klingensfus’ farm.

The results were greater than anyone expected. Not only did the custom tillage tool function, it worked so well that we had to pry it away from Mr. Klingensfus just to make modifications the following year! The same tool has been in use at the farm for over three years now. Mr. Klingensfus reports that the tool has improved herd health and reduced the amount of bedding material needed to operate, providing an annual cost savings of $10,000 to $35,000.

Editor’s note: John Evans went on to complete an MS under Dr. Michael Sama, where he continued to develop the system by adding forced aeration and a novel data acquisition system for wireless monitoring of the spatial distribution of oxygen within the CBP to measure the system’s effectiveness. Evans is currently pursuing a PhD in biological engineering at the University of Nebraska-Lincoln. He credits his experience with Senior Design for giving him the inspiration to pursue his graduate degrees, with the goal of providing engineered solutions for the problems that producers face.
The transition from academia to the workplace can be difficult for graduating students to negotiate, but ABE 469, the Capstone design course in the Department of Agricultural and Biological Engineering at the University of Illinois, equips students with the knowledge and skills they need to become proficient and competent engineers. The overall goal is to allow students to experience modern engineering practices with industry-linked, team-oriented, open-ended design projects.

The course was established in 1985. When I began teaching the course in 2004, as a former engineer, business manager, and entrepreneur, I broadened the format developed by my predecessors. They created an excellent foundation that focused on industrial product development. Now the course has expanded, and we focus on the process as much as the product. Time management, project planning, working as a team, talking with clients, following protocol, submitting reports—those aspects of the job are as important as the end product.

We impress on students the need to prepare a package that they can hand off to the client. In the real world, engineers often hand off a project to another group or organization. The likelihood of taking a project from start to finish is pretty small. When they hand off their projects, the students must ask their clients, “Can you work with what we’ve given you?” And the clients almost always say, “Yes, we can take this into our organization.” About half of our projects find their way to implementation.

Although many projects are still industry-oriented, the project sponsors have become more diverse. We’ve tried to provide a broader project portfolio to encompass student interests in our various concentrations. Those concentrations include renewable energy systems, off-road equipment engineering, soil and water resources engineering, bioenvironmental engineering, ecological engineering, food and bioprocess engineering, and nano-scale biological engineering. Many of the “engineering toolbox” skills learned along the way and through guest lectures by industry experts are incorporated into the projects.

This past year, eleven teams with a total of 43 students were sponsored by ten clients. Each team must recruit a faculty member in their project’s area of concentration to act as an advisor. It’s an opportunity for the students to leverage the expertise that we have in our department, and the faculty members are always helpful.

One team, called Naturally Fun, worked with the University of Illinois Primary School (UPS) to design and construct a drainage solution for the runoff problem on the school’s playground. “We implemented a three-fold solution,” said team member Anav Pant. “First, we installed two subsurface drainage tiles to increase infiltration and divert water away from the play area. Second, we seeded the entire play area with a robust species of clover, to further increase infiltration and reduce soil erosion. Third, on sloped areas, we installed erosion control blankets, composed of jute and straw held together by nylon netting, to reduce the loss of seeds due to runoff before the seeds were able to germinate. Because the jute and straw biodegrade and the nylon photodegrades, the play area will be left completely covered with clover.”

Seth Partridge, another member of Naturally Fun, said, “This was a real-life engineering project, and we had the freedom to change things as we saw fit. That meant we had to decide what was important to present to the client, the professor, and the class. At times, it was difficult to decide what information was most important. But we worked together as a team to determine what each audience would want to know about the project.”

“The most valuable tool I gained from this project was personal development,” said Natalie Walk, a third team member. “I became more confident in presenting to the class and to the client because I was able to communicate our team’s ideas in an effective way. And I loved working with UPS!”

Dr. Ali Lewis, director of UPS, was equally enthusiastic about the project and the members of Naturally Fun. “This team worked so well together,” said Lewis. “They had a clear way of designating responsibilities according to their specialty areas. Their timeline was really aggressive. After doing their research on the slope of the area, the type of soil, and the most effect kind of ground cover, they put together a work day for our parents. One team member, who had a unique ability to lead without dominating, was the point person. As a team, they organized the priorities for the work day, and we all felt that our time and our efforts were honored and worthwhile. I’m still in awe of all this team was able to accomplish.”
The ability to design, build, and test technology is critical to the development of undergraduate engineering students. Our Capstone senior design class is driven by student innovation, and the teams are encouraged to seek advice from professionals other than the instructors and collaborators who are directly involved with the project. This allows students the flexibility needed to create innovative solutions to complex engineering challenges.

The Capstone senior design class is the second part of a two-semester design sequence taken by all ABE students. Students have the opportunity to work on a wide variety of projects under the guidance of a faculty member or professional engineer as project mentor. The students demonstrate learning through a series of design-build-test homework exercises, in-class writing activities, written reports, and two oral presentations in front of professional engineers and business executives. In addition to their design work, the teams attend guest lectures given by a diverse group of experts from UF and outside the university.

The two projects summarized below addressed food security and safety issues in rural agriculture, with a focus on developing nations. These projects represent recent efforts to incorporate biotechnology (e.g., sustainable hydroponics) and nanotechnology (e.g., biosensors) into urban agriculture.

Hydroponics in urban East Africa

There is a widespread, urgent need for reliable, cost-efficient technologies to maintain a safe supply of basic resources in East African countries. Due to the poor soil quality in dense urban areas, many cities are exploring the use of hydroponics to improve net food production, and the practice has moved from research labs to community-based efforts. Hydroponic systems typically have higher yields and reduced costs for transportation, tilling, cultivating, and fumigation. However, while hydroponics is a useful practice, it imposes new risks of disease transmission through waterborne pathogens. For this reason, a disposable biosensor for monitoring pathogen indicator organisms is a critical design challenge.

A food security project—designing Robert Gresham—called for conceptualizing autonomous hydroponic systems for use in dense urban Africa (Nairobi, Kenya, or Addis Ababa, Ethiopia). The students also designed and tested biosensors for measuring dangerous bacteria in irrigation water.

The goal of the senior design projects for 2014 and 2015 was to build and demonstrate a sustainable hydroponic unit for urban production of food crops, complete with biosensors for monitoring pathogens. The student teams designed, tested, and demonstrated a number of working hydroponic systems, including ebb-and-flow, aeroponic sprayers, and solar-actuated irrigation. The teams constructed pathogen sensors for measuring *Escherichia coli* in hydroponics systems using either electrochemical techniques or gold nanoparticle (optical) transduction.

Water treatment in Colombia

According to the UN, over 10% of the global population does not have access to clean drinking water. In addition, the chemicals used to disinfect drinking water also produce harmful byproducts, which is a serious problem in developing countries. Non-chemical treatment methods, such as filtration membranes and solar disinfection, are being implemented, but inactivation or removal of pathogens over long periods remains a challenge. Disinfection of water using natural biological products that can be produced locally is a critical tool to augment physical and chemical treatment methods.

In the last decade, a number of organizations have designed water treatment projects to address the needs of communities in developing countries. Non-chemical treatment methods, such as grinding and salt precipitation. The senior design teams in 2016 were tasked with designing a field-ready kit for extracting seed lectins and demonstrating proof-of-concept for a lectin-based water filtration device combined with activated carbon.

The feedback that these projects have received from faculty, students, and funding agencies has been overwhelmingly positive, particularly for the global aspects of the projects. In addition, these projects have produced a number of academic achievements for the students, including two student-authored peer-reviewed papers that were published in 2016.
The Capstone design project in the Biological Systems Engineering program at the University of California, Davis, is conducted as a full academic-year course sequence in which students address an important engineering topic of concern. In the fall quarter, the course is primarily classroom and laboratory instruction where design principles, ethics, safety, teamwork, and communication are emphasized. In the laboratory sessions, all students fabricate a simple assembly of metal, plastic, and wood elements to gain experience in manufacturing, machine shop operations, communication and safety, reading drawings, and creating bills of materials and cost estimates.

The students also meet with project sponsors, typically including campus faculty, industry cooperators, and representatives from nonprofit organizations. These potential sponsors present their engineering problems and design needs. The students then form teams, select projects, and submit design proposals. During the winter and spring quarters, the students work with two or more faculty advisors and complete their design projects, including fabrication and testing. The experience concludes with a College of Engineering Design Showcase in which all projects are presented to industry judges and the public.

The 2016 cohort of 26 students engaged in seven team projects. The projects represented the spectrum of instruction and research in the department and ranged from mechanical designs of separation systems for removal of noxious weed seeds from certified crop seeds, to the development of processes for encapsulating nutraceuticals into algae to preserve their effectiveness, to the design of a production system for insect larvae as a poultry feed source.

A recent Capstone project was the design and deployment of a mobile irrigation system for farmers in Uganda. Through a collaboration with the UC Davis D-Lab, a design-focused program including students from all majors on campus, the Humphrey Fellows Program, and the Richard Blum Center for Developing Economies, a client in Uganda presented the need for a mobile irrigation system that could be locally produced and deployed by Ugandan farmers. A team of three students undertook the challenge of designing a motorcycle-based irrigation system in which the motorcycle both transported the system and powered the pump.

The project presented not only mechanical design challenges but also management and communication challenges, including time, language, and technology barriers and the uncertainties of translating and adapting a design developed in California to the local capabilities, resources, and customs of Uganda. Throughout the stateside design, fabrication, and testing processes, it was critical to anticipate the unanticipated challenges that would be present in Uganda. The project concluded with members of the team traveling to Uganda, along with tools, components, and fabrication instructions necessary to implement the design among local machine shops and farmers.

The team members reported that the experience challenged their technical design and fabrication skills and highlighted the importance of the human element in engineering, particularly in the communication of design goals and constraints and in the ability to adapt as the situation changes. Team member Noelle Patterson, who worked on-site in Uganda, provided an example of this need for adaptability and how opportunities can arise from perceived problems: “There was a week when the power was out almost every day, which meant we couldn’t use the equipment in the shop. On those days, the only thing I could do was visit the local internet café and use power from their backup generator to edit the design manual on my computer. It ended up being very helpful to have the design manual completed while we were still in country, and that wouldn’t have happened if the power had not gone out!”

Even without power, for these students clearly the light still shines. For UC Davis students, the scope of engineering opportunities, from specialty crop production in California to more basic needs in developing countries, provides challenges for the high-quality students in the Biological Systems Engineering program.
The primary goal of the Capstone design class in the University of Arizona’s Biosystems Engineering program is to provide a student-driven interdisciplinary design experience for our students. Benefits for the students include expansion of skills, opportunities to work with professionals in industry, and ultimately obtain a job. A benefit for the Department of Agricultural and Biosystems Engineering is contact with industry supporters and outside funding for projects. Recruiting meaningful projects for the students is a year-long effort with our industry partners. This effort steps up in the summer as the fall semester looms. Most students register for their fall classes in March or April. Once the class roster is available, the instructor starts polling the students on their interests and backgrounds. This information is used to prioritize the search for projects and establish the number of projects that will be needed. Faculty members are solicited to mentor the projects, and the industry sponsors are asked to cover the material costs. The ABE department has some funds of its own ($1,000 per project), so we also accept one or two projects per year from faculty or industry without funding.

The first few class meetings in the fall are used to continue the project selection process. Questionnaires are distributed to the students to gather details on their skills and interests. A second handout provides short descriptions of the available projects. Normally, the instructor can readily assign students to the various project teams. In rare cases, there may be groups of students who do not connect with any of the available projects. When that happens, the instructor meets with them to identify common interests, and the search begins for additional projects.

The primary instructional goal of the fall semester is to teach the design process to the students. The lectures start with preliminary tasks, such as process diagrams, data collection, and identification of standards applicable to the design, ethics, safety, and environmental consequences of the projects. The lectures include a presentation on LEED because students are encouraged to evaluate their projects based on life-cycle costs. The students’ ultimate goal for the semester is to have a final design completed and accepted by their mentors.

Once the preliminary skills needed for design are mastered, the students meet with their mentors to obtain further project information so that they can move ahead with alternative formulations. These alternative designs are based on client-provided constraints, but the students are encouraged to formulate outside-the-box solutions. The alternatives are then compared in a decision matrix using standard criteria that include capital cost, operation and maintenance costs, skill level required to operate the design, and environmental impacts. The students present their decision matrices to the class and their mentors in a round-table format. The preferred alternative is typically a combination of features from multiple designs. Once a preferred alternative has been identified, the students prepare a final design. Designs should include computer-generated drawings (ACAD or Solid Works), material lists, a refined budget, and a detailed implementation schedule. We teach Microsoft Project. This software is an expensive add-on to the MS Office package, but we feel that it is an important skill for the students, as they will encounter this tool in industry.

The design phase is the key to success in the construction phase. If the students don’t have a detailed design, then they will have trouble staying on schedule.

All of our students are expected to fabricate their designs. Our instrument maker teaches the students how to use the shop fabrication equipment. Many teams start with models printed using department 3-D printers. Most teams have a team leader, whose job is to update the MS Project schedule, assist with procurement of materials, serve as primary contact with the mentor, and manage the team. So far, we have mastered the technical side of teaching project management; in the future, we will spend more time on the personnel side of the equation. The construction schedule is dictated by the Design Day competition, which is sponsored by our College of Engineering. The college brings in judges from industry to review over 100 Capstone projects and award cash prizes to the teams. Team management becomes critical as the semester winds down and Design Day approaches.

A container-based growth chamber was developed at the request of a UA donor who challenged students to provide a percentage of daily nutrition needs for a family of four living in an apartment.

Mushroom Growth Chamber
An inquiry came from an individual in Atlanta looking for a student team to design and build a container-based mushroom growth chamber for a food desert. Twelve students were interested in this project, so we divided the project into three teams: irrigation, plant infrastructure, and growth chamber. A student project manager was chosen by the students to handle communication between the teams and the mentor, acquire the needed supplies, update the MS Project schedule, and manage the team members. Each team also had its own team leader. The project was a great success and culminated with the sponsor coming to Tucson for Design Day. The success of this project has inspired the sponsor to fund other projects in the future.
The Global Design Team (GDT) class spans the academic year to provide real-world engineering challenges from the private and public sectors. Teams of three to five students work with their sponsors to develop practical solutions to the challenges posed. Projects are high-impact, full-cycle design experiences that help raise global awareness at home and abroad. GDT is part of the BAEN Capstone course. Teams travel to the project site, whether in Texas or abroad. The stakeholders, students, partner organizations, interested corporations, academic partners, and community members in the host locations share the costs. Working together, using the technical skills and competencies of the students, employees, and volunteers involved in the project, the goal is to address a specific challenge within the community for mutual benefit.

Projects are selected based on their relevance to community-identified needs and their ability to offer the students an opportunity for creative, effective, sustainable problem solving. Quality control and accountability are ensured through ongoing assessment of personal and community needs, and progress toward the end goal is carefully monitored. Logistical and engineering support is provided by the partner organizations (NGOs, government organizations, industry and business, and academic institutions), and financial assistance comes from the partner organization, the university, and the students themselves.

GDT offers hands-on experiential learning that develops skills useful in future careers, family life, and the community. The students and their community partners give and receive time, energy, knowledge, and creativity while accomplishing the requirements of the senior Capstone project. The 2016 GDT projects included:

- A mobile unit for remote sample collection for the San Antonio River Authority.
- A low-cost, locally sourced, off-grid system for improved water quality and heavy metal removal for Progressive Vellore in India.
- A streamlined process to maximize profits for post-harvest processing of cardamom in Guatemala.
- Sustainable, effective, and budget-friendly stormwater mitigation for a Texas Target Community.
- An effective, cost-efficient water storage and distribution system in Nicaragua.
- A design, operation, and maintenance plan for a small wastewater treatment facility in Ecuador.
- A rainwater harvesting system with inexpensive technologies for wastewater treatment and improved water quality in Mexico for the World Wildlife Fund.
- A mobile app reader for an RFID chip to assist with cotton ginning processing management.
- A plan for crop layouts and irrigation installation for local community-supported agriculture.
- An environmentally friendly, natural food-growing method that combines the best attributes of aquaculture and hydroponics.

For the last project listed above, our aquaponics team worked with Organized Organics, a San Diego-based NGO. The project goal was to grow nutritious, often organic, food plants for home consumption with a low-power indoor aquaponics system that is aesthetically pleasing, automated, and produces a small carbon footprint. The impact of this project could be widespread, as freshwater scarcity and depletion of soil nutrients are increasingly addressed through aquaponics. The method used could help reduce the need to produce food on water-stressed land by relying instead on the symbiotic relationship between vegetables and fish in a self-contained ecosystem.

The student team, Cody Mertink, Cody Nedbalek, Andrew Polasek, and Grant Weaver, built a family-sized vertical farming unit using retrofitted furniture, a custom growbed with an innovative irrigation system, sensors, and solenoid valves. The growbed at the top of the unit is irrigated with water from a fish tank below, and any runoff re-enters the tank to feed the fish. The team found that LEDs produced the most suitable lighting, which keeps electricity consumption low.

The team also provided a detailed analysis of the power consumption and water requirements for the prototype. The overall monthly cost of operation is approximately $6.92 per month in San Diego, $7.66 in New York, and only $4.69 here in College Station, Texas. This environmentally friendly, natural food-growing system combines the best attributes of aquaculture and hydroponics without wasting water or adding chemical fertilizers.
DSU’s 2015-2016 ABE senior design course had 15 students out of the 70 enrolled in ABE. This year’s group was remarkably successful and took home three of the six awards at the annual Engineering Expo for the College of Engineering for their final design projects. One ABE team took first in the Non-Consumer Products category for their design of an air filter aspiration system for AGCO machines. Another team took first place in the Consumer Products category for their design of a position control systems for axle width on a Rogator for AGCO. Third place in Consumer Products was awarded for the design of a second-tier bale accumulator for Farm King.

Other senior design projects from the 2015-2016 academic year included an AGCO project for designing the mapping and analysis protocol to test the field performance of sprayer systems in a static mode and a USDA-NRCS project to redesign a sheep production facility and runoff management system. The final senior design project also involved working with the NRCS to redesign a beef feeding facility with a runoff management system.

The senior Capstone design experience is the culmination of an ABE student’s educational experience at SDSU. Industry partners provide the design problems based on the needs and desires of their companies. These design problems are thus based on real-world problems that industry partners want solved. Senior ABE students work on these problems in teams of three to five students for two semesters. Industry partners have a direct stake in their sponsored project. Each sponsor meets with the student design team multiple times per semester to ensure that the team is considering relevant issues such as safety, standards, and other constraints.

Students begin to assimilate design skills in their second year in the Engineering Properties of Biological Materials course and lab. Design skills are added and refined in subsequent courses, such as the second-year Project Development for ABE and the four core courses generally taken during the third and fourth years of study. Lower-level courses tend to focus on building skills and gaining experience with design problems while becoming fluent in the design process. Upper-level courses then focus on designing components, structures, or systems to solve specific problems. Examples include power takeoff (PTO) shafts, grassed waterways, and hydraulic drop structures.

The Capstone design experience integrates all the students’ knowledge and experience into a two-semester project. ABE students begin during the fall semester and complete their design projects by the end of the spring semester. We have been fortunate to have excellent participation from machine industry partners in the recent past. Companies such as AGCO, Raven, and Bobcat consistently bring excellent Capstone design projects to the table for our students. Company representatives stay in communication with the design team and provide guidance to students while challenging them.

"The students did a great job with their projects and were able to work with industry groups to solve a problem. The last few weeks of the spring semester are the best because all the teams are getting their prototypes ready. My favorite experience: I accompanied the Amundson, Bakker, and Logeais team to the SDSU Dairy Farm to test the third-row stacking round bale trailer. When the lift arm system they designed easily raised the bale, they cheered with excitement and high-fived. I smiled and thought to myself how well this experience encapsulated all their coursework.”

—Joseph Darrington
Assistant Professor

South Dakota State University Agricultural and Biosystems Engineering

Prize-Winning Designs
Jasmine Greene

Shawn Mack exhibits his test sprayer module.

Sam Amundson, Andrew Bakker, and Tom Logeais designed an arm lift system for stacking bales.
The Capstone projects at Purdue University are designed to mimic the objectives and responsibilities of an entry-level engineering job within a “safe” academic environment. Typically, Capstone projects run from the fall through the spring semesters, and 30 to 35 projects occur each school year. Project sponsorship varies from industrial clients needing to explore potential commercial solutions, to academic researchers requiring the design and construction of specialized apparatus, to NGOs seeking assistance for specific issues in the developing world. The communication and interaction between sponsor and students is critical to a successful project, and communication skills are emphasized throughout the course. For Capstone team member Jakob Keldsen, “having the opportunity to interact with and take advice from industry representatives” was the key aspect of the experience.

ABE professors Bernie Engel, Martin Okos, and Bob Stwalley emphasize how vital communication is to the successful completion of technical projects. Stwalley says, “We continually tell students that they can have the best idea in the world, but if they can’t communicate anything about it, it will have no impact.” Business developer and Capstone judge Larry Loehr agrees: “In an industrial company, presentations are a part of life! We advance ideas, gain support for resources, report on status, communicate to stakeholders, and leverage our learning into other projects through presentations. During my Purdue years, I would have really welcomed a Capstone experience and an introduction to the presentation and group effort processes."

Teamwork is also a valuable part of the program. Although self-proposed individual efforts are allowed in the Purdue ABE Capstone sequence, team experiences are the normal route. Course instructors place most students on project teams to provide diverse skill sets and backgrounds, maximizing each team’s collective effort. Mike Cox, a USDA conservation engineer and Capstone judge, states that “working together as a group for a common goal and utilizing the individual talents of each team member to achieve the goals of the project is how professionals function.” Students also come to understand this fundamental aspect of the professional world. Graduating senior Danielle McNeely says, “I learned how to bond with team members, spend long hours on a difficult process, and work for a community sponsor.”

Purdue ABE Capstone projects are designed to be meaningful. Students need to see the utility of what they do, along with how it will affect their organization. A reasonably steady panel of external and internal reviewers provides consistent feedback, and the opportunity for the students to make corrections during the program is provided by multiple reviews over the length of the program. The reporting structure concludes with a poster session defense of the year’s work. Many students have told us that the impact of the program was significant for them in determining the initial direction of their professional careers.

―Scott Snider

Senior Justin Lewton explains his seed press wheel project.

“The capstone experience was a great opportunity to have a chance to see what it would be like working with a company on a design project. It was by far the best part of my senior year at Purdue University.”

―Scott Snider
When Penn State’s ABE department introduced its new senior Capstone design experience in fall of 2015, I had no idea it would make such an impact so soon. The new Capstone program is a team-based engineering design experience in which most projects are sponsored by external organizations, such as companies or local communities. However, in spring 2015, Dennis Murphy, Nationwide Insurance Professor of Agricultural Safety and Health, and Davis Hill, Senior Extension Associate for Agricultural Safety and Health, sponsored a project to create a portable grain bin facility to train workers and emergency response personnel on the dangers of grain bin entrapment and how to rescue entrapped workers.

The challenge to create a suitable entrapment simulator was met by five senior biological engineering undergraduate students: Ean Julius (team leader), Daniel Lutz, Rachel Sacchetti, Samantha Goldberg, and Jordan Fair. They enrolled in a series of two design courses that make up the Capstone experience taught by Megan Marshall and me. In the first course, we teach the students how to manage a design project, including how to become a high-performance team, establish design specifications, develop and select preliminary design options, and consider safety and ethical issues in their design. In the second course, the students do the detailed design, testing, and an economic analysis.

I am amazed by the project diversity, which engages over 40 students per semester. Projects range from ag machinery to food and bioprocessing to natural resources engineering, so that the Capstone experience can be customized based on student specialization. For example, many of the natural resources projects were sponsored by local communities seeking creative solutions to stormwater management challenges. Students analyzed stormwater flow rates, generated AutoCAD design drawings, and tested their designs using simulation software.

In contrast, projects like the grain bin entrapment simulator required students to construct the final design and test the device. I mentored the grain bin safety design team, and they were unique from the beginning. First, team leader Ean Julius, who worked to get the project off the ground in the summer of 2015, proposed including the project in the Capstone course. He connected with Davis Hill, who became the technical sponsor for the project, and Len Lobaugh, owner of TAM Systems, who was a financial sponsor. The grain bin safety design team also engaged Brock, GSI Group, and Sudenga Industries. In total, the sponsors donated approximately $15,000 in funds and materials used to construct the simulator. After more than a semester of work, the team constructed a working mobile grain bin that allowed eight people to watch a rescue demonstration.

According to Julius, “This project taught me valuable lessons about working in a team and building off each other’s strengths to develop an extremely useful final project. There were also practical lessons as well about the building process and communicating with industry sponsors—very useful for transitioning from college to industry.”

Goldberg echoed those thoughts: “I think the most valuable lesson was working in a team in which everyone had different skill sets. The most challenging aspect was fully understanding the task at hand. Being from Long Island, New York, grain bin safety was not a familiar issue for me.” She agreed that the most rewarding aspect is making an impact: “It is amazing to think it took us two semesters to build something, and Penn State is already using it to potentially save lives.”

“On average, about 30 grain entrapments occur each year across the U.S., many resulting in death. The simulator is a hands-on tool that illustrates what it’s like to become entrapped and not be able to escape without assistance. Our hope is that staying out of the bin—or at least wearing a harness attached to a lifeline and having a second person watching—will become standard practice. It will help improve farm safety and emergency response training.”

—Davis Hill
Senior Extension Associate
The BAE Capstone design course sequence allows students to demonstrate their ability to develop solutions for real-world, open-ended projects for clients in private industry and government agencies. Project suggestions come from departmental faculty, alumni, the external advisory committee, and business. Occasionally, projects focus on a design problem for a philanthropic or charitable organization. Students are often very eager to perform “public service” engineering design. Collin Craige, a 2013 BAE graduate says, “My team and I were able to use classroom skills to design, develop, and manufacture an ultrafiltration technology to increase drinking water availability in developing regions of the world.

Senior design prepared me well to enter the professional engineering community.”

The OSU Applications Engineers are a major source of project suggestions. The Applications Engineering Program is a partnership between Oklahoma State University, the Oklahoma Alliance for Manufacturing Excellence, and the Oklahoma Center for the Advancement of Science and Technology (OCAST), which brings engineering assistance to rural Oklahoma’s small manufacturers. These small companies often lack the technical expertise required to solve their problems, or the problem might not be their most pressing priority. The Applications Engineering Program has been a pipeline for companies willing to sponsor a senior design project. The OSU Food and Agricultural Products Center (FAPC) and the OSU New Product Development Center (NPDC) are also sources for and partners in BAE senior design projects.

The BAE senior design class has had a significant economic development impact. Over $345,000 in cost savings have been realized by clients, as well as 49 jobs created and at least 30 jobs retained. The Oklahoma Alliance for Manufacturing Excellence conducts assessments of the Applications Engineering Program and the benefits to the program’s clients. Their data summarize the economic impact of senior design projects instigated through the FAPC and Applications Engineering Program.

In spring 2014, we took on a different design challenge. An interdisciplinary group of OSU faculty submitted a proposal to the NASA eXploration Habitat (X-Hab) Academic Innovation Challenge program. The proposal was for an interdisciplinary senior design project to design, build, and evaluate a deployable greenhouse for food production on long-duration missions to the Moon or Mars. The proposal was funded with more than $25,000 for the 2014-2015 academic year.

The project included a short-term goal of an interdisciplinary senior design project to design, build, and evaluate a horizontally oriented habitat and a long-term goal to develop capabilities in education, research, and outreach in the field of space habitat design. This included both technical engineering and outreach efforts and will continue our ongoing work to build a complete habitat mockup for use in research and education. This project was the focal point of our efforts in the 2014-2015 academic year and is part of OSU’s continuing development of a formal interdisciplinary program in space engineering and architecture. This development includes diverse specialties from the various schools involved, with the ultimate goal of developing technology and designs to facilitate human habitation in space.

A scale model of the X-Hab.

Interior of the X-Hab.

Grow lights in the greenhouse.
How "real" can a Capstone project be? The MSU Biosystems Engineering (BE) Capstone design program is a sequence of two courses (three credits each): BE 485 Biosystems Design Techniques is taught in the fall, and BE 487 Biosystems Design Project is taught in the spring. The projects are open-ended, relevant, real-world challenges with real constraints, providing students unique, team-based problem-solving experiences. Each team has three to four members, a project sponsor who serves as a client, faculty advisors, and an industrial guidance and evaluation panel. Projects are solicited from industry in mid-summer for a fall start, vetted, and selected by BE faculty using the following criteria:

- Requires a substantial amount of design.
- Integrates science with engineering.
- Relates to macro- and/or microbiology.
- Requires a systems approach.
- Requires understanding of design impacts on society and the environment.
- Involves data analysis and the use of statistics.
- Considers the efficiency of the solution as measured by economic analysis.
- Requests funding from industry (direct and/or in-kind) to support project expenses and associated costs to improve and maintain the Capstone design experience.
- Matches the program emphases and concentrations (food, ecosystems, bioenergy, and/or biomedical).
- Requires a sponsor to serve as a client with realistic demands, expectations, and constraints.
- Requires a BE faculty advisor with the appropriate expertise to support the project.

BE 485 instructors assign teams within the first two weeks of the fall semester. From the project list, students individually submit their top three choices with their rationale and the qualifications they would bring to the projects through a formal cover letter and résumé. The students also submit a self-rated competency evaluation of 11 core skills and can voluntarily select one peer they desire to work with and one peer they prefer not to work with. Instructors form design teams based on student interest, prior experience, skills needed for the projects, diversity and balance of skill sets, and potential confidentiality or conflict-of-interest issues.

Thereafter, necessary background materials are provided on the problem, as well as non-disclosure agreements, design alternatives, and instruction in project management, technical writing, and elements of effective presentations. The semester culminates with a preliminary design report that is approved to move forward to the spring for final design, possible prototyping, possible modeling/testing, optimizing, and full-scale economic analysis.

Teams present their designs to the full BE faculty, who evaluate the project outcomes (for a portion of the course grade) and provide suggestions for finalizing the design. Through several iterative project reviews by instructors, faculty advisors, the faculty jury, and the client, feedback on the technical content is incorporated into a 90% project completion report that is submitted to an industry evaluator panel (two to four practicing professionals, with at least one P.E. preferred for each panel). BE 487 culminates with a public BE Design Showcase in April, where the evaluator panels, who received the project completion report two weeks in advance, spend one hour with their assigned teams discussing the designs and providing feedback and a grade. The teams must also present publically and in a poster session to other diverse audiences for critique before submitting a final report to their clients.

BE 485 and 487 emphasize significant contact with industry representatives. Industry representatives and non-instructors contribute approximately 10% of the grade for each course. Teams and industry interact through project introductions, required client meetings, industry advisory board interactions (including formal meetings, required communications, and final report critique), on-site visits (for evaluation, measurement, prototyping, and testing), public presentations, and the poster session.

Is a Capstone project "real"? Team member Jackie Thelen put it this way: "I put over 500 hours into this project alone. It’s the closest I’ve ever felt to a real project outside my actual industry co-op experience, and I think it will be one of the most valuable experiences in my professional career for a long time to come.”

How “real”? Chris Taylor’s senior design project turned into a career opportunity, as he was hired by the client, JBT Corporation, upon graduation in 2015. The same can be said for 2016 graduates David Olson and Nicholas Niedermaier, who were hired from the JBT Capstone team, too.

“JBT Corporation is a leading equipment solutions provider to food processors globally. JBT and MSU BE have primarily interfaced with engineers at our Tech Center in Sandusky, Ohio, which houses full-scale industrial ovens, freezers, fryers, portioning, and coating equipment for continuous processing. JBT provides spiral, impingement, fluidized bed, and contact chilling and freezing of meat, seafood, poultry, ready-to-eat meals, fruits, vegetables, and bakery products; cooking, frying, and coating processing solutions for poultry, meat, seafood, vegetable, and bakery products; and intelligent slicing, trimming, and portioning of red meat, pork, fish, and poultry.

Several of the JBT-sponsored design projects have included increasing the cooling rate or mixing performance of batter mixers, exploring hygiene improvements related to belt washer and dryer technologies for spiral freezers, and exploring sustainable alternatives to the disposable polyethylene film used on film and plate contact freezers. By mentoring and financially supporting Senior Design students and their projects, JBT gets direct contact with talented BE graduates for possible recruitment. Participation on the BE Industry Advisory Board allows JBT to provide relevant feedback based on industry needs within food processing.”

—Andrew Knowles
JBT Sales Support Manager
Kansas State University Biological and Agricultural Engineering
Senior Design Wraps It Up
Edwin Brakesh, P.E.

Kansas State’s BSE Senior Design class is a three-credit Capstone class offered annually during the fall semester. It’s a required course that students must complete for their BS in biological systems engineering. Students who enroll in the course are in the last two semesters of their college career. Because of the single-semester format, a successful project will propose, at minimum, a design ready for construction. In an industrial setting, the project would be at the point where management could approve it for prototyping. To actually build their projects, students are encouraged to take an elective companion class, BSE Design Project, during the spring semester after Senior Design. In this second-semester class, students further develop their projects, build prototypes, and conduct testing. Project teams consist of three to five students, with a preferred team size of four.

The ideal design project will have a client who has a problem in need of a solution and will also have a high likelihood of being implemented should the proposed design be approved by the client. These two criteria increase the difficulty of the class and the quality of effort by the students. These two criteria also reinforce each other: the clients have tough problems that they’re really concerned about; when the students see this concern, they’re inspired to help by finding a workable solution.

A great example of an ideal project was completed during the 2015-2016 school year and competed for the AGCO National Design Competition this past summer. The team wanted to develop a device that would remove the net wrap from large round hay bales. Net wrap is the material used to hold most large round bales together. The current removal process involves manually cutting and removing the net wrap, a time-consuming task that exposes farmers to a number of hazards. The team proposed a mechanical device that would allow a farmer to remove the net wrap from bales without leaving the safety of the tractor seat. Before project approval, the students were asked to find a customer for the project. Through Kerri Ebert of the Kansas AgrAbility program, the team found a farmer with a handicap who would benefit from such a device.

With the project idea and the customer in place, the team began work in August 2015. As part of the project, the team conducted an extensive literature search, including popular press articles, technical papers, and design and safety standards related to large round bales. Additionally, because the team felt they had an original concept, they explored relevant patents. Finally, because the project’s customer is disabled, the team spent a considerable amount of time interviewing and watching their customer work with round bales to understand the individual’s needs and limitations.

“The BSE Senior Design Capstone project has been beneficial to the Kansas AgrAbility Project, helping to solve accessibility problems for Kansas AgrAbility farmers. First, the student teams bring a fresh perspective to solving problems on the farm. That fresh perspective, without preconceived notions of what won’t work, has proven helpful for farmers, and in turn, the project introduces the students to real people, with real limitations. In that respect, the Capstone project humanizes the engineering process. An unexpected benefit has been the joy that farmers experience in working with college students. The farmers take their roles as mentors seriously, and they spend a lot of time walking the students through the details of their disability and farming practices while offering helpful guidance throughout the process. Connecting students with farmers has been excellent public relations for the Department of Biological and Agricultural Engineering, Kansas State University, and Kansas AgrAbility.”

—Kerri Ebert, Kansas AgrAbility Project coordinator

Once the constraints and criteria necessary for the project were understood, the team developed the design by creating CAD models in PTC’s Creo software. They built a number of different test stands to explore different wrap removal strategies. Based on the tests, the CAD models were refined. At the end of the first semester, the team proposed a design to the Kansas AgrAbility director and the client for approval to build a prototype. The project was approved for prototype development during the spring semester.

The team built several iterations of a working prototype. They located a local farmer who ground net-wrapped hay bales almost daily. Working with this farmer, they were able to repetitively test many different aspects of their design in a controlled environment. The prototype was built, tested, rebuilt, and retested multiple times over the spring semester. Consistent incremental improvements were made, and the design was completed over the summer, with the net wrap removal device delivered to the client in time for the fall feeding season.
L ast April, a group of over 110 students presented their Capstone projects in the Department of Agricultural and Biosystems Engineering at Iowa State University. The Capstone program serves students in engineering and technology and is a required component of all ABE undergraduates. Capstone programs in engineering and technology are divided into two phases: a first-semester focus on defining the scope of the problem, and an emphasis on solution development and evaluation in the second semester. At the end of the first semester, the teams present their accomplishments at a poster session, where they receive feedback from ABE faculty and industry clients. They return to the second component of their projects with new ideas and a sharper focus on potential solutions.

One of us, Norman Muzzy, a lecturer in ABE, leads the engineering Capstone program. “Capstone is a team project that is more self-directed,” he said, “Making a plan and working the plan are very important. The lack of definition is sometimes frustrating. My goal is that students learn how to struggle with these issues in Capstone. It will prepare them for their professional careers.”

The Farming Conservation Project team, composed of agricultural engineering seniors Jace Klein, Dillan Glock, Quentin Schneider, and Alex Martin, evaluated remote sensing maps to determine land characteristics and the most beneficial conservation practices. Their scope changed between semesters after they realized that they were too ambitious in their initial project plans. “First semester, we looked at different conservation practices and applied a site selection process,” said Klein. “Based on field characteristics from over 100 fields, including topography and soil type, we examined what conservation practice might best suit them. In the second semester, we worked with a farmer, visiting his field and designing a conservation plan.”

The hands-on aspect of the project and interaction with a real client proved valuable. When asked about their favorite part of the Capstone experience, the team members talked about the gratification of seeing their project come together in the end. “We spent the first month trying to see if anyone in our area would be willing to let us work on their field,” said Martin, who also serves as 2015-2016 treasurer for ASABE’s International Preprofessional Community. Glock agreed, “Going to see the site and how our conservation practice would be implemented was really great.”

Another of us, Gretchen Mosher, an assistant professor in ABE, leads the technology Capstone program. “Our primary learning goal is for the students to apply the content they learned in class and on internships to a practical, unstructured problem in engineering or technology,” she said.

A team of technology students, including Ethan Brehm, Rob Hermsen, Brandon Ludwig, and Charlie Rettey, developed a 3D scanning process for tillage sweeps. The team used innovative technologies and specialized computer programming to scan 3D images of tillage sweeps to quantify and visualize the superiority of their client’s product. One student saw a real application based on his personal experiences: “I come from a farming background,” said Ludwig. “It can be a pain to change the sweeps every year, sometimes twice a year, so I see the benefit of learning more about it and being able to prove that the proposed solution would require fewer change-outs.”

The most enjoyable, yet most frustrating, component of the project was learning different aspects of the scanning technology. “To learn the software takes time, and you have to be willing to put in that time,” said Retty. The students also learned that clear communication with their client clarified expectations and ensured that everyone was on the same page. Strong communication also facilitated the team’s connection to project resources. Hermsen stated that knowing the location of resources and who to talk to were keys to keeping the project moving.

Even though the two projects differed in approach, tools, and end products, both teams emphasized the importance of time management and clear communication as critical for success in the Capstone program. “There is so much going on senior year. Your team must find time to meet together, and then you have to find time to talk with the client. It can be a struggle,” said Klein. The technology team added that it was important to ask questions. “You can’t be afraid to ask your client questions. And be persistent when looking for answers,” said Ludwig.
Auburn University’s Biosystems Engineering program is home to 156 undergraduate and 25 graduate students. Undergraduate students are enrolled in three curricula: biosystems (104 students), ecological (43 students), and forest engineering (9 students). Class size of the senior design Capstone sequence has grown steadily from 15 students in 2011 to 40 registered for 2017. Capstone design teams are formed during the fall semester during a two-credit Professional Development class. This article highlights two Capstone design projects from spring 2016 that represent biological engineering and traditional agricultural engineering designs: 3D printing for new biofilter media (http://aeobioworks.weakly.com) and an automated poultry feed bin gate (http://hlh0017.wix.com/poultry-bin-gate).

Holly Haber, a member of the feed bin gate team, wrote at the end of her class experience, “I am proud of the final product we produced through this senior design project. We were able to meet all of our design objectives as well as build a functioning prototype. The senior design project experience gave me an insight into what working as an engineer will be like.” A similar sense of accomplishment was echoed by 3D printing design team member Ann Nunnelley in her e-portfolio reflection: “Involvement in this design process not only exposed me to additive manufacturing, but also gave me valuable experience working with an interdisciplinary engineering team. I am grateful to have been part of this design team and am proud of the final result!”

Senior design team members Holly Haber, Trey Colley, and Brock Daughtry with a working prototype of the automatic poultry feed bin gate opener.

Although not all project clients act as financial sponsors, all student design teams provide a professional engineering design service to their client. During class, the students submit weekly work logs, monthly oral and written updates, design journals, and confidential team peer evaluations. In addition to a final report and presentation, students provide a proposal report and presentation, pre-final drawing submittals, a poster presentation, and participate in the College of Engineering E-day recruiting event.

Trey Colley, a member of the feed bin gate team, emphasized problem-solving as a key skill needed in his future engineering career: “The senior design project has provided an element of our educational experience I have not experienced before. Previously, my skills at problem solving and my ability to cram slide notes helped me in the lower-level classes; however, this is the first time the whole process has been put together.”

Holly Haber reflected on the importance of the soft skills she learned: “During this design process, in addition to my technical knowledge, I have developed my soft skills. Not only has my design team been collaborating with our peers and faculty in the department, we also worked with our industry client. Learning to write memos and provide constant updates on the progress of our project to all of these groups is something new that we have not had to do in previous classes. The importance of being able to communicate the design process, both orally and written, is a crucial skill that will benefit any engineer.”

For us, as faculty instructors and project mentors, one of the most rewarding aspects of the Capstone class is the positive energy and outlook of the graduating engineers. Recent graduate Brock Daughtry reflects this sense of accomplishment and excitement as he looks ahead to a fulfilling engineering career: “This class required almost weekly informal presentations on the development of our project and also required formal presentations to our clients, professors, and other professionals. Being a part of the development of this project has greatly prepared me for my professional career. I’m a much better team member now than when we started this project, and I know this skill will help me tremendously in my career”

Holly Haber summed up some of the benefits of the Capstone experience: “Engineering Design for Biosystems takes the technical concepts used in our engineering discipline and forces application to real-life problems. Not only have I learned a large amount about biosystems engineering principles and regulations through this Capstone course, I have also expanded my knowledge in other engineering disciplines. The senior design process has built on concepts learned in previous courses and taken them one step further by applying them to meet specific objectives. For example, during the design process, my team used prior knowledge and expanded on it to compute the force needed to open and close feed bin gates in order to specify a linear actuator to meet this force requirement.”

No more could be hoped for than to have our graduating engineers gain a level of confidence in their future profession, as implied by Holly Haber at the beginning of this article, “The senior design project experience gave me an insight into what working as an engineer will be like.”
A SABE members have long recognized that the intersection of our dependence on energy, the stress on our water supply, our need to grow more food, and the resulting impact on our environment is the “grand challenge” of our time. Agriculture is at the heart of this intersection, relying on access to energy and a supply of fresh water to safely grow, process, and distribute our food. An increase in food production is required due to population growth, which includes an increase in meat consumption as more countries develop economically.

Previous issues of Resource have focused on the grand challenge of feeding our world while conserving resources and protecting the environment. Universities, corporations, cooperatives, government agencies, and foundations are active in this area, but few are specifically engaging the next generation. Getting youth globally involved is essential to feeding our world in this generation and the next.

Generally speaking, young people are not as interested in agriculture as their predecessors. Fewer than 2% of workers in the U.S. are classified as farmers, and most people are not familiar with our food production systems. In the U.S. and similar economies, the trend toward urban living and a decreased agricultural workforce have led to highly mechanized agriculture, as robotics, unmanned aerial vehicles (UAVs), smart irrigation systems, and automated processing plants do more with less labor input.

The same has not been true in developing countries, where up to 80% of the workforce, including many women and children, is directly involved in small-scale agriculture. Farm incomes in developing countries are often at subsistence levels with no margin for droughts or pest problems, and labor shortages and lack of connectivity to markets lead to yield losses (due to underused land, few crop inputs, late planting, and limited plant care), post-harvest losses (due to late harvesting, poor storage, and lack of transportation), and reduced income. However, while the yields are currently a fraction of those in developed countries, developing countries also have significant potential for increasing their food production and feeding their growing populations.
This article describes a partnership between five universities and Land O’Lakes, Inc., to engage undergraduate students in agriculture, domestically and internationally. Students from multiple majors, including agricultural and biological engineering, have participated in the program.

You’re probably familiar with Land O’Lakes—a member-owned agricultural cooperative known for dairy foods, animal nutrition, and crop inputs. Since 1981, the company has also been active in international development (http://www.landolakes.org/) by partnering with organizations such as the USDA, the U.S. Agency for International Development (USAID), and the Bill & Melinda Gates Foundation to support farming around the world. Many of these projects involve connecting smallholder farmers to technologies and markets through local cooperatives, capacity building, and programs focused on achieving self-sufficiency. Land O’Lakes has also sponsored many farmer-to-farmer training programs throughout the world.

The Global Food Challenge

In the fall of 2014, Land O’Lakes initiated the Global Food Challenge (http://foodchallenge.landolakesinc.com), partnering with faculty, staff, and students from Iowa State University, George Washington University, Northwestern University, Purdue University, and the University of Minnesota. Initial participation was limited to sophomore students from colleges of agriculture, business/management, and engineering at these universities. During the first year (2014-2015), ten faculty and staff members and ten students participated in the program. Agricultural and biological engineering was represented by several students and faculty members. For the second year (2016-2017), eligibility was expanded to include all sophomore students from the partner universities, regardless of their college or major.

The goal of the program is to identify exceptional college sophomores and enable them to become emerging leaders for food security. Students apply to the program by first submitting a one-minute video. If selected, they move to the next round and are interviewed by Land O’Lakes program leaders. Each selected student is matched with a professor or academic mentor, as well as a Land O’Lakes mentor. During the academic year, teams of students work on challenges in agriculture and food security. The emerging leaders also receive an eleven-week paid summer internship at Land O’Lakes headquarters in Minnesota, which includes visits to domestic agricultural sites (farms, cooperatives, processing plants, marketing firms, etc.), to Washington, D.C. (to learn
about agriculture policy), and a two-week trip to rural African communities (to learn firsthand about international development and global food security).

**Highlights of the 2014-2015 Program**

In the program’s first year, the selected students worked on a wide variety of projects, including the impact of food storage innovations on food security, vertical farming, communicating the global food challenge message, global education on GMOs, on-farm processing, reducing food waste, and improving logistics and transportation. The students had frequent Skype meetings and presented their projects to their peers and faculty mentors. Each project culminated in a final report and action plan that was presented to Land O’Lakes program leaders.

A highlight of the program for both the students and their mentors was the two-week trip to Malawi, Zambia, Botswana, and South Africa. Our international travel was full of new experiences. We had opportunities to see best practices for improving food security at the farm scale, cooperative scale, and factory scale. We also had opportunities to discuss international development efforts with in-country teams from Land O’Lakes International Development as well as USAID.

We started our trip in Malawi with cultural and Chichewa language lessons. After acclimating ourselves, we visited agricultural operations throughout the country. These operations included a maize farm, a permaculture farm, a GMO cotton field trial, a cassava test plot, a smallholder goat association, a smallholder dairy cow recipient, a dairy cooperative, a village savings and loan, a small-scale slaughterhouse, a water users association (that had built a dam and irrigation system for the local community), a large dairy farm, a commodity exchange, a large tobacco trading house, a tobacco processing factory, a dairy processing factory, and a farm-scale cassava processing operation. All of these visits were informative and inspirational. A common denominator of these operations was the strong desire of their owners to improve their lives, to improve their families’ lives, and to reinvest in their operations to increase their business. In other words, everyone was working to increase their food security and their financial security.

In Botswana, we spent time with a dairy cooperative, a seed grower, a field school for farmers, a goat farmer, and an agricultural research institute. We also spent a day at Victoria Falls as tourists. We wrapped up our trip in Zambia with safaris in the Chobe National Park, where we were immersed in African wildlife, including lions! We then spent a day in Johannesburg, South Africa, where we visited Nelson Mandela’s first and last homes, the Apartheid Museum, and learned about the history of South Africa.

Overall, our experiences in Africa were life-changing. Learning about food insecurity here in the U.S. is one thing; seeing its many dimensions and talking to the people who live with it every day is another. At the same time, all of us were inspired by the great strides that are being made in all the places that we visited.

**Projects and Plans for 2016-2017**

One of the assignments of this year’s program was for students to organize food challenge awareness events on their home campuses. The events on each campus were creative and informative. At Purdue, the students organized a Global Food Insecurity Seminar and Organization Fair that included a short introduction by Gary Burniske, managing director of Purdue’s Center for Global Food Security, followed by presentations from the ASABE student chapter, the National...

At Iowa State, several student clubs organized a canned food drive and participated in a canned food sculpture contest. Prizes were given for the club that collected the most canned food items—as well as the most creative sculpture. More than 1,600 canned food items were collected and donated to a local food pantry. The event also gave representatives from Land O’Lakes and the Salvation Army an opportunity to talk to students about hunger and food issues. In addition, Iowa State’s two emerging leaders from the 2014-2015 program talked with their fellow students about their experiences with the Global Food Challenge.

As in the first year of the program, the selected students, their faculty mentors, and Land O’Lakes representatives traveled to Africa in late June of 2016. We visited various farms, villages, and food cooperatives in Rwanda and Kenya and learned firsthand about international development efforts and best practices for improving global food security. (Editor’s note: as this article goes to press, the authors are on their way home from Africa.)

Opportunities for Students and Others

The Land O’Lakes Global Food Challenge is a great opportunity to engage students in the grand challenge of global food security. We need students from all backgrounds to find solutions for feeding a growing population, using less energy, water, and labor, and using environmentally sustainable methods. Obviously, students in agricultural and biological engineering can bring unique strengths to this program. In addition, ASABE, ABE curricula, and much current ABE research are already focused on sustainably feeding the world. Here’s how you can get involved:

• If you are a student at one of the Global Food Challenge partner schools, apply to become an emerging leader! The application dates and instructions are available at http://foodchallenge.landolakesinc.com. This program is an incredible opportunity to immerse yourself in the global challenge, including a paid summer internship and international travel. It will be an unforgettable educational experience.

• If you are faculty member at one of the Global Food Challenge partner schools, let your students know about the program, and consider applying to be a faculty mentor. It’s a profoundly rewarding teaching experience.

• If your school is not a partner, contact the Land O’Lakes Global Food Challenge and let them know you are interested in being a partner school. We need to engage our students in the broader challenges of agriculture. Challenges create opportunities.

• If you have a corporate background, find ways to engage youth in agriculture. Work with your university partners and professional societies to inspire our next generation of problem solvers.

ASABE member John Lumkes Jr., P.E., Associate Professor, Agricultural and Biological Engineering; Associate Director, Global Engineering Programs; Purdue University, West Lafayette, Ind., USA, lumkes@purdue.edu.

ASABE member Kurt Rosentrater, Associate Professor, Agricultural and Biosystems Engineering, Iowa State University; Executive Director of the Distillers Grains Technology Council, Ames, Iowa, USA, karosent@iastate.edu.
Students’ biofilter media design vies for EPA prize

In Brief: A multidisciplinary team of undergraduate students from Auburn University’s department of biosystems engineering and department of industrial and systems engineering showcased their senior work—a biofilter media design aimed to improve water treatment systems—during the USA Science and Engineering Festival in Washington, D.C., in April.

A national science, technology, engineering, and mathematics event, the USA Science and Engineering Festival gave the seven-member undergraduate team a large venue for sharing their research and interacting with thousands of attendees, including officials from the U.S. Environmental Protection Agency. The work and travel of Auburn’s student team was funded by a Phase 1 award from the EPA’s People, Prosperity, and the Planet program, also known as P3. During the P3 event, the team competed against 50 universities for a Phase 2 award, which provides for the development and commercialization of the project.

ASABE member David Blersch, assistant professor in Auburn’s department of biosystems engineering, and Andres Carrano, Philpott-WestPoint Stevens associate professor in the department of industrial and systems engineering, collaborated on the Phase 1 proposal, which developed the concept, and mentored the cross-curricular student team. Following the Phase 1 award announcement in October 2015, Blersch and Carrano recruited students from their respective departments and streamlined the deliverables so that the project could also serve as the students’ senior Capstone project.

“A combined senior design team from two engineering departments is a unique model for Auburn, and it made for an excellent learning experience for the students, as demonstrated by their exemplary performance at the P3 expo,” Blersch said. “The cross-seeding of ideas from this collaboration enriched their educational experience as they developed expertise in another academic field through interactions with their peers.”

At the P3 expo, the team’s booth featured a display of 3D printed spherical objects and a large glass cylinder filled with bubbling green gooey water, which was a hit with the curious youngsters who came by. “Although they couldn’t compete with the penguins from SeaWorld or the rockets from NASA, their booth was one of the most popular university exhibits,” Carrano said. “I was amazed at the innovation from this undergraduate team. Their work has clearly expanded the technical and functional limits of biofiltration.”

Stephanie Gray, industrial and systems engineering team leader, explained the project to a group of small children this way: “We use super cool shapes to filter water. We place the
shapes into a bioreactor that contains a bunch of dirty water. Bacteria in the water attach to the super cool surfaces of the shapes and start to live and grow there. The super cool shapes are like fancy houses. As the bacteria live there, they get hungry and eat the pollution in the water.”

Having learned about 3D printing in her industrial and systems engineering courses, Gray was excited to share her knowledge with the team and happy that her cohorts in biosystems engineering did the same, introducing her to nitrification, bioreactors, and fisheries. “I didn’t know anything about 3D printing until this project, but we taught them about biology,” said ASABE member Eric Vogt, biosystems engineering senior, who designed and fabricated the bioreactor. “Our team had a lot of fun throughout the semester and at the expo. We educated many people about our project.”

In addition to Vogt and Gray, team members included ASABE member Ann Nunnelley and Olivia Elliot from biosystems engineering and Zane Trott Jr., Michael McClay, and Bakr Nassief from industrial and systems engineering. The outcome of the project was a biofiltration system that uses more efficient media capable of treating 50% more water than the current product on the market. “I would not be surprised if some of the students’ ideas are commercialized in the near future,” Carrano said.

Blersch, sponsor of the 3D printed biofilter media project commented, “The capstone project was a tremendously valuable experience for the students. The project was to design new media shapes for increasing the performance of mixed bed bioreactors for wastewater treatment using 3D printing. The project moved easily to the P3 student design competition in technologies and strategies for sustainability. The multidisciplinary team provided adequate depth of expertise in the broad areas of the topic, namely, bioreactor design and 3D printed manufacturing.

“The Capstone design experience was valuable to the students, as the process of designing the media as well as the equipment and procedures to test it was a simulation of real-world experiences that these students will face in their careers. The deadline for presentation of their work was rigid, as they were required to have full development and preliminary testing complete for presentation at the national competition in the middle of the semester.

“The interdisciplinarity of the team was a critical component to the student learning, as it again simulated real-world consulting experience in which a group with broad expertise is formed to address a problem. Student learning was heightened by this interdisciplinarity, as students from each department developed expertise in another field to be able to accomplish the work. Most of the learning was done through peer-to-peer instruction, encouraged and supported by regular meetings of the entire team, and through collaborative planning of the objectives and tasks. Overall, the students successfully developed a design and presented their design at a national competition that was highly competitive with the potential for patentable technology.”

For more information, contact Gail Riese, Communications and Marketing Specialist, Auburn University, Samuel Ginn College of Engineering, gail@auburn.edu.
Building and racing edible vehicles

In Brief: Claiming that the dog ate your homework isn’t too far-fetched. The Incredible, Edible Vehicle Competition fosters teamwork among students at the University of Nebraska-Lincoln, and the wheels are turning as the annual event rolls into a new academic year.

A different sort of fast food takes to the track when UNL hosts the Incredible, Edible Vehicle Competition every year. ASABE member Mark Riley, head of UNL’s department of biological systems engineering, requires the students in his introductory biological systems and agricultural engineering class to demonstrate edible vehicle designs—really. The cars must be functional, they must be made entirely of food, and the students must be able eat their cars at the end of the competition.

Every fall, student teams, as well as alumni returning to show their support, race their cars down a sloped track to see which one travels farthest and stays in one piece. The top three teams receive a certificate. Each team must also submit a poster that details the process of making their car.

The event was started many years ago by ASABE member Dennis Schulte, a now-retired UNL professor, as part of Engineering Day, and is coordinated by Evan Curtis, student services coordinator in UNL’s department of biological systems engineering. Curtis said the competition inspires unique designs using a variety of products. Vegetables, sausage, cheese, and candy are just a few of the materials students use. With the new addition of a calorie limit, last year’s vehicles were healthier than ever before.

Creativity rules, with team names like “Meals on Wheels” and entry names like “Tasty Taxi.” The teams, each with three or four students, work for several weeks on brainstorming, designing, shopping, prototyping, testing, and tweaking. Rigid, round cookies and rice cakes usually serve as wheels, although a few teams have used slices of summer sausage. Axles are typically pretzel rods or candy canes. Chassis choices range from hard bread to carrots, with an effort to balance function and taste.

The competition fuels the teams’ design and problem-solving skills, as well as their appetites. At the previous event, one team blew away the competition in calories used—less than 200 for a vehicle that consisted of two dill pickles, four rice cake wheels, two pretzel rod axles, and gummy candies to hold everything together. Its two runs totaled more than 190 inches, which was more than double the runner-up from Team Salami Tsunami.

However, although their car didn’t go farthest or get the most miles per calorie, Team Salami Tsunami walked away with the top prize. What won the day was their consistently high placement in each of the evaluation categories despite having a high calorie count of 1,127, based on a design that used a salami log, fudge-striped cookies, pretzel rods, gummy candies, and black licorice. After their two runs down the track, team members Jared Bowker, Isaac Frerichs, Thomas Huff, and Will Neels devoured their creation.

“We honestly didn’t expect to end up in first place,” said Neels of his team’s car, which was looked more like a tractor. “I figured that the distance would have been more of a prioritized category. I guess we had the right combination of things, both in our presentation and our car. We wanted to get a nice design that would roll straight. That was number one—making it functional. But we also were thinking that we had to have something that we could chow down fast, and salami’s the first thing we thought of.”

Riley said the demands for consistency across the evaluation categories—distance and durability (scored on two runs), components (must be edible and no more than 1,500 calories), and cost (less than $10)—are meant to replicate the demands placed on engineers in real-world projects. The calorie limit was instituted this year to make for a healthier competition.

Team Salami Tsunami will likely take a break for a year. “I think we’re all kind of burned out on salami,” Neels said.

For more information, contact Communications Specialist Karl Vogel, kvogel2@unl.edu.
The ASABE Foundation has been in existence since 1987 and has done great work in raising funds to ensure the success of selected projects, such as the switch to electronic publications, support of Standards work, our 100th anniversary celebration, and of course our vibrant awards program. However, the Foundation Board of Trustees (FBOT) has lacked a clearly defined process for receiving direction from the ASABE Board of Trustees (BOT) concerning the fundraising priorities of the Society. Now that the Foundation has made a concerted effort to reorganize its fundraising activities with the addition of a director of advancement, the FBOT and the BOT want to make sure that the focus for fundraising to support ASABE programs and initiatives remains well aligned with current Society needs and objectives.

Over the last year, the BOT has made great strides to address this need. At their April 2016 meeting, they approved the bylaws for the newly created E-06 Foundation Liaison Committee. The overarching purpose of E-06 is to oversee, develop, and review activity related to interactions of the Society with the Foundation. More specifically, the committee will:

• Generate ideas for Society initiatives and activities through outreach to ASABE communities and communicate these to the BOT.
• Communicate fundraising needs to the Foundation to support Society initiatives and activities.
• Provide feedback to the Foundation on fundraising opportunities.
• Stimulate member engagement in fundraising activities, in conjunction with the Foundation.
• Appoint ad-hoc committees, as needed, to manage funds provided to the Society through Foundation fundraising activities or to conduct other liaison activities.

The E-06 committee, which consists of representatives from the FBOT, BOT, both the young professional and pre-professional communities, and ASABE staff, is being initially chaired by ASABE Past President Lalit Verma and met for the first time at the Annual International Meeting in Orlando.

Among other items, two immediate needs that had been raised at the April BOT meeting were discussed at the AIM in Orlando: increasing prize money for specific student competitions to bring them in line with others, and waiving AIM registration for on-site competitions. As a result of this collaboration through E-06, the FBOT now has these two needs as a specific fundraising focus. These are good examples of the sort of BOT-identified initiatives that E-06 can identify in the future.

With the establishment of the Foundation KEYS Fund (K-12 education, Encouraging humanitarian outreach, Youth career development, and Student branch support) a few years ago, it was a natural that the KEYS Fund Management Committee (E-06/1) be created and reside under E-06. The BOT approved bylaws for this new committee in April as well. Although fundraising activity will remain within the Foundation, the objectives of the E-06/1 committee are to annually solicit and select the best submissions to receive any discretionary monies from the KEYS Fund and to give feedback to the ASABE Foundation regarding fundraising opportunities and needs within the KEYS objectives. The two needs described above seem to be a perfect fit for a KEYS fundraising effort.

With these formal committees in place, we welcome your input on activities and initiatives you feel should be considered for possible funding or as a fundraising focus of the Foundation. Submissions can be presented by any unit of ASABE. Please send your thoughts to E-06 chair Lalit Verma (lverma@uark.edu).

Mark Crossley, ASABE Director of Advancement, St. Joseph, Mich., USA, crossley@asabe.org.
Your personal or company consultant business card could appear here. For information on rates ($95 and up) visit www.asabe.org/Advertise or contact Sandy Rutter, 269-932-7004, rutter@asabe.org.
Capturing the Big Picture
The 2015 Capstone Design Survey
Susannah Howe

Although Capstone design courses are common in engineering programs, they vary substantially. In an effort to capture current practices, the first nationwide survey of Capstone courses was conducted in 1994. Another nationwide survey was taken in 2005 to update the data and capture trends over time. The 2015 Capstone design survey marked the continuation of a decennial data collection effort on many pedagogical and logistical aspects of Capstone design. Some highlights of the data are presented below.

Respondents
A total of 522 respondents, representing 464 distinct departments at 256 institutions, participated in the 2015 survey, all but two of whom had a Capstone design course. Of the respondents, 14 were from agricultural and/or biological engineering programs; this represents one-third of U.S. institutions with ABET-accredited programs in agricultural and/or biological engineering. An additional 12 respondents noted that they involve agricultural and/or biological engineering students in their multidisciplinary Capstone design courses.

Course Information
Capstone design courses can be structured multiple ways, but the most common approach continues to be running the design projects and the class in parallel. The duration of Capstone design courses is increasing; more than half of the 2015 respondents reported a two-semester Capstone course, and some had even longer durations.

Pedagogy and Evaluation
Capstone courses typically cover a wide range of topics. The top five topics selected by respondents to the 2015 survey were written communication, planning/scheduling, oral communication, concept generation/selection, and team building/teamwork. A common debate in Capstone design circles is about “product vs. process” — in other words, is the outcome more important than the approach used to achieve it? The 2015 survey shows a roughly normal distribution along the product-process spectrum, with the peak located between “balanced” and “slight emphasis on process.” For evaluation of student performance, Capstone instructors provide the most input, followed by project coaches, industry liaisons, other students, and other faculty. Final reports, presentation, and product have the largest role in evaluation, but process and design reviews are also important.

Faculty and Students
Capstone faculty commonly have previous industrial experience in engineering design; more than half of the 2015 respondents had six or more years in industry, and many had 25 years or more. Capstone design is considered normal teaching activity for tenure and promotion by nearly all respondents to the 2015 survey, but few faculty members receive teaching credit for their involvement in Capstone; fewer than 10% of respondents provide Capstone-related teaching credit to all their departmental faculty. Meanwhile, student enrollment in Capstone design (like engineering enrollment in general) has increased from 2005 to 2015. The average Capstone enrollment in 2015 was 51, with some respondents noting upwards of 200 students per Capstone course cycle.

Projects and Teams
Capstone design projects are sourced from many places, most commonly industry, followed by faculty research. The prevalence of entrepreneurial and service learning projects has increased since 2005 as well. In keeping with rising enrollments, the number of projects per course cycle has increased in the past ten years; 25% of respondents in 2015 had more than 15 projects concurrently. Team sizes of three to five students remain most common.

Expenses and Funding
Typical expenses in Capstone courses include project supplies, hardware, and software, among others. While the range of expenses varies significantly by institution, discipline, and especially project, most Capstone courses have relatively low breakeven costs. Of the 325 respondents in 2015 who provided breakeven cost data, 300 were under $5000, 200 were under $1000, and 50 had no costs at all. The institution and external sponsors are the primary source for project funding. Students are less likely to fund Capstone projects now than they were in 1994 or 2005.

Sponsors
Sponsor funding spans as broad a range as project expenses, but 75% of programs that responded in 2015 receive less than $5000 per project from sponsors, and 50% receive less than $2000 per project, typically as gifts, grants, or reimbursement for expenses. The majority of sponsors are still located within 20 miles of the institution, but there has been an increase in international sponsorship since 2005.

Further Reading
These 2015 Capstone design survey data were highlighted in the keynote presentation at the 2016 Capstone Design Conference. Slides from that presentation as well as papers from the Capstone design surveys are available at the Capstone Design Hub (www.cdhub2.org) and the Capstone Design Conference website (www.capstoneconf.org). Readers are encouraged to see how their Capstone programs compare with other programs around the country. These surveys are an important step in understanding, assessing, and ultimately improving engineering Capstone design education.

Stay tuned for the next decennial survey in 2025!

Susannah Howe, Senior Lecturer of Engineering and Director of the Design Clinic, Smith College, Northampton, Mass., showe@smith.edu.

Views expressed are solely those of the author and do not necessarily represent the views of ASABE.
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