

Hands-On Engineering Gets a Leg Up

The ABCs of agrability

Kerri Ebert and Stacy Hutchinson

When it comes to retention of learned material, experts agree that experiential education allows students to engage more completely in the learning process while offering some control over the direction and flavor of a chosen project.

Kansas State University's Department of Biological and Agricultural Engineering has structured a Biological Systems Engineering Senior Design Course (BAE 536) to integrate experiential learning into students' final semesters of college course work. Client-based interaction between students and their customers with real-world design problems offers seniors a more meaningful capstone experience than could be produced with classroom work alone.

The course uses a self-paced, laboratory-based, student-team approach to solve design problems that may involve equipment or systems used to produce food, fiber, or energy; to ensure environmental quality; to perform damage remediation; or to conserve natural resources.

During the Fall 2007 semester, one of the BAE 536 teams chose to work with the Kansas AgrAbility Project, a USDA-funded Extension program based in the K-State BAE department that assists farmers with disabilities, and a western Kansas farmer who experienced significant upper body mobility and range-of-motion limitations. Their client's problem: safely entering and exiting his four-wheel-drive, articulated tractor.

The client was a row-crop farmer whose lifetime of work had taken a physical toll on his body. He had severe rotator cuff problems in both shoulders caused by years of over-compensating for his bad knees. By the time the student designers met him, he had undergone knee surgery, which greatly enhanced his lower extremity mobility. The rotator cuff damage, however, was irreversible. Unable to lift either of his arms above waist level, he had to place his left hand under his right elbow and push his right forearm up to reach



ABC Design Team members work on installing the spring-loaded step that they built and designed for their client.

the handrail on the tractor ladder. Because the motion caused him to lose balance, he leaned against the wheel hub of the four-wheel-drive articulated tractor, and then pushed off with his legs once he had hold of the handrail. The high-end solution to his problem was a \$5,000+ mechanical tractor lift designed to assist farmers who are paralyzed. However, the lift was too expensive, not to mention more technology than he needed. His AgrAbility case worker sought a more low-tech solution.

Enter the ABC Design Team from K-State's BAE 536 course. The students, Emily Beck, Anthony Mignano, and Lindsay Ott, traveled to the farm to interview their client and his wife, and take pictures (still and video) and measure-

ments. Back in the BAE department's on-campus workshop, the team researched and designed a spring-loaded, retractable extra step, with handles, for the tractor. The new design halved the distance from the ground to the first step, thereby eliminating the balance issue. Because the farmer still had strength in his arms, just limited mobility, the spring had to be set so he could lower the step with his hands without having to raise his hands over waist height. Several lab hours were spent experimenting with the spring constant. In addition, because the step was to be mounted on a tractor, the student design team determined that the spring must be protected from the elements, so they designed a housing that allowed access for maintenance but could also be sealed to prevent weather extremes from damaging the spring. Their experiments included testing tube-enclosure configurations as well as construction of a wooden test model.

With testing completed and the extra step and handles constructed, the students returned to the farmer's home to mount their invention. With the use of their client's tools and assistance from a neighbor with a welder, the design team was able to install the extra step in a single afternoon.

Following installation, their client could stand straight, hold on to the new handles while raising his leg to reach the new step, and then lower that step with his leg. With the handles at waist height, he didn't lose his balance or need to lean on the wheel hub. When he reached the top of the ladder, the spring retracted the new step so that it was even with the original step, which eliminated the hazard of damaging the step by catching it on field debris.

The student team left knowing that they had made a positive impact on their client because they had worked through

the problem-solving process together. Today, all three students are attending graduate school in Biomedical Engineering. Emily (Beck) Mangus and Lindsey Ott are studying at the University of Kansas, and Anthony Mignano is studying at Drexel University.

Design courses offer real real-world experience

One of the intangible benefits of an experiential learning course like BAE 536 is the opportunity for students to get to know real people and to help those people solve real problems. The ABC Design Team from fall 2007 learned from their initial interview that both their client and his wife held bachelor's degrees from Fort Hays State University. From the many employment options available to them upon graduation, they had both chosen to farm. As a result of this career choice, ABC's client found himself with physical limitations caused by years of farm labor. Nevertheless, he continued to find the work rewarding, even as it took a toll on his body.

As the ABC Design Team worked through an installation complication at the farm and determined the need for a welder, they also experienced the benefits of living in a tightly knit rural community. Their client's neighbor (five miles away) had a welding shop, and he was happy to offer his expertise. Everyone became acquainted over the welding task, and the conversation started to flow. The team members described their class experiences, and the welder talked about his favorite pastime—constructing toys from scrap metal. In addition, two of his sons had attended KSU, and one was a graduate of the BAE department!

Since the original ABC Design Team's experience in 2007, two additional teams have worked with AgrAbility Project farmers. The 2008 team assisted a commercial vegetable grower, who suffered from severe back and shoulder damage, by designing and constructing a raised garden bed that eliminated the need to bend and stoop to plant and harvest low-growing vegetable crops such as lettuce, spinach, and leeks. In 2009, a third team began working with a farmer who lost a leg in a farm accident. Their task is to help him access his combine. As we go to press, this project is still in the design process. When the students have finished the project, we can expect another useful solution that improves the life of another hard-working farmer.

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ABC Design Team and their client, left to right: Alvera Davison, Kent Davison, Emily Beck, Lindsay Ott, and Anthony Mignano.