2012
Mechanical & Aerospace Engineering

UNDERGRADUATE NEWS

"This school is a national leader in developing new sources of energy and advanced vehicles . . ."

-President Barack Obama

(see related article, page 7)

THE OHIO STATE UNIVERSITY

A Message from the Chair

OSU is switching to semesters effective Summer 2012. Recognizing that this was a rare opportunity for implementing significant change in the mechanical engineering undergraduate curriculum, the department of mechanical engineering initiated a dialog with alumni, employers of its graduates, and members of its departmental advisory board in summer 2009. That dialog stimulated discussions among its faculty members on the nature of the changes that would best enhance the undergraduate mechanical engineering program. Independently of this development, the department of aerospace engineering was engaged in discussions on revising its undergraduate curriculum concurrently with the switch to semesters. In July 2010, the two departments merged to form the Department of Mechanical and Aerospace Engineering. Highlights of the significant changes in both programs are listed here and many of these changes are described in this publication.

K. (Cheena) Srinivasan
Professor and Chairperson
Department of Mechanical
and Aerospace Engineering

Mechanical Engineering Program

- more design and manufacturing in the curriculum, including a sophomore design course, an expanded year-long capstone design course providing students a full design-build-test experience, and a senior-level manufacturing process course
- improved laboratory experiences including a new, open-ended, capstone laboratory course that will require students to make connections across the curriculum
- better progression in the development of engineering skills in design, computation, experimentation, and open-ended problem solving
- increased elective options for better training in 'soft' skills

Aeronautical and Astronautical Engineering Program

- renewal of the laboratory experiences for sophomore students
- a year-long laboratory experience has been added to provide seniors the opportunity to undertake open-ended projects involving significant planning and experimental design, and a meaningful research experience

These changes build upon local strengths but are also broadly responsive to needs identified by national studies. For example, the relative lack of practical experience (how devices are made and work) was identified as the most significant weakness of recently hired BSME graduates by the extensive industry survey conducted in 2010 by ASME's Center for Education Task Force as part of its Vision 2030 study. We recognize the importance of validating the effectiveness of these changes and, toward that end, expect to be engaged in their assessment and evaluation as well. Further, we recognize that, while the proposed changes are extensive, we will need to ensure that our graduates continue to be competitive in an increasingly globalized engineering workforce. In this undertaking of renewing the undergraduate curricula, our alumni are proving to be a significant source of support, both intellectually and financially. And for that, we are grateful.

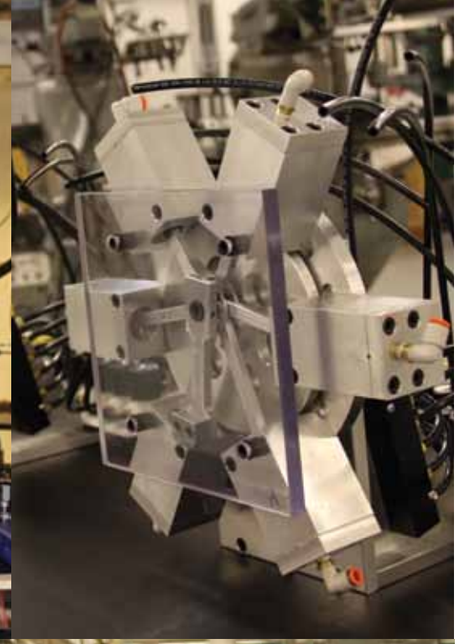
Sophomore Aero Students Up for New Challenges

In the past, some aerospace engineering students might have described the difference between their freshman and sophomore years by using a sports analogy, probably something akin to a great rookie year followed by a year of sitting on the bench. With the switch to semesters, aerospace engineering sophomores are about to see more time on the "field", whether on the grounds of an actual airfield or, more figuratively, in the lab.

Assistant Professor James Gregory explains, "Our freshman engineering students are grouped together, regardless of engineering path, for the engineering survey course. As freshmen they get to participate in a few small-scale, but fun, design-build-test projects that allow them to sample the various engineering disciplines. After that, most of those who opted to follow the aerospace engineering path spend a great deal of their sophomore year sitting, listening, watching, and hopefully learning. Beginning this fall, they'll be quite literally out of their seats and back in the game."

With the "launch" of the semester schedule, sophomores will continue to study many of the same topics (equations of fluid motion, wind tunnels, viscous flow, airfoils, wings, aircraft performance, stability and control, aircraft propulsion, space propulsion, rockets, orbital mechanics, etc.) as before, but will now engage in new lab activities that will range from: high-altitude balloon launches; analysis of data from the well known Flight 1549 Hudson River landing in 2009; glider competitions; flight simulations using realistic control interfaces; rocket design, construction, and launch; and smartphone-based data acquisition calculations.

Not only does Gregory expect the curriculum change to provide more meaningful lab experiences for the students, he believes it will create greater synergy with junior year courses, the senior year experimental projects course, and many of the technical electives chosen by aerospace engineering students. He added, "Developing lab experiences that are less about demonstrations and more about hands-on learning with rapid feedback should increase student retention rates. By highlighting how aerospace engineering is impacting areas associated with other forms of transportation and energy such as automotive manufacturing and wind energy, I think our sophomores will continue to be excited about the career possibilities ahead."



Air Motors Drive Sophomores' Enthusiasm for Intro to Design in ME

Ohio State's decision to shift to a semester–based academic calendar provided all degree-granting departments with an opportunity to re–think curricula from the ground up. In mechanical engineering, it was clear that the program lacked a well–defined gateway course that would introduce students to the entire discipline in a way that would both engage them in engineering and motivate them to continue. After significant input from alumni and much discussion among the faculty, the goals for this new course were defined. It was decided that the course should:

- Present mechanical engineering as an integrated field of study
- Emphasize design as the core engineering activity
- Provide hands–on practice in basic engineering skills
- Improve oral, graphic, and written communication skills

As the thinking about this course evolved, the idea emerged to structure the entire course around a single, integrated hands–on laboratory project. Lecture material would be designed specifically to support this unifying design, and would be presented to the students on a 'just-in-time' basis: students would learn material in lecture and immediately apply it to that week's machine shop or laboratory task. Given the constraints and goals imposed on the course, the selection of this core project was clearly crucial to its success.

After much deliberation, insructors settled on a six–cylinder, compressed air motor as the integrating project. The motor, which was patterned after the famous Wright Cyclone engine, is controlled by a widely available microprocessor, the Arduino™ Uno, which students program to inject air directly into each cylinder. The six–cylinder design helps to overcome the daunting task of teaching this course to approximately 300 students per year; students fabricate components individually, and then assemble them into working prototypes in teams of six. Using compressed air as the power source allows us to incorporate the design of a prime mover into the class without the problem of dealing with combustion in a laboratory environment. Controlling the motor with a microprocessor rather than cams and valves greatly reduces the number and complexity of the machined components, but more importantly, necessitates introduction of control concepts into the course in a way that makes perfect sense to the students. The motor design achieves the goal of integrating the subdisciplines of mechanical engineering into a single project, while also actively engaging the students in its creation.

The course has been successfully piloted to approximately fifty students during the current academic year, and will be rolled out to all second–year students entering the major in Autumn 2012. This effort has required the active participation of faculty from every interest group in the department. For more information about the new course, contact Blaine Lilly at lilly.2@osu.edu.

Sophomore students team up to tackle the hands-on challenges of the new ME "gateway" course.

Fundamentals of Manufacturing Processes Reworked for ME Seniors

A key component of the new semester–based curriculum for mechanical engineering is a senior–level course in manufacturing processes that will be taught by the Department of Integrated Systems Engineering at Ohio State. ISE Professor Jose Castro is leading a faculty team that is creating a completely new approach to teaching manufacturing to mechanical engineers, one that takes advantage of previous coursework to give our students a much more quantitative exposure to manufacturing processes.

Prior to the semester conversion, the required mechanical engineering curriculum included ISE 350, a sophomore–level course that was also taken by students in the Industrial & Systems Engineering and Welding Engineering programs as well. Because the course was offered relatively early in the curriculum, and because it was required of three disparate majors, the course could not cover at length topics of interest to mechanical and welding engineering such as the physical details of fabrication processes, likewise industrial engineering students felt short changed in material covering statistical process control. The material was also introductory in nature because of its sophomore level status.

The new course, ISE 4500, is designed specifically with mechanical engineering students in mind. It will be taken by seniors during their penultimate semester in the program and will require coursework in machine design, fluid flow, and heat transfer as prerequisites. These changes permit the material to be presented at a much higher level than is typical in such courses. The course will be designed to expose students to process physics (in lecture), process practice (in the laboratory) and process simulation (in the computer lab). Students will experience a given process in the lab one week, and will learn how to simulate the process the following week.

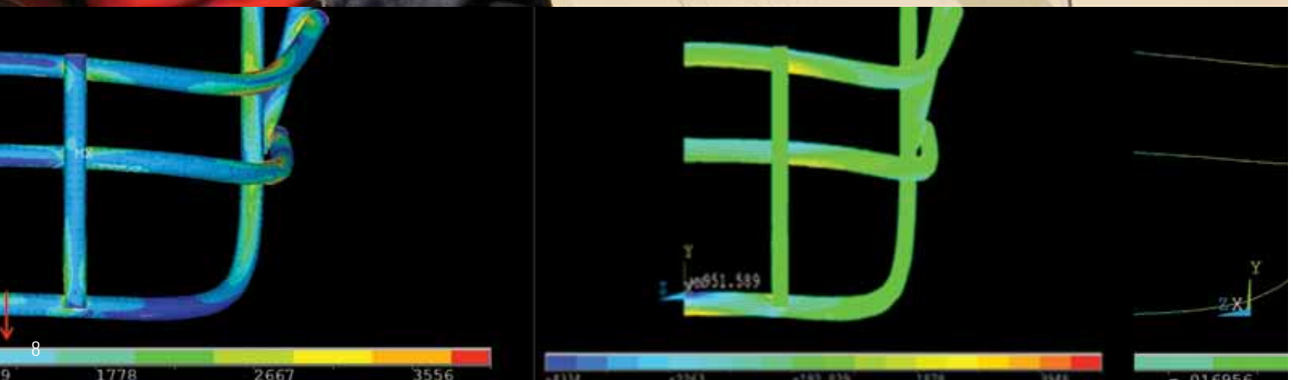
Positioning the course at the very end of the curriculum, rather than in the sophomore year, provides an additional advantage. By integrating material from several other courses, such as heat transfer and strength of materials, the course serves to integrate important ME fundamentals in the students' minds. As an example, because the students will have previously had a course in heat transfer, the metal solidification process can be approached at a much higher level. Students will also be exposed to materials science concepts in a very practical, 'need to know' manner.

The mechanical engineering program at Ohio State has traditionally been a major source of engineering talent for manufacturing firms in the industrial Midwest. A very large percentage of our graduates go on to careers with manufacturing firms. By ensuring that our students have a thorough grounding in manufacturing processes before they leave our program, we give them a career headstart, and position them better for success in a very competitive workplace ennvironment.

President Obama Visits Ohio State's Center for Automotive Research

Several ME students and faculty couldn't help but feel a bit "revved-up" when President Barack Obama took time during his visit to Columbus on March 22 to drop by Ohio State's Center for Automotive Research (CAR). In a speech later that day, the President declared, "This school is a national leader in developing new sources of energy and advanced vehicles that use a lot less energy. We've got to look at renewable energy as the key to our future and we've got to build cars and trucks that get more miles to the gallon . . . and we'll do it by harnessing the same type of American ingenuity and imagination that's on display right here at Ohio State."

On hand to explain the various motorsports projects housed at CAR, were faculty advisors Giorgio Rizzoni, Marcello Canova and Shawn Midlam-Mohler. Evan Maley, an ME undergraduate commented, "It was an honor to explain our project to the President and show how we are trying to advance alternative energy transportation." Obama met students and faculty working on EcoCAR2, an international student competition focused on fuel efficiency. (Ohio State placed second in the first year of EcoCAR2 competition just concluded at the end of May in Hollywood, CA.) He also met Buckeye Bullet, Formula SAE and Buckeye Electric Motorcycle team members.



Analyzing the Appeal of the Applied Finite Element Method Course

Perhaps instructing a course that is steeped in visualization techniques gave Associate Professor Rebecca Dupaix a natural advantage in "seeing" how the lab exercises of a 10-week quarter-based course could be adapted and transformed into a 14-week semester-based course.

Dupaix, who has been steadily evolving the course titled 'Applied Finite Element Method' for the past six years, knew Ohio State's shift to semesters would provide an even greater opportunity for conveying essential techniques of modeling. The technical elective course, which originally attracted a largely graduate student audience, is now heavily populated by ME seniors who find the course to be a mix of challenging, practical and creative lectures and computer lab exercises. Students who have previously completed the class have provided helpful feedback about the course and frequently suggested additional topics about finite element analysis (FEA) and expressed interest in learning additional commercial software packages beyond the ANSYS® simulation application. This is something that the semester conversion will directly improve: students will be able to explore how different commercial FEA packages can be used to tackle the same problem, helping them see that the engineering task of simplifying and modeling a physical problem is the same regardless of the software package.

Dupaix added, "learning to understand and solve complex elasticity and structural analysis problems will continue to be the primary objective of the class. In addition, students will gain a greater comprehension of the topic through the inclusion of more in-depth projects – three to four sizeable projects, each spanning two to three weeks." A pre-requisite for the course will be the Introduction to Mechanics of Materials class.

The ever-increasing popularity of the course has led the department to add two additional elective courses in computational engineering. New under the semester system will be a course about computational fluid mechanics and one on dynamic system simulation. Beginning this fall, students will be required to take a minimum of one course with a strong computational component as part of the ME undergraduate degree requirement. This expansion of computational engineering in the ME curriculum is also a reflection of the growing need of employers to hire employees with the computer skills required to conduct better research, analysis and testing of effective, safe and sustainable products.

Dupaix concluded, "with two hours of lecture and two hours of computer lab each week, I believe students will walk away not only with more knowledge of engineering designs and increased familiarity with modeling software, but just as importantly, the value of the finite element method to the design process and the innumerable ways it benefits industry and the consumers of manufactured goods."

The popularity of the elective course has prompted the department to add two additional computational engineering courses.

Extending & Elevating the Capstone Experience

In reformulating the capstone course for the semester system, department faculty knew they wanted to extend the course across an entire academic year and elevate the interest and enthusiasm of engineering students for the course by incorporating a design-build-test cycle in it. In its new form, the capstone will be taken in two back-to-back semesters and students will be able to select their favorite "flavor" of capstone from among the following five options:

Industry projects that are sponsored by engineering corporations and that require students to focus on projects of interest to the sponsor and in turn require students to interface with their engineers. Projects may involve product or system design. The course was piloted by Associate Professor Anthony Luscher of the ME department about seven years ago and, with success and growth to cover other areas of engineering, was transferred to the College of Engineering.

Assistive device projects that focus on aiding people with movement disabilities. The course currently involves seniors from mechanical engineering and biomedical engineering working with graduate students in occupational therapy, physical medicine and rehabilitation, to ensure that the assistive devices created by the students meet the needs of the patients as well as the objectives of the capstone course. The course was piloted by Assistant Professor Robert Siston over three years ago, and was recently joined by the biomedical engineering department.

Student competition projects that involve design tasks relevant to the engineering competitions in which Ohio State students participate. Current and past examples include the Solar Decathlon, Formula SAE competition, the ecoCAR competition and its precursors sponsored by the Department of Energy, electric vehicle land speed races, and aerial robotics among others. Design projects within these competitive endeavors that may be carried out in structured educational settings compatible with a capstone design course are identified and senior year students assigned to perform the tasks.

General design projects that give students a holistic view of all design phases from idea generation to fabrication. These projects involve the design, construction, and testing for proper functionality of mechanical systems, but may vary greatly from project to project, ranging for instance from a remote controlled hazardous inspection robot to a re-envisioned programmable thermostat. This version of the capstone design project would build upon a highly successful course that Associate Professor Anthony Luscher initiated about three years ago.

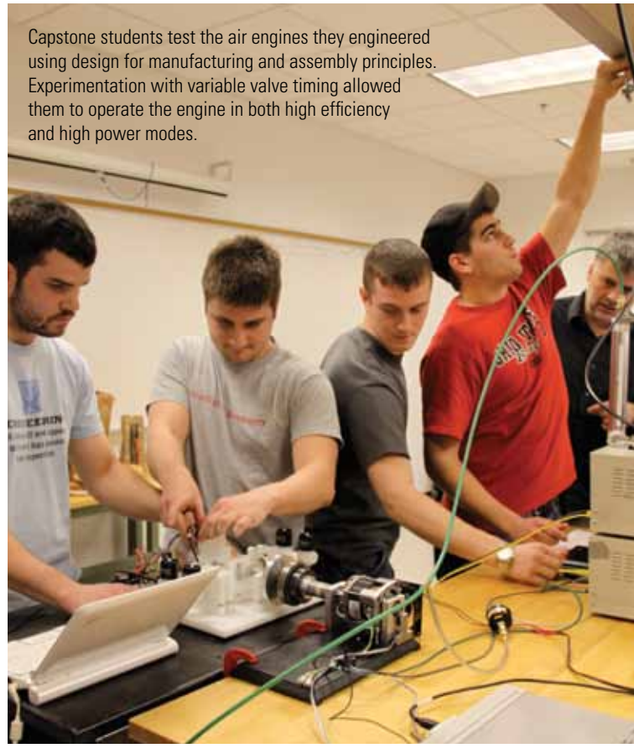
Social innovation and commercialization (SIAC) projects that pair capstone students with the associates or clients of nonprofit or charitable organizations that wish to fund the creation of products or devices that would aid their user communities. SIAC projects are expected to become self- sustaining through commercialization of project designs with funds returning to the sponsoring organization and Ohio State for reinvestment in ongoing SIAC ventures. ME students and students of other engineering disciplines may participate in this College of Engineering-led initiative.

Amping Up ME Design Skills

Given the opportunity to "bake" more robust design into the Product Design capstone class and expose ME students to the entire design-build-test process, Associate Professor Anthony Luscher, set about the task of piloting a new version of the Capstone Design course. "Design is one of the most creative and satisfying parts of engineering. Design uses all of the technical aspects of engineering as well as the ability to synthesize novel solutions to product or process needs," he said.

In general, seniors will work in teams of four-to-five students to accomplish a given capstone project. Students will be expected to engage in preliminary design, analysis, and planning tasks. At the end of the fall semester they will present their product concepts and prototypes. During the spring semester, the prototypes will be further developed and tested, with the goal of producing completed devices, perhaps even patent–ready concepts.

Looking forward, the faculty values the importance of introducing its seniors to activities that require thoughtful planning, organization, and time management, in addition to the more comprehensive design lecture content planned for the semester curriculum. An equally important objective of curriculum modification has been to prepare job-ready graduates who are not only competent engineers, but individuals with good business and communications skills. These new changes should allow seniors to enter job interviews with a stronger portfolio that summarizes their experience and the knowledge they've gained through their capstone project.



Capstone students test the air engines they engineered using design for manufacturing and assembly principles. Experimentation with variable valve timing allowed them to operate the engine in both high efficiency and high power modes.

Getting a Grip on Bow Mechanics

The effort required to 'fiddle around' in one senior capstone course might have surprised the interdisciplinary team of five students who chose to study how to design and implement adaptations for one-handed musicians playing stringed instruments. As with other ME/Biomedical Capstone projects, discovering how physical constraints affect the motivation of a disabled individual to engage in their favorite activities became part of the knowledge that students needed to acquire before initiating the design-build-test steps associated with their capstone endeavor.

Lecturer Dr. Sandra Metzler, who is advising the team of capstone students, found the group's project selection intriguing. The group learned first-hand from stroke victims attending Ohio State rehabilitation clinics about the challenges of regaining the ability to make music. Fortunately for the capstone team, one among them was an experienced violinist, a talent that proved to be a bonus as they researched the motor skills required to play the violin. To begin the design phase of their work, the team examined how the instrument is typically played and might be adapted. To do this they employed motion capture technology, using six infrared cameras, to gain useful data about the overall posture of the performer and the strength required of the violinist's bowing hand.

Beyond the data collected by the motion capture markers, the team studied the many kinds of physical coordination associated with violin play, including gross motor skills, fine motor skills, eye/hand and left/right coordination. Ensuring that the stroke patient experienced no additional physical harm or negative effect on progress and motivation while attempting to regain their musicianship was a primary concern of the team.

The final instrument adaptation design consisted of a wrist brace to support and help alleviate fatigue, a bow grip to insure proper finger placement, and a guide that attaches to the violin and assists in proper bow location and movement. The modular design allows the user to select the specific assistance and support that meets their individual needs. The team constructed a working prototype of the device, which was tested by a panel of occupational and physical therapists at Ohio State's Martha Morehouse Medical Plaza. The response to the device was overwhelmingly positive, and it was noted by the therapists that use of the device would provide practice with movement of the arm across the body, which is an important but sometimes difficult maneuver to complete.

The Capstone Project "Unilateral Upper Extremity Adaptation for Bowed Instruments " proved to be an insightful exercise in the mechanics of musicianship.

Trumpeting the Value of Lessons to be Learned in New Capstone Lab

At first glance it might be difficult to grasp what baseball bats, golf clubs, and Vuvuzela stadium horns (famously used at World Cup Soccer games) have in common, but after Professor Rajendra Singh explains how all three items could be used in this fall's first ME Capstone Laboratory, you begin to see the connection between the objects.

Given the "sporting" appeal of each, they could make for interesting devices for students to analyze as they begin their first mini lab project focused on the effect of material or medium properties (density, elastic modulus) and limitations of a mechanical system. And after completing the four-week study of Continuous System Dynamics of 1-D Structures and Acoustic Ducts, students will be tasked with completing two additional mini-projects that review the theories and principles of lumped system dynamics of fluid and acoustic systems and the diagnostics of consumer products using sensor based information processing.

The Capstone Lab will further serve to connect the lessons taught earlier in the ME curriculum including measurements, machine elements, systems integration and control, and fluid mechanics and heat transfer. The course will emphasize the complementary nature of analytical and experimental approaches in solving problems by using the student's previously acquired knowledge of sensors, fabrication methods, measuring instruments and data processing techniques.

During the course of the 14-week semester, seniors will be required to measure, compile, interpret and report the experimental data associated with their three mini-projects. Current suggested project options include study of: Flexural and Longitudinal Vibration

of Continuous Beam Structures; Dynamics of Liquid, Gas, and Acoustic Systems; Combustion Flame Instabilities and its Control; Thermal Management of a Prototype Microscale System; Thermal Management of a Computer CPU; or Actuation System Selection and Control System Design for High Performance Applications.

Among other valuable engineering lessons learned, it is assumed that students completing the course will have a whole new appreciation for the pitch variation of Vuvuzelas, the loft and lie of golf clubs, and the trajectory of any broken baseball bat that flies out of the hands of a batter.

Semester Switch Eases Concerns of Student Competition Teams

Research Scientist and Adjunct Assistant Professor Shawn Midlam-Mohler is among those who consider the switch to semesters a very positive change for Ohio State students. "From a practical standpoint, most student engineering competitions align with the semester calendar. For several of the past years, the final rounds of many regional or national competitions have overlapped with the end of our spring quarter in the month of June. This has forced our students to miss the last week of class and take exams earlier than planned – not an ideal situation from a student's perspective," said Midlam-Mohler.

With students arriving on campus in August rather than September, student teams will, in effect, get an extra month to complete their projects. Given the ambitious timelines of most student projects, an extra month can have a major impact on the end product, a benefit not lost on Ohio State's student competitors, whether freshmen or graduate students.

Midlam-Mohler added, "the other upside of our shift to semesters means greater number of seniors may opt to enroll in the capstone sequence that gives students credit for the tremendous amount of design-build-test work they perform as members of engineering competition teams." Recently, seniors participating in Ohio State's Solar Decathlon, the EcoCAR challenge (now EcoCAR2), and Formula SAE were among those who earned senior capstone credit.

The earlier start to the academic year coupled with a generous winter break gives students nearly eight weeks of additional project time compared to the quarter schedule. Students will have their detailed capstone design completed around the end of the first semester which gives them time to submit orders for material and components during winter break. Even items with 8-week lead times will arrive shortly after the spring semester gets into full swing. This extra time gives more flexibility in project scheduling, acquiring long-lead time components, and will allow more ambitious projects to be successful.

Previously, many of the student competitions were treated as extra-curricular activities. With the new semester curriculum, Midlam-Mohler expects that student teams will continue to attract underclassmen because the academic year will better coincide with students' availability and their interest in multi-year engineering projects, which could potentially conclude with the two-semester Student Design Competition Capstone Course. Midlam-Mohler believes the change will result in greater peer-to-peer learning, larger student teams, and a thriving number of student projects, especially those of the motorsports variety, which are near and dear to his role as a Research Scientist at Ohio State's Center for Automotive Research.

It's a Match!

"Speed Dating" & Tech Commercialization

Had Cupid realized that his matchmaking skills would be long associated with a February holiday, he might have licensed the rights to the modern form of speed dating. Lucky for Mechanical Engineering Assistant Professor Robert Siston and two collaborators from Ohio State's Office of Technology and Commercialization (TCO), the method remains in the public domain and adaptable to purposes beyond dating. In mid-February, they hosted an event that borrowed the "speed dating" format, and invited Rehabilitation Engineering Program students to pitch their concepts for new assistive devices for persons with disabilities to representatives of the TCO offices and Tech Columbus.

Nine engineering teams (comprised of a mix of undergraduate seniors in mechanical engineering (ME) and biomedical engineering capstone courses and graduate students in occupational therapy) made four separate, 20-minute appeals for their designs and explained how those designs would satisfy current market demand. ME senior Brian Schings concluded, "The individuals that we met with were able to share their knowledge of intellectual property (IP), design for commercialization, and market segmentation – all subjects that are not traditionally covered in depth in our engineering curriculum." Schings and his team are designing a device to help patients recovering from hip labral tear repair surgery. Their device aims to administer a type of physical therapy called continuous passive motion, which has been shown to increase mobility following surgery, reduce scarring and inflammation, and restore range of motion to the hip joint.

Though no one participating was pressured to embrace or reject any of the concepts discussed, they may have considered the event one of the sweetest networking affairs they had ever attended thanks to the variety of pies that were served plain or à la Mode. Another tactic that Cupid might wish to consider in lieu of the pesky arrow?

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