ABSTRACT
With the current increase in concern and awareness regarding sustainability and energy, a new focus has been placed on the field of engineering. In this realm of focus, how to educate engineers, more specifically how to continually educate engineers to keep up with technology and the changing workforce has become a very important topic of interest. There exists a gap between graduate studies and professional implementation of technology which the Energy Systems Engineering [ESE] program currently in deployment and development between the University of Michigan and General Motors seeks to address. This work outlines current efforts in encouraging new engineers to enter the field, but focuses primarily on continuing and re-educating the workforce to meet the needs of new technologies. Examples of academic-industry cooperation will be discussed, with some focus on the benefit and experience of the student.

INTRODUCTION
With the current increase in concern and awareness regarding sustainability and energy, a new focus has been placed on the field of engineering. As society seeks to solve problems around global climate change and energy supplies, they are looking to engineers to help find the solutions to these problems. The solutions will require companies to continue advancing and adapting technologies, a workforce with a constantly developing skill set, as well as a continuous supply of new engineers. We, as a society, must concern ourselves not only with how to inspire a new generation of engineers, but how to retrain the current workforce to pursue technological advancement in new areas.

More specifically, for American engineers, there is another challenge. The challenge of the ever growing global engineering workforce will require American engineers to stay one step ahead to continue to warrant the higher pay that has come to be expected. This will require engineers who are able to add exceptional value to the problems they work on. Part of this value added must include an ability to adapt and quickly learn new skills and areas of expertise. To keep their competitive edge, American engineers must pursue lifelong learning.

CURRENT EFFORTS IN ENGINEERING EDUCATION
In primary education, continuing work is carried out to improve the mathematical and scientific development of the youth in America. As attempts are made to sure up the future of the American Engineering workforce, these areas of education should not be overlooked. There is a report, which was issued from the National Academy of Engineering [1] outlining a proposal to include engineering education in primary and secondary institutions. The engineering education would be carried out in conjunction with standard mathematics and science curricula to insure a base knowledge in students, but also to support “problem solving, systems thinking, and teamwork aspects of engineering[1].” It is believed that this approach to education would also help students understand what engineers do, allowing for a greater understanding of the field, and potentially more interest in it.

In addition to efforts for reworking math and science curricula, engineers getting involved in the classrooms of primary and secondary schools are another key component in expanding interest and understanding in the field. One such effort to bring the engineering workforce to the classroom to encourage learning and future engineers is the A World in Motion [AWIM] program of SAE. “AWIM incorporates the
laws of physics, motion, flight and electronics into age-appropriate, hands-on activities that reinforce classroom STEM (science, technology, engineering and mathematics) curriculum[2].” The program allows students to work on interesting and engaging projects, while also having the chance to interact with professional engineers. This allows them to ask questions, not only about the AWIM projects, but about the volunteer's job and their personal experience in engineering. Since 1990, “over 4 million students have participate in the program in all 50 U.S. states and 10 of 13 Canadian provinces[2].”

With increased interest of primary and secondary school students, there will hopefully come increased enrollment at universities for bachelor and masters degree programs in STEM related fields. As the field of engineering changes, there are many people focusing on how to structure educational experiences to insure that students are fully prepared for entering the professional workforce upon graduation.

One such study, “Educating Engineers: Designing for the Future of the Field[3],” investigates parallels between engineering and other professional development curricula. In drawing comparisons with the fields of Architecture, Religious Vocation, Medicine and Law, engineering education was broken down into core focus areas. The focus in this work is that of professionalism, how it is taught and would subsequently allow for a more rigorous skillset. It is believed that professionalism and accountability were reserved for specific training experiences, as opposed to being treated as a requirement throughout the course of study. This is seen as one area where engineering educational approaches should be refined.

Another study, “Engineering for a Changing World: A Roadmap to the Future of Engineering Practice, Research and Education[4],” focused more on the need to engage a wider variety of students, and to produce engineers of broader world understanding. This report supported the idea that a bachelor's degree in engineering should be a “Pre-professional” degree, similar to pre-medicine, or pre-law. This would, in essence, allow students of broader interest to pursue education in the area of engineering, but would allow for more flexibility than is currently available in course selection. It is believed that this leveraging of the liberal arts education would help to produce engineers of broader points of view, and would subsequently allow for a more rigorous specialization in requirements when obtaining a master's degree.

Both of these studies examine the current academic structure for engineering education and what can be done to change, and better refine the process of being educated to become an engineer. Both of these studies also touch on the idea of professionalism, and what it takes to prepare students for entering the engineering workforce. A less developed topic was that of continuing education, and how to prepare engineers in a changing engineering workforce.

The Energy Systems Engineering [ESE] program currently in development at the University of Michigan seeks to address this gap. The academic rigor of the program focuses on a wide array of skillsets. This was done because the field requires new engineers with a refined skillset focusing not only on technology, but also on implementation and policy. The students who participate in this program through the University are required to complete an internship at one of the partnering companies, and complete novel work for credit towards completing their degree. This internship prepares the student with work experience in a fast paced environment.

Very often they are working to define the parameters of new technology, not just learning to operate under process and protocol. They are given the opportunity to develop the necessary skills to operate in a dynamic professional setting and establish an effective style that can stay with them through their careers. The internship also offers the company access to an energetic addition to their workforce with newly refined skills in key areas.

Furthermore, there are many professional students also taking part in the course work. The students taking part through the University of Michigan directly are often placed into project work groups with these professional students. They are thus required to operate more professionally in their group work as well- which helps foster a high level of communication and integrity through their whole program experience.

In addition to the program offered by the University of Michigan, there is a partnership between the University and General Motors. This partnership allows GM to offer the ESE degree through their Technical Education Program [TEP]. The students who participate in this program through TEP are offered a more focused course set, with up to 4 classes from other Universities. The focus is on automotive and utility infrastructure related topics to insure the students have a broad understanding of the upcoming needs of vehicle development- as well as the broad impact their decisions will have on energy supply and generation.

Students are required to complete coursework ranging from battery electrochemistry to electrical infrastructure, and can specialize in areas related to batteries or power electronics and fuel cells. Courses from other universities are offered to ensure that the students are learning from the experts in specific fields, such as electric machines and power electronics. As new gaps in technological understanding are identified in the industry, the program is able to work with experts around the world to put together course offerings and fill the need for education on the specific subject matter.
The focus of the program is not only to prepare the participating engineers for working on cutting edge automotive technologies, but also to expand their understanding of energy infrastructure beyond the automobile- offering more in depth understanding of the relationships between automobile design and advancement and energy sources. Throughout the program there are many course projects that are encouraged to focus around technologies of interest to General Motors. The students gain expertise in new areas, at the same time that they add to the collective knowledge of the company. These projects range from batteries and charging to exploring new fuel sources and novel control approaches. They force students to work outside the bounds of their daily work, and often to work with students from other industries or departments at the University.

In the establishment of required and offered curricula, subject matter experts were consulted to determine what skills were deficient in the industry, and in the company. These recommendations were then brought into course offering discussions with the University of Michigan, and other Universities, with which TEP partners. TEP coordinates the communication of the educational needs of industry, and then investigates the availability of training in academia. This has lead to a very dynamic and cutting edge course offering in the program, which is reviewed annually, to make sure that it is keeping pace with current technology.

In addition to the feedback provided by the subject matter experts of General Motors, as well as other participating companies and industries, committees have been formed to steer the ESE program and insure that all parties are benefiting as much as possible. There is an executive steering committee, which reviews the advancement of the workforce, and the advancement of the students’ skillsets. There is also an academic steering committee at the University of Michigan, to insure that departments are being leveraged and advanced in such a way that they will be able to continue to meet the changing needs of industry for training in different key areas.

The last subcommittee, and the one in which I have the most intimate knowledge, is the student subcommittee. The student subcommittee has been tasked with providing feedback on everything from course content to job prospect and development. The tasks of the committee were broken up into 4 key areas to insure the value of the program continues to maintain high relevance. The four committees focus on:

- Graduates: where they are and where we need to prepare current students to go
- Curricula- is the curricula being maintained and planned to meet the needs of the students and the competencies required to advance energy technology
- Course Projects- tracking previous capstone, internship, and course projects to understand room for improvement and growth
- Networking- insuring that students within fields and between fields continue to have strong communication to foster understanding and innovation across the spectrum of energy systems engineering.

The individuals who participate in this committee are graduates and current students of the program with a keen interest in nurturing the successful growth and establishment of this format of professional degree. The graduates come from a variety of backgrounds- many are General Motors TEP students, with equal representation of students who completed the degree as a University of Michigan student. The graduates work in a wide array of fields, and have varying educational backgrounds, which lends the group to a strong diversity in ideas about how to approach improving this educational forum.

With the foundation for multiple avenues for input and direction, the program seeks to establish a framework which forces it to remain nimble and relevant as energy technology and usage evolves. This program works not only to educate students broadly on how to affect energy systems, but also to build a strong inter-related network of industry, academia and government through its contributors and alumni.

There are other University related programs which similarly strive to meet the academic and training needs of industry through other formats. One such program is the Michigan Academy for Green Mobility[5], in which the Michigan Department of Energy, Labor & Economic Growth teamed up with automotive manufacturing industry employers. They are working together to establish training and skill redevelopment for the Michigan workforce. The governing board is made up of employers, educators and training providers, Michigan's workforce development system and the State government. This unique blend of government, industry and academia allows the three units to work together to develop a more stable, well trained workforce for a changing economy and industry within the state.

These efforts are specifically geared towards a quick retraining of the workforce through a program for earning a Vehicle Electrification Engineering certificate. The coursework is presented through partnerships between Universities and local industry experts, and is geared to be very hands-on to promote effective and useful learning. Students must complete 12-18 hours of approved coursework to earn the certificate, which includes topics such as battery technologies and hybrid powertrains. In the coursework students must complete not only homework and quizzes, but also laboratories and hands on exercises to deepen the understanding of the subject matter. The goal is to “create the right mix of theoretical knowledge with practical experience,
and build on the strengths of individual organizations in order to provide the highest quality training available in this emerging field[5].”

Another such program, which seeks to meet training needs outside of the 14 week course format, is the Wisconsin Electric Machines and Power Electronics Consortium [WEMPEC]. Through the University of Wisconsin- Madison, they do offer a full range of semester courses for students enrolled in the graduate program on campus and at a distance. With their expertise and corporate relationships they are also able to offer intense short courses on electric machines and power electronics. These short courses are taught by campus faculty and industry experts - giving the participants full exposure to the wide array of concerns and areas of interest of both academic pursuits, as well as industry development. This educational partnership is also fostered by project specific corporate research funding, ensuring that the research projects carried out by this consortium are of high interest and impact to industry[6].

SUMMARY/CONCLUSIONS

In summary, the efforts to encourage future engineers can start in primary and secondary schools. Interaction with professional engineers can help foster a stronger understanding of the field, and hopefully lead more students to pursue degrees and to work in the field. To provide the future engineers with an education which prepares them for entering the field as technology advances more quickly, many individuals and institutions are studying methods of retuning and overhauling the standard approach to engineering education.

The gap in engineering education which requires additional work is that of professional education and understanding how to train engineers to keep up to date in the ever changing horizon of technology. This work outlines the efforts of a few institutions who are attempting to bridge the gap between academia and industry to make sure that the field advances to keep up with the needs of society.

REFERENCES


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