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Curricula and Program Innovations to Enhance the Professional Readiness of Mechanical Engineering Graduates

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Abstract

George Mason's mechanical engineering program is the newest to be established in the Volgenau's School of Engineering. Added in the fall of 2014, themes for the curriculum and program focus on strategies to increase student access through multiple pathways and to enrich their learning experiences once they become part of the department. Using assessment collected in the ASME's vision 2030 report and engagement with its advisory board on curriculum design, improvements in the curriculum are presented. Specifically, continuous improvement to produce a more curriculum flexibility, to expose students to a faculty with a more diverse professional background, and to address the need to expose students to additional professional core skills rather than enhance their abilities in engineering science and design, are presented. Content of the modified senior seminar course, now titled "Developing the Society Engineer™", has been created to address some gaps in professional skills absent in well-established engineering programs for instance. End-of-semester feedback from students and faculty will be used to evaluate how these changes affect the attainment of student outcomes.

Keywords

Profession Skills, Professor of Practice, Curriculum Design, Outcomes Assessment

Background

Located in Fairfax, VA, George Mason University (GMU) is classified as a research university by Carnegie Classification, granting academic degrees through the terminal degrees in research and professional practice. With a student body population of just of 35,000, GMU's student body is 49% White, 10% Hispanic American, 9% African American and 15% Asian American. The transfer student population from Northern Virginia Community College represents roughly 30% of the incoming student population. One of ten colleges and schools, the Volgenau School of Engineering (VSE) offers ten Bachelors of Science degrees across eight departments, the most recent of which is the BS in mechanical engineering. Since its inception student enrollment stands currently at 223 and the faculty includes six assistant professors, four full professors and one professor of practice. The program graduated its first student spring 2016; the graduating class of 2017 will be seventeen students.

Themes for the mechanical engineering curriculum and program are focused on student access and enrichment. The program's curriculum has been aligned with the National Academy

Grand Challenge Scholars Program to expose students to societal concerns that enhance our traditional engineering educational experiences[1]. The program recommends five curricula and co-curricular experiences to prepare engineering graduates. Implementation of the NAE framework into the program is expected to be completed fall 2017. In addition, curricula components also have been aligned resulting from research presented in ASME's Vision 2030 report. To improve the professional readiness of students who graduate with a BS ME degree, an academic environment that fosters greater innovation, offers curricular flexibility, exposes students to a richer practice-based engineering experience, elevates students' professional skills to higher standards, offers greater diversity among students and faculty and one that creates a new balance of faculty skills within a program, are encouraged. The Dual Admissions COMPACT program establishes a sustainable collaboration with its community college partner – Northern Virginia Community College (NOVA) – by promoting access for a more diverse student population including first generation college students, underrepresented minorities, women and military veterans[2]. The primary goal of the COMPACT is to increase the numbers of students who completed requirements for an AS degree in Engineering at NOVA and who then transfer to VSE to complete their BS in engineering. The Department of Mechanical Engineering is piloting the program. An addition goal of the COMPACT is to enhance student efficacy through activities that foster professional engagement and wellness, and to create a culture of interaction among the faculties at both institutions leading to curriculum innovation and faculty development.

Figure 1 diagrams the strategy of the mechanical engineering program's development

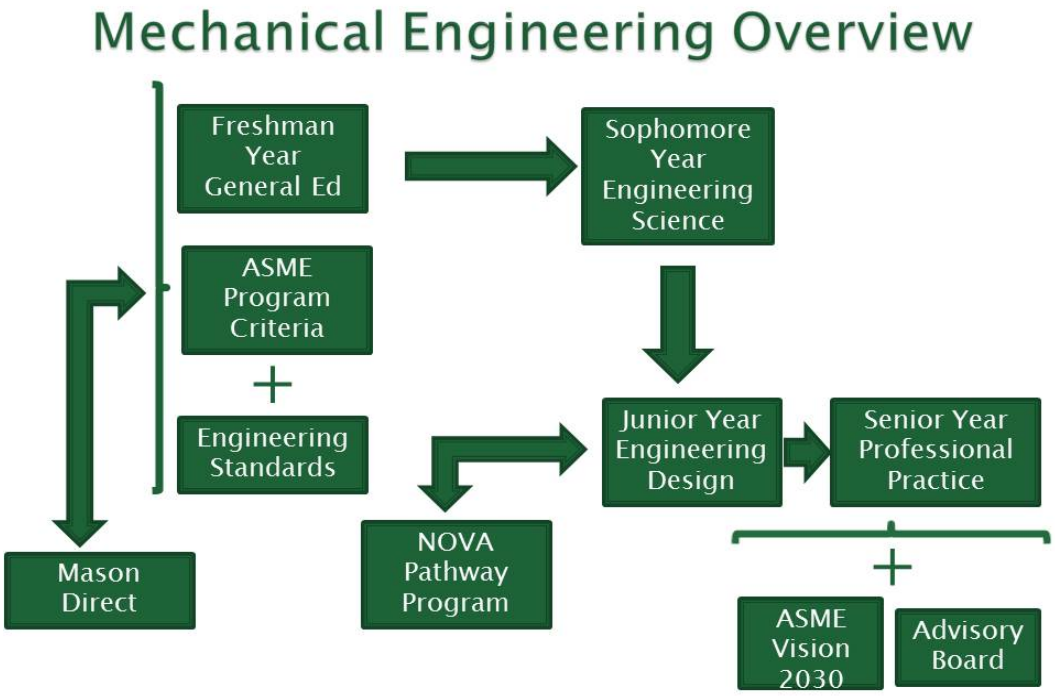

Figure 1 Strategy for Mechanical Engineering Program Development

Program Improvements Driven by Society Assessment

All engineering programs which are accredited by ABET or that plan to seek ABET accreditation are required to demonstrate their level of compliance with both a general criteria and a program criteria[3]. Collection of direct or indirect data through assessment, evaluation of these data and demonstrating how these data are used to improve the program through continuous improvement are essential. While assessment typically rests with information collected from course data, from surveys of faculty and students, and with interviews from alumni and advisory board members, professional societies can be valuable sources as well. It is this assessment that was used to drive change in Mason's mechanical engineering program and what is discussed.

"*ASME is a not-for-profit membership organization that enables collaboration, knowledge sharing, career enrichment, and skills development across all engineering disciplines, toward a goal of helping the global engineering community develop solutions to benefit lives and livelihoods. Founded in 1880 by a small group of leading industrialists, ASME has grown through the decades to include more than 130,000 members in 151 countries. Thirty-two thousand of these members are students.*"[4]

ASME's Board of Education, now the Committee for Engineering Education, engaged leaders in government, academia, and industry to understand the current state of mechanical engineering education and to then prescribe curricula changes to meet the demands of education in 2030 and beyond. Specifically in the Vision 2030 report[5], the committee identified the following area for improvement:

1. Richer Practice-Based Experience
2. Stronger Professional Skills
3. More Flexible Curriculum
4. Greater Innovation and Creativity
5. Technical Depth Specialization
6. New Balance of Faculty Skills

While each recommendation is equally important, implementation of the change is not. For instance, the department does not yet have a graduate program so focusing on post graduate education for specialization as prescribed through recommendation 5 is not possible; recommendations 2, 3 and 6, and the impact of these are presented.

Curriculum Improvement - More Flexible Curriculum

The State Council for Higher Education in Virginia (SCHEV) approved the program for offering beginning in the fall of 2014 requiring 124 credits to graduate. Unique to this program was a required course in statistics, three technical elections beginning in the senior year, and four engineering science courses with associated labs components – solid mechanics, materials science, fluid mechanics and heat transfer. Through concentrations, the technical electives form opportunities for immersion on areas of interest. For example, bioengineering is one of interest

for many students. Table 1 shows changes in the curriculum to reduce the number of credits needed to graduate from 124 to 121 credits, to afford more depth in concentrations with a 33% increase in technical electives and 25% increase in total electives and to consolidate laboratory experiences into one that concentrates on materials science and mechanical characterization and the second the concentrates on thermal-fluids. While reducing the number of credits to graduate was important in the eyes of state officials, this reduction also proved beneficial to the students. Including a math/science elective rather than a required course in statistics benefit students who have interest in the bioengineering concentration, for instance, because of prerequisite needed for upper level bioengineering courses.

Table 1 - Curriculum Changes to Enhance Flexibility

Credits Required To Graduate - 124	Credits Required To Graduate - 121
Catalog 2014-15	Catalog 2015-16
3 Technical Electives	4 Technical Electives
Required Course in Statistics	1 Math/Science Elective
Distributed Labs	Consolidate Labs

Figure 2 shows the current curriculum mapping resulting from these changes.

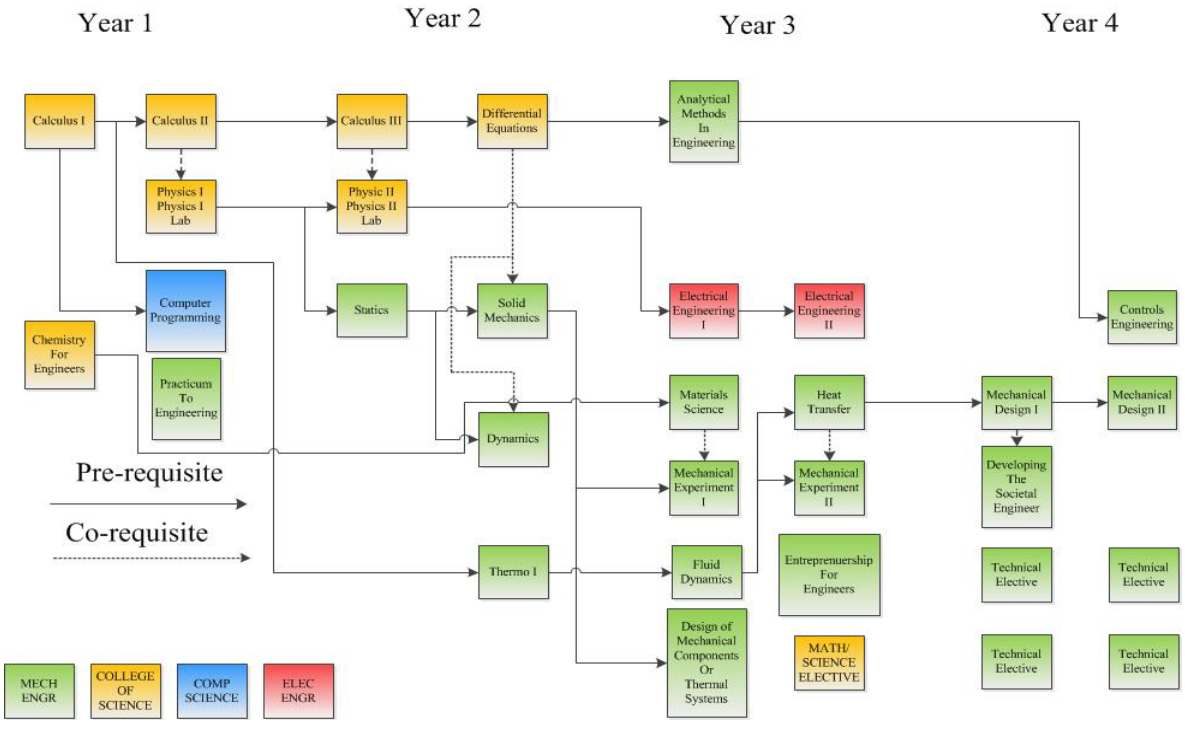

Figure 2 Revised Curriculum Mapping

Curriculum Improvement – Stronger Professional Skills

Through focus discussions with upper level students, many view entering the job market immediately after graduation the preferred career path over enter graduate or professional schools. Improving the professional and career readiness of our students motivated the curriculum re-design into ME 453 Developing the Societal Engineer a required 2 credit course that replace the Senior Seminar. This redesign falls in line with assessment from V2030.

Developing a student's career readiness by increasing their professional skills is a key driver of change for mechanical engineering education. Specifically identified are the following content areas – business process, computer modelling and simulations, information processing, interpersonal skills, negotiating, conflict management, innovation, oral and written communication and interdisciplinary team work. ME 453, Developing the Societal Engineer™ represents the department's effort to address several of the areas. Organized using industry expert speakers, case studies and required writtings, the team that created the course consisted of a newly hired Professor of Practice and one member of the Volgenau's Advisory board. The course was offered to seniors in the major for the first time in the fall 2016. Table 2 provides a mapping of critical coverage areas presented in V2030 into course content areas in ME453.

Table 2 - Mapping of V2030 into ME453

V2030 Study	Topics Covered
Interpersonal Skills Conflict Management	Emotional Intelligence Professional Association Awareness Engineering Leadership Business Conduct Societal Impact
Oral and Written	Communications for Engineers
Business Processes	Engineering Financial Management Supply Chain Management
Negotiating	Engineering Management and Science Contract Law
Information Processing	Engineering Information Management

Guest speakers were identified as subject matter experts to address topics in the course. To discuss the area of Interpersonal Skills and Conflict Management, a retired Navy Admiral valued the importance of professional conduct which had to be maintained during the investigation into a corruption scandal within the US Navy, popularly known as the Fat Leonard scandal.

Course Learning and Student Outcomes Assessment

While there is alignment with these components, how well students achieve the course objective of professional and work-force readiness requires having well-defined course learning outcomes; a mapping of these outcomes into ABET's student outcomes; and requires a defined assessment and evaluation strategy for attainment.

Table 3 presents the mapping of the five course learning outcomes (CLO) – (1) Knowledge of the importance of interpersonal skills and communication effectiveness for career readiness; (2) Understand the legal aspects and the fundamentals of financial management relevant to engineering solutions in a global context; (3) Apply the principles of professional engineering ethics, codes and standards to case studies; (4) A recognition of the need for, and an ability to engage in life-long learning; and (5) Knowledge of contemporary issues – into five of the eleven ABET student outcomes. To evaluate the level the attainment of the CLO's and student outcomes required defining a rubric which identified performance indicators for each CLO, establishing levels of achievement, and collecting and compiling sample data. An expected level of attainment for each CLO was prescribed and no level is prescribed for the student outcomes since these are program level outcomes.

Table 3 - Outcomes Mapping

	Course Learning Outcomes				
Student Outcome	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
(f)			X		
(g)	X				
(h)		X			
(i)				X	
(j)					X

Fal1 2016 was the first semester ME 453 was offered. Performance results for the CLO's and the student outcomes, providing in tables 4 and 5, represent the initial assessment. Performance results are obtained using the rubric for assessment instruments consisting primarily of case study reports. Achievement results for CLO's are percentage based obtained using cumulative performance beginning at the satisfactory level while achievement results for student outcomes represent cumulative performance beginning at the developing level. Levels of

expected attainment are only be assigned for course learning outcomes and not for student outcomes because these outcomes are at the program level.

Course Learning Outcome	Table 4 - Course Learning Outcomes Results					
	Unsatisfactory	Developing	Satisfactory	Exemplary	Achievement	Expected Attainment
1	4	7	18	31	81.7%	75.0%
2	6	3	12	19	77.5%	70.0%
3	8	7	13	32	75.0%	75.0%
4	1	19	19	21	66.7%	60.0%
5	1	10	14	35	81.7%	70.0%

Student Outcome	Table 5 - Student Outcomes Results				
	Unsatisfactory	Developing	Satisfactory	Exemplary	Achievement
f	8	7	13	32	75.0%
g	4	7	18	31	81.7%
h	6	3	12	19	77.5%
i	1	19	19	21	66.7%
j	1	10	14	35	81.7%

Conclusion

This paper presents curricula improvements resulting from assessment driven from professional society as well as course learning outcomes assessments. Revision of curriculum requirement for graduation, course content and faculty composition will have positively impact the profession and career readiness of our graduates; evaluation is ongoing. Assessment and evaluation of the level of attainment course learning and student outcomes are important to meeting the course objective.

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Biographical Information

Oscar Barton, Jr., Ph.D, PE is the founding department chair of the Department of Mechanical Engineering, George Mason University.

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