On the Restructuring of the Undergraduate Mechanical Engineering Curriculum for Quarter to Semester Conversion

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Abstract

Most schools in the U.S. have moved, and continue to move, from a Quarter to a Semester system (Q2S) curricula. From student learning the point of view of, it is well known that the semester system has many advantages over the quarter system. At our institution, most students of the mechanical engineering program work full-time in the industry during the day, and take classes in the evenings. Additionally, due to classes meeting once a week in our 10-week quarter system, we firmly believe that transitioning into a 15-week semester system will immensely help student engagement and retention due to truncated semester class meeting times each week as well as the dissemination of the same lecture topics over longer time-frame. Our university transitioned from the Q2S system in fall 2017. Furthermore, in order for our program to be competitive with other schools, we have reduced the total number of semester credit hours necessary for graduation, with every effort made to ensure full comprehension of the course contents in the quarter system in this Q2S transition. The present paper discusses the restructuring of our ABET accredited undergraduate mechanical engineering (ME) curriculum for Q2S, its challenges, advantages, and changes made to the content in some courses.

1. Introduction

Currently, there is no publication in the literature (conference or journal paper) that discusses a full conversion of the mechanical engineering program from Q2S. Many educators have discussed the impact of Q2S on a single lecture or lab course [1]-[5]. However, Eastman and Walker [6] gave a detailed Q2S conversion process specific to the entire undergraduate Electrical Engineering Technology program. In their paper, they highlight that about 90% of the institutions in the United States are in the semester based system. They also list some schools that have recently undergone Q2S conversions. The present paper is the first publication in the literature that discusses a full conversion of the undergraduate mechanical engineering program from Q2S,

Q2S conversion process gives the program an opportunity to restructure the curriculum through adding or reducing courses, modifying existing course contents, and combining courses. The current paper discusses how our 223 quarter credits, equivalent to about 149 semester credits, have been reduced to 120 semester credits, thus enabling full-time students to graduate in 4 years as opposed to 5 years in the quarter system, and also better positioning our program to be competitive with programs of other institutions, especially those in our school's vicinity. As more institutions continue to migrate from a quarter to semester academic years, we strongly feel that this paper, in itself, is a unique contribution to the engineering education community, thus filling the gap in the literature.

It is well known that a semester system has many advantages over a quarter system [7], [8]. The benefits of a semester system are its reduced student cognitive load each week, better student engagement both inside and outside the classroom, smooth student transfers, and better timing of students' availability for internships and employment. Most of our students have day

time jobs, thus with the shortened contact hours each week in the semester system, there is less likelihood of student and faculty burnouts; and enhanced opportunities for project based learning, group exercises, field trips, and subdivision of projects into several phases in design oriented courses.

Why is our college converting to semesters?

- Aligns our academic calendar with the majority of institutions in Michigan and nationwide. Approximately 90% of colleges and universities operate on a semester calendar.
- Aligns our academic calendar with high school calendars, providing more collaborative opportunities and better support for dual enrollment/direct credit initiatives.
- Decreases the number of courses that students are required to take.
- Allows for more efficient and equitable transfer of credits to and from other colleges and universities.
- Provides opportunities for students to participate in enhanced internships for a longer period.
- Allows students to finish spring semester earlier, enabling them to compete for summer jobs.
- Permits graduating students to enter the job market earlier than in a quarter-based system, concurrently with most graduates from other colleges and universities. Most large employers align recruitment schedules to the semester calendar.

In a Q2S conversion, it is paramount to ensure that the program and student learning outcomes as well as benefits of the quarter system for student learning are not compromised.

2. Q2S Conversion Process of the ME Curriculum

The transition to semesters provided our institution an excellent opportunity to review all programs of study we offer. In order to maximize efficiency, the institution decided to bring all bachelor programs to a total of 120 semester credits.

In the quarter version, our ABET accredited BS Mechanical Engineering program had 223 credits, equivalent to about 149 semester credits. The normal graduation time for a full-time student was 5 years in the quarter system. To enable our ME program to be competitive with other schools, a relatively large amount of credits were needed to be eliminated from the program, while maintaining its breadth and depth in all areas as well as remaining in compliance with ABET requirements. The graduation time now for a full-time student with 120 semester credits is 4 years. The following curriculum changes took place as the program moved to the semester version:

1. The institution revised its General Education requirements for all bachelor programs. The number of General Education courses in the quarter system was more than required to meet the ABET accreditation requirements. This was the main reason for eliminating some of the General Education courses. Additionally, some of the courses in both General Education and Mechanical Engineering had topics that overlapped. Therefore, these courses were combined, and in some cases, additional credit hours were added to the combined courses to ensure that all necessary

contents are comprehended. The number of semester credit hours in most schools is between 120-130. The 223 quarter credits in our program, equivalent to about 149 semester credits, far exceeded the requirement needed to graduate students in 4 years. The restructuring of our mechanical engineering curriculum was necessary to reduce the credit hours to better position our program to be competitive with programs of other institutions. The courses in our 120 semester credit hours restructured curriculum are similar to most schools and therefore no compromises are made toward decrease in program effectiveness.

Five general education courses were eliminated from the BS ME program, equivalent to a reduction of 12 semester credits. The current requirements for General Education total 30 semester credits, 18 of which are in the areas of oral and written communications, ethics, cultural diversity, and personal/social environments areas. The remaining 12 required credits consist of mathematics and science courses.

2. The following pre-calculus level mathematics courses were eliminated from the program: Introductory Algebra, College Algebra, and Trigonometry. These amount to a reduction of 8 semester credits. The first mathematics course in the program is now Calculus I. Students who are not ready to enroll in Calculus I as they start the program have the opportunity to enroll in Pre-Calculus during the summer before freshman year.

3. The two separate 4-credit hour quarter courses - Introduction to Differential Equations, and Linear Algebra - have been combined into one 4-credit semester course. This amounted to a reduction of 1.3 semester credits.

4. The two 4-credit hour Mechanical Design I and II quarter courses have been combined into one 4-credit semester course. This amounted to a reduction of 1.3 semester credits. This was possible through reviewing the content of the two quarter courses and noticing that Mechanical Design I had some overlap with the Solid Mechanics course. The overlapping topics (amounting to 4 quarter weeks)-Equilibrium and Free-Body Diagrams; Shear Force and Bending Moments in Beams; Mohr's Circle for Plane Stress; General Three-Dimensional Stress; Elastic Strain; Stresses in Tension, Compression, Bending, and Torsion; and Deflection Due to Bending have been eliminated from the new Mechanical Design course.

5. Four courses with EGR prefix (Engineering Graphics, Introduction to Engineering and Design, Computing for Engineers, and Engineering Economy) and the Introduction to Computer Aided Engineering course became 2-credit courses in semester version, equivalent to a 3.3 total credit reduction.

6. The number of technical elective courses needed for students to graduate was reduced from 4 to 3.

7. There were several other small changes that resulted in a net reduction of credits to bring the total number to 120. The current structure of the curriculum following ABET interpretation is given in Table 1. This continues to satisfy Criterion 5 of the Engineering Accreditation Commission of ABET.

Table 1. BS ME Curriculum Structure

Area of concentration	Credits	% of total credits
Math and Basic Sciences	31	25.8
Engineering Topics	71	59.2
General Education	18	15.0
Total	120	100

Other curriculum changes took place that did not impact the number of credits, but were introduced to improve student learning. A lab hour, where students work on problems under instructor guidance, has been added after the lecture portion to each of the Statics and Dynamics courses. Both Statics and Dynamics are foundation courses, and therefore the necessity of the extra contact hour for lab. In the past, study sessions were conducted for these courses but the student turnout was not satisfactory.

In the quarter system, the Solid Mechanics course was 4 credit hours with 3 contact hours of lecture and 2 contact hours of lab. The lab portion of the quarter version Solid Mechanics course has been transformed into a standalone lab course. The 4 credit hour Vibrations course in the quarter system had several vibrations experiments included in it with no extra lab contact time allotted. Given that Vibrations course is one of the challenging courses we felt we needed to decouple the experiments from this course and include them in the newly created standalone Solid Mechanics and Vibrations Lab, a 1-credit hour course. The standalone lab course also gives student more time to perform finite element analysis simulation lab exercises using the commercial software ANSYS.

The Thermodynamics course (ME 3310) we offer is part of a thermal science course sequence that includes Thermodynamics, Fluid Mechanics, Heat Transfer and Thermal Systems Lab. Our ABET accredited program had only one Thermodynamics course in the quarter system too. One of the ABET requirements previously was to prepare students to work professionally in both thermal and mechanical systems while requiring topics in each area. To meet this requirement, we added a standalone Thermal Systems Laboratory course (ME 4350) in fall 2010, in which several thermodynamic systems experiments, designs, and applications are included. Furthermore, the prerequisite to the thermodynamics course, SCI2510 General Physics I, discusses several topics of thermodynamics through lectures on the theoretical aspects and lab experiments. Additionally, the current ABET requirement requires the program to prepare students to work professionally in either thermal or mechanical systems, and not both, while requiring topics in each area. Our program meets this requirement through several courses in the mechanical systems area as well as courses like heat transfer, fluid mechanics, thermodynamics, thermal systems lab, and advance fluid mechanics (elective) in the thermal systems area.

In our 10-week quarter system the final exam was conducted in the 10^{th} week. Thus, in addition to the loss in lecture time, there was no final exam preparatory time for the students. This is not the issue in our semester system as the final exam is in week 16, the week after the last lecture class. Most courses in our quarter system had two exams (weeks 4 and 7) and the final exam in week 10. The expanded 15-week semester system has given us the opportunity to

have three exams (weeks 4, 8, and 12) and the final exam in week 16. Having this extra exam benefits students going in to each exam, in the retention of information and preparation of less course topics. The BS ME semester program rotation is given in Table 2.

Table 2. BS ME Semester Program Rotation.

BS Mechanical Engineering	**Credit Hours**	**Contact Hours**
FALL 1		
EGR 1010 Engineering Graphics	2	4
ENG 1010 Composition I	3	3
MTH 1510 Calculus I	4	4
PSY 1010/PSY 1110/ECN 2010/ECN 2020	3	3
SCI 2460 General Chemistry	4	5
SPRING 1		
EGR 1050 Introduction to Engineering and Design	2	3
ENG 1020 Composition II	3	3
MTH 2510 Calculus II	4	4
SCI 2510 General Physics I	4	5
SPK 2010 Oral Communication	3	3
FALL 2		
EGR 2710 Computing for Engineers	2	3
ISE 2110 Manufacturing Processes	3	4
ME 2210 Statics	3	4
ME 2410 Introduction to 3D Modeling	3	3
SCI 2520 General Physics II	4	5
SPRING 2		
ME 2110 Materials Science	4	5
ME 2250 Dynamics	3	4
ME 2450 Introduction to Computer Aided Engineering	2	3
MTH 3550 Differential Equations and Linear Algebra	4	4
FALL 3		
EE 2110 Circuits and Electronics I	4	5
ME 3210 Solid Mechanics	3	3
ME 3220 Solid Mechanics and Vibrations Lab	1	2
ME 3250 Vibrations	3	3
MTH 3510 Multivariable Calculus	4	4
SPRING 3		
EGR 3210 Engineering Economy I	2	2
ME 3270 Mechanical Design	4	4
ME 3310 Thermodynamics	3	3
ME 3410 Fluid Mechanics I	3	3
MTH 2750 Statistical Methods	3	3
SUMMER 3		
WRK 3010 Work Experience	3	
FALL 4		
EGR 4910 Engineering Project Management	3	3
ME Technical Elective I	3	3
ME 4310 Heat Transfer	3	3
ME 4350 Thermal Systems Lab	1	2
SOC 3210 Cultural Diversity	3	3
SPRING 4		
EGR 4920 Senior Design Project	2	4

HUM 4010 Philosophy of Ethics	3	3
ME Technical Elective II	3	3
ME Technical Elective III	3	3
ME 4610 Dynamic Systems and Control	3	3
TOTAL CREDITS	**120**	

3. Conclusions

We have successfully effected the Q2S conversion of our undergraduate ME program through proper planning and execution. The 223 quarter credits, equivalent to about 149 semester credits, have been reduced to 120 semester credits, thus enabling full-time students to graduate in 4 years as opposed to 5 years in the quarter system, and also better positioning our program to be competitive with programs of other institutions, especially those in our vicinity. The reduction in the semester credits was possible through reviewing the curriculum, combining, modifying, and eliminating courses, without diluting student learning or deviating from ABET requirements. Both full-time and adjunct faculty members were involved in the Q2S conversion. The semester system went into effect in fall 2017. There is no quantitative assessment of the impact of these changes. Given that our students hold daytime jobs, we strongly feel that the shortened semester contact hours each week, helps in better student engagement, increased time for solving homework assignments, and enhanced opportunities for project based learning, group exercises, field trips, and better management in design oriented courses.

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