A Survey of Credit Hour Requirements in BS Civil, Electrical, and Mechanical Engineering ABET Accredited Programs

Dr. Derek Guthrie Williamson, University of Alabama

Dr. Williamson obtained his undergraduate degree in 1990 in Engineering and Public Policy from Washington University in St.Louis. He received his MS (1993) and Ph.D. (1998) degrees in environmental engineering at The University of Texas at Austin. Dr. Williamson joined the faculty of the the Department of Civil, Construction, and Environmental Engineering at The University of Alabama in 1999. He has enjoyed 15 years of a dynamic profession of teaching, research, and service. he now serves as the Director of Undergraduate Programs for his Department.

Dr. Kenneth J. Fridley, University of Alabama

Kenneth J. Fridley is the Senior Associate Dean for the College of Engineering at The University of Alabama. Prior to his current appointment, Fridley served as Professor and Head of the Department of Civil, Construction and Environmental Engineering at the University of Alabama. Dr. Fridley has been recognized as a dedicated educator throughout his career and has received several awards for his teaching efforts, including the ExCEEd (Excellence in Civil Engineering Education) Leadership Award in 2010. At the University of Alabama, Fridley has led efforts to establish several new programs including new undergraduate degree programs in construction engineering, architectural engineering and environmental engineering, a departmental Scholars program allowing highly qualified students an accelerated program to earn their MSCE in addition to their BS degree, the interdisciplinary "Cube" promoting innovation in engineering, and the cross-disciplinary MSCE/MBA and MSCE/JD dual-degree programs.

A Survey of Credit Hour Requirements in BS Civil, Electrical, and Mechanical Engineering ABET Accredited Programs

Abstract

The purpose of this paper is to present the results of a sampling and analysis of today's ABET accredited Bachelor's Degree Programs in Civil, Electrical, and Mechanical engineering curricula. U.S. programs submitting ABET reports in 2015, were polled for their Table 5.1 data. The sampled programs were examined for total credit hours and credit hours in each of the following categories: math and science, engineering, general education, and other. While there has been considerable discussion nationally about a trend to reduce credit hour requirements and on how credit hours can/should be distributed between different categories, there is a need to establish a database of credit hours use in engineering degree programs. The degree of variability within and across degree programs will be evaluated. Such information can help professional societies understand how programs are using credit hours as they consider and update Bodies of Knowledge. This will also provide individual programs a sound base to which comparisons may be made.

Introduction

Curricula of engineering programs slowly evolve in response to drivers including professional needs (as expressed by the discipline's FE exam content and body of knowledge (BOK)), accreditation, employer and other constituent input, and cost structure issues in higher education. The authors wanted to establish a point-in-time snapshot of curricula composition in engineering programs to establish how different engineering disciplines are using a finite supply of curricular hours. This snap shot should help curricular researchers in the future by providing a "baseline" against which to judge how: (1) drivers broadly shape different discipline curricula, (2) curricula evolve in response to changes in drivers, (3) different types of institutions respond differently to these drivers. Such an understanding can help inform policy development within these driver systems. For example, understanding how curricula respond to drivers may inform choices made in updating and modifying accreditation criteria, professional bodies of knowledge (such as ASCE's BOK), or curricula. Understanding engineering curricular responses to drivers, even in a preliminary way, may help institutions make informed decisions in response to future changes in accreditation standards, whether they are across all of ABET EAC or within a specific program. The first step to developing such detailed nuanced understanding is developing data describing how curricula are broadly composed; which is the focus of this work.

Data Collection

In order to collect a meaningful sample of relatively consistent curricula data, the authors selected Table 5.1 in ABET Self Study Reports (SSRs) to be the source of data to mine (shown in Appendix 1). ABET INC was very supportive of this work and the authors would like to

acknowledge their support. The data of interest were: total credit hours, math and basic science credit hours (and % of curriculum), engineering topics credit hours (and % of curriculum), general education credit hours (and % of curriculum), and other credit hours (and % of curriculum). While there certainly is some interpretation and variance in the supplied data, it is a uniformly recognized source among engineering institutions in the U.S. and throughout the world. Additionally, a well-developed review process insures relative comparability of the data. This data is private and secure under ABET provisions and; therefore, had to be mined with extreme care to preserve the anonymity of the individual institutions and programs. Moreover, due to the data being solely contained in program-by-program SSRs, the data needed to be manually extracted and anonymized. Therefore, a particular subset was chosen to balance resources required to mine the data by hand, the usefulness of the data, and the comparability of curricular data sets. ABET lists approximately 2530 accredited engineering program in the U.S[1]. The authors decided to limit this survey and evaluation to only the United States for reasons of consistency and known curricular traditions. Given a six year accreditation cycle, this equates to a approximately 425 U.S. engineering programs submitting SSRs per year (new programs and re-reviews will make this number even larger). The most recent set of complete reports that was available through ABET was 2015-2016 cycle of SSRs and we chose this single cycle for this initial survey. Finally, we selected three disciplines out of the approximately 28 ABET accredits. Civil, mechanical and electrical engineering were chosen because (1) they represent the three largest programs in the US in terms of numbers of undergraduate degrees awarded per year, and (2) they have substantially different program specific criteria. In 2014/2015, the US produced 107,000 graduates with BS degrees in engineering with: 24,436 in mechanical, 11,900 in civil, and 11,385 in electrical engineering[2].

The data were collected from ABET headquarters in Baltimore during a single day visit. ABET staff had brought 153 SSRs from 72 institutions that met the criteria of having filed a 2015-2016 SSR in at least one of the selected disciplines. The data were collected into a prepared data table shown in Figure 1. The ID numbers were randomly assigned to each institution after final data collection and all links to the institution name were immediately deleted from the data table before leaving the ABET facility. Only the credit hours in the four categories of “Math and Basic Science”, “Engineering Topics”, ”General Education”, and “other” were entered by hand while collecting data. The cross hatched cells in Figure 1 were calculated based on the entered data. The total hours were calculated and cross-checked against the reported value in Table 5.1 While 153 SSRs were available, not all were appropriate to obtain a consistent data set.

ID Coding		Hours					Percent Hours				
Program	ID#	total Hours	Math & Basic Science	Engin. Topics	Gen Ed	Other	Math & Basic Science	Engin. Topics	Gen Ed	Other	total percent
C	39										
E	17										
M	15										

Key: C-Civil, E-Electrical, M-Mechanical Engineering

Figure 1: Data Collection Template

The data were omitted during collection for one of several reasons. First, a number of the reports were interim reports and did not contain Table 5.1. Interim reports are partial reports responding to specific from a previous visit and did not contain Table 5.1 as it was not relevant for that follow up report. Secondly, several "mechantronics" programs were intermixed in the files and they were removed as they were not one of the three selected programs. Thirdly Electrical Engineering Programs that contained the words "telecommunications" or "Computer Engineering" were removed as the ABET program specific criteria for those includes different requirements than electrical engineering alone. Finally a few programs were eliminated because their Tables 5.1 were not internally consistent or reported in non-standard format. After these real-time audits, curricular data from 121 civil (33), mechanical (43), or electrical (45) engineering programs from a total of 51 U.S. institutions were collected. The full set of this data is shown in the Appendix.

Data Analysis

Once the data set was established a number of research questions were addressed. The first question is: "Do different degree programs (e.g., civil, electrical, and mechanical) have different total hours?" Table 1 shows a comparison of total hours across the three disciplines investigated. As can be seen the three different degree programs have on average the same total hours (verified with one-way ANOVA at P=0.05). Table ABET Table 5.1 is constructed in terms of the minimum hours for engineering and math and basic science with the basic tenant that a curriculum is 128 hours ("the minimum of 32 hours or 25% of the total hours" see Appendices A1 and A2). With that basic tenant and the constant pressure on universities to reduce curricular credit hours to minimums allowed by accreditation, the observed total hours of ~129.5 conforms to the authors expectations that total credit hours would be near the 128 mark and not significantly different across engineering disciplines. .

Table 1: Credit Hours per B.S. Degree Program

Program Name	No. of Programs	Avg. Total hours	Std. dev. (hours)	COV (%)
Civil	33	129.61	4.56	3.52
Electrical	45	129.55	7.37	5.69
Mechanical	43	129.81	6.99	5.39

The next research questions to consider are "How are curricular hours distributed across the four categories?" and "Are they distributed differently across the three examined disciplines?" ABET general criteria (see Appendix A1) and ABET Table 5.1 (Appendix A2) provide some expectations of minimum credit hours for math and basic science (32 hours or 25% of curriculum) and engineering topics (48 hours or 37.7% of the curriculum). The implication of this on the curriculum can be seen in Figure 2. Figure 2 brings a follow-up question to light: "Once programs meet the minimum hours of engineering topics and math and basic science, how do they utilize the remaining 38% or approximately 48 hours of their curriculum, and do the three examined programs use them differently?"

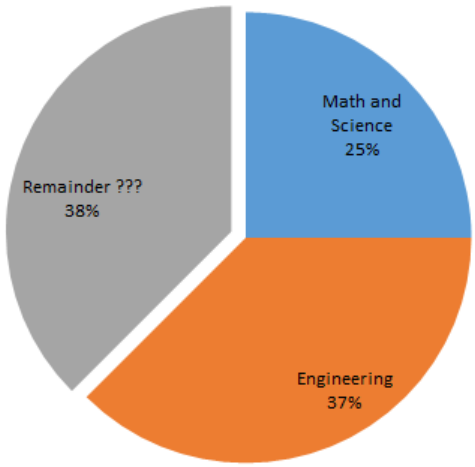


Figure 2: Distribution of Credit Hours Implied by ABET Table 5.1

Before proceeding to review the analyzed data, the question may be asked "Why would one expect differences in credit hour distribution between these three disciplines?" ABET program-specific criteria for Civil, Electrical, and Mechanical Engineering are provided in Appendices B, C, and D, respectively. The program-specific curriculum criteria are presented in Table 2 below. A review of these program specific criteria shows both civil and electrical engineering specifically require statistics and that electrical engineering specifies math courses in more detail. Civil Engineering also requires chemistry, physics and one additional area of science. This would tend to imply that we might expect to see more math and basic sciences in the civil and electrical engineering programs. Civil engineering specifically mandates more breadth "four areas appropriate to civil engineering," "design…in at least two engineering contexts," and also explicitly lists different types of professional competency and design constraints. Thus, one may expect civil engineering programs to include more credit hours of engineering than the other two.

Table 3 provides the average credit hours in each of the four categories of hours reported in ABET Table 5.1 (full data, arranged per individual program are provided in Appendix F) for each examined discipline (civil, electrical, and mechanical). The percent of the total curriculum (on average) is also shown to indicate the distribution of hours within the curriculum. The range of hours in each category as well as the standard deviation and the coefficient of variation are shown. Table 3 clearly shows that in no category do the three discipline's curricula differ by more than two credit hours (less than one standard semester course). Full ANOVA testing verified this (except in the case of math and science hours where, though statistically different, the disciplines did only differed by 2.1 hours).

It is important to realize that general education in ABET terms is more limited than the conventional higher education definition of a general education core because math and science have been removed and treated in their own category. Not having a uniform definition across institutions, "general education" and "other" showed the most relative variation across institutions as demonstrated by the higher coefficient of variations. Given the broad guidelines for "general education" and "other" in terms of definitions and hours required, these were combined into a single category "General Education and Other (GEO)" in counterpoint to the well-defined and "math and basic science" and "engineering topics" that have minimum

hours/curricular fraction specified. In summary, Table 3 indicates that despite reasonable expectations to the contrary, credit hours are (on average) not distributed differently for civil, electrical, and mechanical engineering programs across the U.S.

Table 2: Breadth Comparison of Civil, Electrical, and Mechanical Engineering Program-Specific Criteria [3]

	Civil Engineering	Electrical Engineering	Mechanical Engineering
Math and Science	apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science	mathematics through differential and integral calculus; sciences (defined as biological, chemical, or physical science); advanced mathematics, such as differential equations, linear algebra, complex variables, and discrete mathematics	apply principles of engineering, basic science, and mathematics (including multivariate calculus and differential equations)
	apply probability and statistics to address uncertainty	probability and statistics, including applications appropriate to the program name	
Engineering	analyze and solve problems in at least four technical areas appropriate to civil engineering	engineering topics (including computing science) necessary to analyze and design complex electrical and electronic devices, software, and systems containing hardware and software components	prepare students to work professionally in either thermal or mechanical systems while requiring topics in each area
	design a system, component, or process in at least two civil engineering contexts		to model, analyze, design, and realize physical systems, components or processes
	include principles of sustainability in design		
	conduct experiments in at least two technical areas of civil engineering and analyze and interpret the resulting data		
	explain basic concepts in project management, business, public policy, and leadership		
	analyze issues in professional ethics		
	explain the importance of professional licensure		

Table 3: Observed Distribution of Hours by B.S. Degree Program Type

	Math & Basic Science Credit					
Program	Average (hours)	Average (% total hours)[1]	minimum (hours)	maximum (hours)	Std. Dev. (hours)	COV (%)
Civil	35.55	27.47	32.00	44.00	3.11	8.75
Electrical	34.74	26.53	29.00	50.00	4.17	11.99
Mechanical	33.44	25.92	30.00	42.50	2.01	6.01
	Engineering Topics					
Program	Average (hours)	Average (% total hours)[1]	minimum (hours)	maximum (hours)	Std. Dev. (hours)	COV (%)
Civil	65.56	50.42	55.00	75.00	4.94	7.53
Electrical	64.88	50.28	46.00	77.00	6.81	10.50
Mechanical	67.35	52.12	54.00	82.00	6.49	9.63
	General Education					
Program	Average (hours)	Average (% total hours)[1]	minimum (hours)	maximum (hours)	Std. Dev. (hours)	COV (%)
Civil	24.53	19.62	9.00	33.00	5.20	21.21
Electrical	26.06	19.76	9.00	54.00	7.08	27.15
Mechanical	25.34	19.22	9.00	43.00	6.86	27.06
	Other					
Program	Average (hours)	Average (% total hours)[1]	minimum (hours)	maximum (hours)	Std. Dev. (hours)	COV (%)
Civil	5.04	2.49	0.00	15.00	4.83	95.84
Electrical	6.10	3.66	0.00	23.00	6.32	103.59
Mechanical	5.87	2.87	0.00	17.10	5.79	98.55
	General Education + Other (GEO)r					
Program	Average (hours)	Average (% total hours)[1]	minimum (hours)	maximum (hours)	Std. Dev. (hours)	COV (%)
Civil	28.50	21.94	18	39	5.62	19.70
Electrical	30.26	30.26	20	56	7.72	25.50
Mechanical	29.16	29.16	16	45.4	7.28	24.96

1 Avg % is the hours in subject divided by total hours in program averaged across all programs

As significant differences were not observed between the 33 civil, 45 electrical, and 43 mechanical programs, the 121 programs can be treated as a single group or sample. These 121 programs showed the following distribution of credits: math and basic science 27%, engineering topics 51%,and GEO topics 22%. This distribution is shown graphically in Figure 3. Comparing Figures 2 and 3 clearly answers the question: “how programs spend the remaining 38% of their curricula?” All three examined disciplines utilize these discretionary hours similarly, with 2/3 of the 38% (or~32 hours for the average 129 hour curricula) on GEO subjects. All of the programs invest 1/3 of the remaining 38% (or 16 hours) on additional engineering classes.

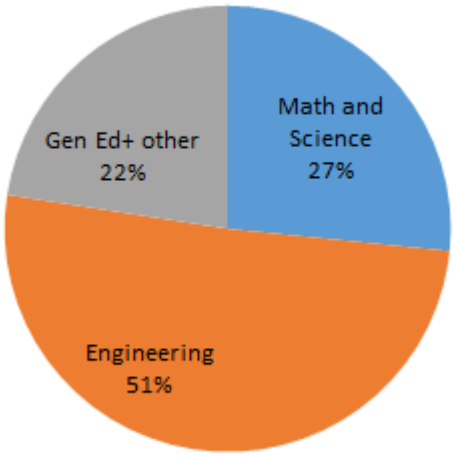


Figure 3 Observed Credit Hour Distribution across 121 U.S. Civil, mechanical and Electrical Engineering Programs

Discussion

Given that we can treat the three program types as one set of 121 programs, several additional anecdotal questions can be examined. One comment that sometimes arises in curricular discussions is "With our higher general education requirements, our total program hours must rise." Figure 4 explores this question by plotting total program hours vs. GEO hours. The plot as a whole shows that the average total program size is just under 130 credit hours over a very large range of GEO hours. The data set was divided into two pieces as there appears to be at least a qualitative difference in the plot at more than 36 credit hours of GEO. Neither trend is statistically significant, but if GEO hours have any impact on total credit hours, it is only when they account for more than 36 credit hours (nominally 27.5% of total curriculum).

Another comment that comes up frequently is "We have so much engineering credit hours that our total program hours must increase". Figure 5 indicates that, while there is a great deal of scatter, no significant trend exists between engineering hours and total credit hours. Total credit hours stay just under 130 hours regardless of the number of engineering hours. Given that total hours do not vary in any consistent way with engineering credit hours, the question now becomes "how can programs afford to offer more engineering hours." Figure 6 explores the relationship between engineering hours and GEO hours. Figure 6 indicates that at lower than 36 credit hours of GEO, Engineering hours decrease as GEO hours increase. This is not a statistically valid trend, but a qualitative observation. However, at more than 36 GEO hours Figure 4 indicates total hours may increase to accommodate the increase in GEO. Therefore, any relationship between engineering hours and GEO abruptly ceases at more than 36 credit hours as observed in Figure 6. This points to at less than 36 hours of GEO credits, programs increase engineering hours without increasing total hours, tend to do so at the expense of GEO hours. Conversely at less than 36 hours of GEO, increasing GEO hours tends to decrease engineering hours.

One driver for hour redistribution may be the newly proposed ABET EAC criteria. The newly proposed ABET EAC Criterion 5 standards are reworded for 30 hours of math and basic science and 45 hours of engineering topics[6]. This is a de facto reduction of 5 credit hours. Figure 3 and

the preceding discussions seem to indicate that total hours will not be reduced by these five hours, but that we may expect a rise in engineering topics credit hours.

Figure 4: Total Program Hours as a Function of General Education and Other Hours

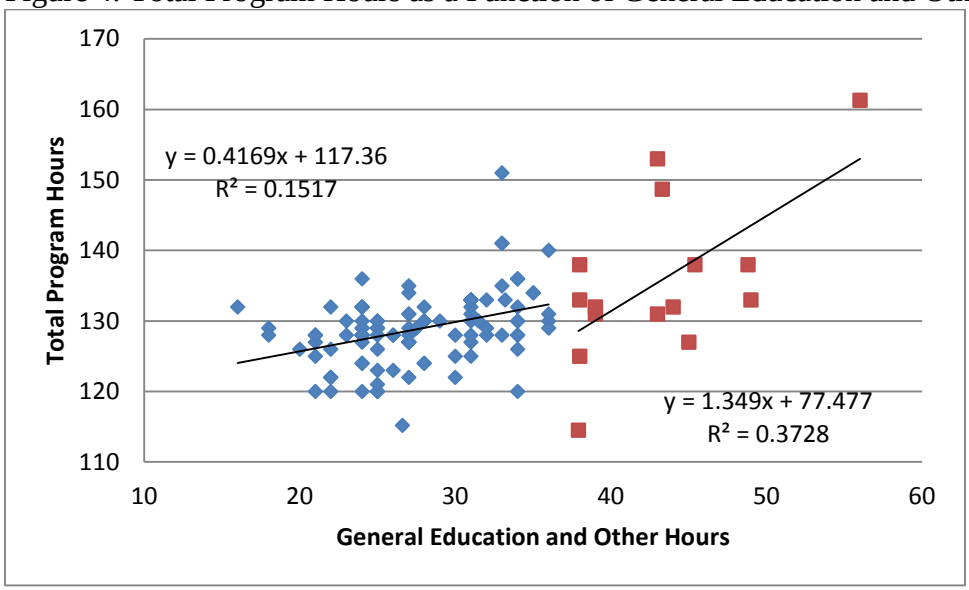


Figure 5: Total program credit hours as a function of Engineering Topic Hours

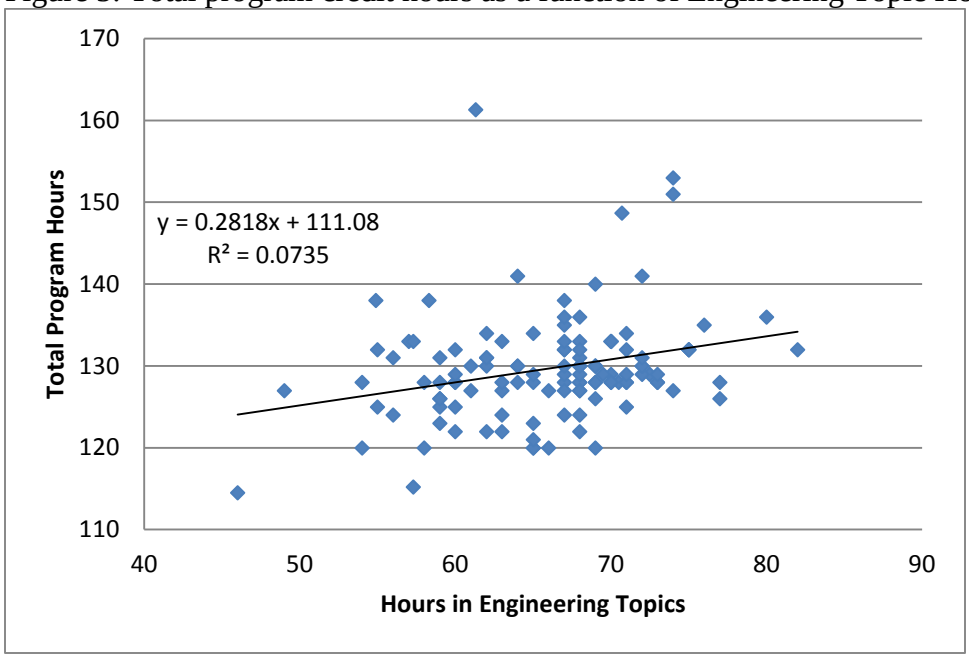
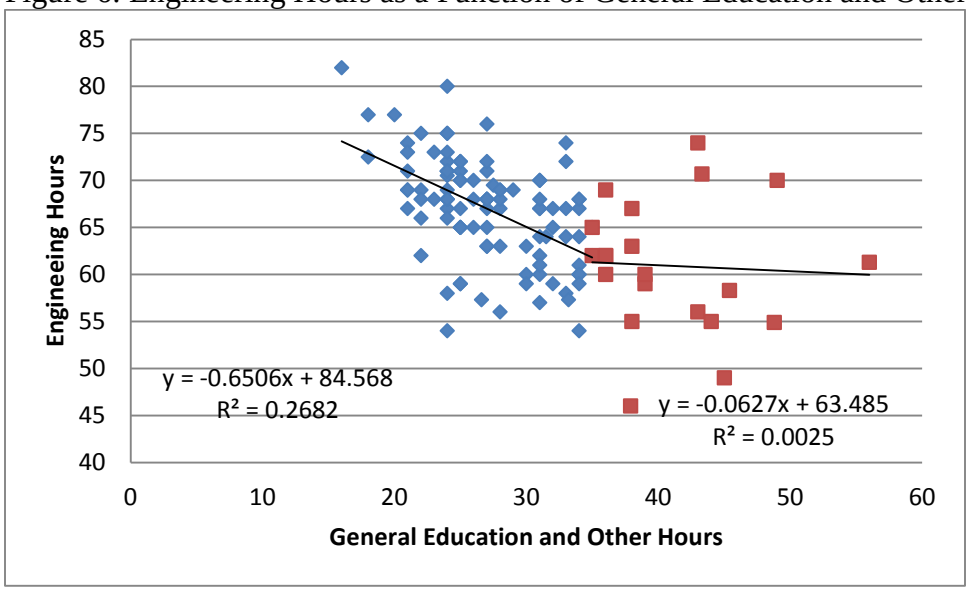


Figure 6: Engineering Hours as a Function of General Education and Other Hours



Curricular Implication on FE Exam Performance

Table 3 makes clear that all three examined disciplines have (on average) nearly identical total hours and nearly identical engineering hours. Two observations are made about the use of engineering credit hours within the disciplines. Firstly, program-specific requirements (Appendix B and Table 2) tend to drive civil engineering programs to use their engineering credit hours more broadly to cover these four areas of civil engineering. Mechanical and Electrical do not have this prescription and, therefore, have more freedom to add more depth in their engineering hours. Secondly, the civil engineering FE requires students to answer in depth questions in six broadly unrelated areas of civil engineering practice. It appears that electrical and mechanical engineering FE topics are more vertically aligned than civil engineering and would be supported by deeper not broader expenditure of engineering course hours. These observations fall in line with those reported in a recent paper by Fridley[5] discussing the alignment of civil engineering curricula, the ASCE BOK, and the FE exam.

Findings and Conclusions

An initial credit hour survey for the three largest engineering disciplines was performed. We believe that this survey of data will provide a baseline for comparison of future curricular changes across and among engineering programs. The most significant finding is that both the total credit hours and the distribution of credit hours within a curriculum do not vary, on average, across civil, electrical, and mechanical engineering.

In addition several anecdotal finding were made, including that when GEO (general education and "other") account for less than 36 credit hours, programs with higher GEO content do not have larger total curricular hours. Observations indicate that GEO hours greater than 36 are associated with curricula that are larger than the national average of just under 130 hours. There

is no statistically significant relationship between number of engineering credit hours and total curricular hours across 121civil, electrical, and mechanical engineering programs. For programs of less than 36 credit hours of GEO, higher numbers of engineering credit hours are associated with lower GEO hours. All of these observations indicate that if less hours are mandated by accreditation or other drivers, those hours will tend to be replaced with additional engineering hours.

In the future the authors hope to expand the number of institutions involved and look at other program characteristics including: type of institution (private or public), regional accreditation body, the intensity of research activities, and other factors.

Acknowledgement

The Authors would like to acknowledge the cooperation and support of ABET in allowing us supervised access to data and encouraging peer-reviewed publication of this anonymized data.

References

(1) ABET, 2017. ABET Program Search. Accessed February 10, 2017: http://main.abet.org/aps/Accreditedprogramsearch.aspx

(2) Yoder, Brian L. 2015. "Engineering by the Numbers 2015." from 2015 ASEE Profiles of Engineering and Engineering Technology Colleges, American Society of Engineering Education, Washington, D.C. Accessed February 10, 2017: https://www.asee.org/papers-and-publications/publications/college-profiles/15EngineeringbytheNumbersPart1.pdf

(3) ABET Engineering Accreditation Committee, 2014. Criteria for Accrediting Engineering Programs, November 2014, ABET Baltimore, MD. Accessed February 12, 2017: http://www.abet.org/wp-content/uploads/2015/05/E001-15-16-EAC-Criteria-03-10-15.pdf

(4) ABET Engineering Accreditation Committee, 2015 ABET Self-Study Questionnaire Template for a Self-Study Report, ABET Baltimore, MD. Accessed February 12, 2017: http://www.abet.org/accreditation/self-study-templates/

(5) Fridley, K.J., D. Williamson, and W. E. Back, 2016. The ASCE BOK, ABET Accreditation Criteria, and NCEES FE Exam - Are They Appropriately Aligned? 2016 ASEE Annual Conference & Exposition, New Orleans Louisiana, June 26, 2016. **DOIm**10.18260/p.26089. https://peer.asee.org/26089

(6) ABET Engineering Accreditation Committee. "Proposed Changes to Criterion 5" in Engineering Accreditation commission Comparison of Proposal Submitted in 2015 to Proposal Submitted in 2016., ABET Baltimore, MD. Accessed February 12, 2017: http://www.abet.org/wp-content/uploads/2016/08/EAC-Side-By-Side-Criteria.pdf

Appendix A1: ABET/EAC GENERAL CRITERION 5. CURRICULUM [3]

The curriculum requirements specify subject areas appropriate to engineering but do not prescribe specific courses. The faculty must ensure that the program curriculum devotes adequate attention and time to each component, consistent with the outcomes and objectives of the program and institution. The professional component must include:

(a) one year of a combination of college level mathematics and basic sciences (some with experimental experience) appropriate to the discipline. Basic sciences are defined as biological, chemical, and physical sciences.

(b) one and one-half years of engineering topics, consisting of engineering sciences and engineering design appropriate to the student's field of study. The engineering sciences have their roots in mathematics and basic sciences but carry knowledge further toward creative application. These studies provide a bridge between mathematics and basic sciences on the one hand and engineering practice on the other. Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet these stated needs.

(c) a general education component that complements the technical content of the curriculum and is consistent with the program and institution objectives.

Students must be prepared for engineering practice through a curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints.

One year is the lesser of 32 semester hours (or equivalent) or one-fourth of the total credits required for graduation.

Appendix A2[4]

- **Table 5-1 Curriculum**

Name of Program

Course (Department, Number, Title) List all courses in the program by term starting with the first term of the first year and ending with the last term of the final year.	Indicate Whether Course is Required, Elective or a Selected Elective by an R, an E or an SE.[1]	*Subject Area (Credit Hours)*				Last Two Terms the Course was Offered: Year and, Semester, or Quarter	Maximum Section Enrollment for the Last Two Terms the Course was Offered[2]
		Math & Basic Sciences	Engineering Topics Check if Contains Significant Design (√)	General Education	Other		
Add rows as needed to show all courses in the curriculum.							
TOTALS-ABET BASIC-LEVEL REQUIREMENTS							
OVERALL TOTAL CREDIT HOURS FOR COMPLETION OF THE PROGRAM							
PERCENT OF TOTAL							
Total must satisfy either credit hours or percentage	Minimum Semester Credit Hours	32 Hours	48 Hours				
	Minimum Percentage	25%	37.5%				

1. **Required** courses are required of all students in the program, **elective** courses (often referred to as open or free electives) are optional for students, and **selected elective** courses are those for which students must take one or more courses from a specified group.
2. For courses that include multiple elements (lecture, laboratory, recitation, etc.), indicate the maximum enrollment in each element. For selected elective courses, indicate the maximum enrollment for each option.

Appendix B: ABET/EAC Civil Engineering Program Criteria. Curriculum [3]

The curriculum must prepare graduates to apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science; apply probability and statistics to address uncertainty; analyze and solve problems in at least four technical areas appropriate to civil engineering; conduct experiments in at least two technical areas of civil engineering and analyze and interpret the resulting data; design a system, component, or process in at least two civil engineering contexts; include principles of sustainability in design; explain basic concepts in project management, business, public policy, and leadership; analyze issues in professional ethics; and explain the importance of professional licensure.

Appendix C: ABET/EAC Electrical Engineering Program Criteria. Curriculum[3]

The structure of the curriculum must provide both breadth and depth across the range of engineering topics implied by the title of the program.

The curriculum must include probability and statistics, including applications appropriate to the program name; mathematics through differential and integral calculus; sciences (defined as biological, chemical, or physical science); and engineering topics (including computing science) necessary to analyze and design complex electrical and electronic devices, software, and systems containing hardware and software components.

The curriculum for programs containing the modifier “electrical,” “electronic(s),” “communication(s),” or “telecommunication(s)” in the title must include advanced mathematics, such as differential equations, linear algebra, complex variables, and discrete mathematics.

The curriculum for programs containing the modifier “computer” in the title must include discrete mathematics.

The curriculum for programs containing the modifier “communication(s)” or “telecommunication(s)” in the title must include topics in communication theory and systems.

The curriculum for programs containing the modifier “telecommunication(s)” must include design and operation of telecommunication networks for services such as voice, data, image, and video transport.

Appendix D: ABET/EAC Mechanical Engineering Program Criteria. Curriculum[3]

The curriculum must require students to apply principles of engineering, basic science, and mathematics (including multivariate calculus and differential equations); to model, analyze, design, and realize physical systems, components or processes; and prepare students to work professionally in either thermal or mechanical systems while requiring topics in each area.

Appendix E: ABET/EAC Proposed General Criterion 5. Curriculum [6]

The curriculum requirements specify subject areas appropriate to engineering but do not prescribe specific courses. The program curriculum must provide adequate content for each area, consistent with the student outcomes and program educational objectives, to ensure that students are prepared to enter the practice of engineering. The curriculum must include:

a. a minimum of 30 semester credit hours (or equivalent) of a combination of college-level mathematics and basic sciences with experimental experience appropriate to the program.

b. a minimum of 45 semester credit hours (or equivalent) of engineering topics appropriate to the program, consisting of engineering sciences and engineering design, and utilizing modern engineering tools.

c. a broad education component that complements the technical content of the curriculum and is consistent with the program educational objectives.

d. a culminating major engineering design experience based on the knowledge and skills acquired in earlier course work that incorporates appropriate engineering standards and multiple constraints.

Appendix F Full Data Set

ID Coding		Hours					Percent Hours				
Program	ID#	total Hours	Math & Basic Science	Engin. Topics	Gen Ed	Other	Math & Basic Science	Engin. Topics	Gen Ed	Other	total percent
C	1	124	33	67	18	6	26.6129	54.03226	14.51613	4.83871	100
E	1	127	32	68	18	9	25.19685	53.54331	14.17323	7.086614	100
M	1	124	32	68	18	6	25.80645	54.83871	14.51613	4.83871	100
C	2	128	36	65	24	3	28.1	50.8	18.8	2.3	100.0
E	2	128	33.5	70.5	24		26.2	55.1	18.8	0.0	100.0
M	2	128	33	71	24		25.8	55.5	18.8	0.0	100.0
E	3	133	37	70	45	4	27.8	52.6	33.8	3.0	117.3
C	6	136	34	68	24	10	25.0	50.0	17.6	7.4	100.0
E	6	125	34	60	24	7	27.2	48.0	19.2	5.6	100.0
M	6	121	31	65	24	1	25.6	53.7	19.8	0.8	100.0
C	7	128	35	69	24		27.3	53.9	18.8	0.0	100.0
E	7	129	32	73	24		24.8	56.6	18.6	0.0	100.0
M	7	128	34	68	26		26.6	53.1	20.3	0.0	100.0
C	8	129	38.5	72.5	18		29.8	56.2	14.0	0.0	100.0
E	8	132	37	71	22	2	28.0	53.8	16.7	1.5	100.0
M	8	131	32	72	21	6	24.4	55.0	16.0	4.6	100.0
C	9	122	38	62	9	13	31.14754	50.81967	7.377049	10.65574	100
E	9	123	32	65	9	17	26.01626	52.84553	7.317073	13.82114	100
M	9	122	32	68	9	13	26.22951	55.7377	7.377049	10.65574	100
C	11	134	37	62	24	11	27.6	46.3	17.9	8.2	100.0
E	11	135	32	76	27	0	23.7	56.3	20.0	0.0	100.0
M	11	129	34	68	27		26.4	52.7	20.9	0.0	100.0
C	12	129	32	65	30	2	24.8062	50.3876	23.25581	1.550388	100
E	12	127	33	49	33	12	25.98425	38.58268	25.98425	9.448819	100
M	12	132	33	55	30	14	25	41.66667	22.72727	10.60606	100
M	13	132	33	60	27	12	25.0	45.5	20.5	9.1	100.0

C	14	130	39	68	23	0	30	52.30769	17.69231	0	100
E	14	130	32	67	25	6	24.61538	51.53846	19.23077	4.615385	100
M	14	130	33	72	25	0	25.38462	55.38462	19.23077	0	100
C	15	128	37	59	24	8	28.90625	46.09375	18.75	6.25	100
E	15	127	37	63	27		29.13386	49.6063	21.25984	0	100
M	15	127	35	61	24	7	27.55906	48.0315	18.89764	5.511811	100
C	17	120	32	66	15	7	26.7	55.0	12.5	5.8	100.0
E	17	120	30	65	25		25.0	54.2	20.8	0.0	100.0
M	17	120	32	54	21	13	26.7	45.0	17.5	10.8	100.0
C	21	131	38	62	31		29.0	47.3	23.7	0.0	100.0
E	21	127	33	67	27		26.0	52.8	21.3	0.0	100.0
M	21	126	33	59	34		26.2	46.8	27.0	0.0	100.0
C	23	130	32	69	26	3	24.6	53.1	20.0	2.3	100.0
M	23	127	32	74	21		25.2	58.3	16.5	0.0	100.0
C	24	128	32	70	26	0	25	54.6875	20.3125	0	100
E	24	126	29	77	20		23.01587	61.11111	15.87302	0	100
M	24	128	32	73	23	0	25	57.03125	17.96875	0	100
C	26	128	38	69	21		29.7	53.9	16.4	0.0	100.0
E	26	125	36	59	24	6	28.8	47.2	19.2	4.8	100.0
M	26	128	33	77	12	6	25.8	60.2	9.4	4.7	100.0
E	29	128	35	63	26	4	27.3	49.2	20.3	3.1	100.0
C	33	135	35	67	33	0	25.92593	49.62963	24.44444	0	100
E	33	130	32	62	36		24.61538	47.69231	27.69231	0	100
M	33	140	35	69	36		25	49.28571	25.71429	0	100
E	36	128	50	54	24		39.0625	42.1875	18.75	0	100
M	36	133	42.5	57.3	33.2		31.95489	43.08271	24.96241	0	100
E	38	120	30	65	18	7	25.0	54.2	15.0	5.8	100.0
M	38	120	30	69	18	3	25.0	57.5	15.0	2.5	100.0
C	39	129	37	67	24	1	28.7	51.9	18.6	0.8	100.0
E	39	129	34	70	25		26.4	54.3	19.4	0.0	100.0
M	39	130	34	68	24	4	26.2	52.3	18.5	3.1	100.0
E	40	123	39	59	22	3	31.70732	47.96748	17.88618	2.439024	100
M	40	125	33	71	21		26.4	56.8	16.8	0	100
E	41	136	35	67	32	2	25.73529	49.26471	23.52941	1.470588	100
C	43	128	40	67	21	0	31.25	52.34375	16.40625	0	100

E	43	128	36	68	21	3	28.125	53.125	16.40625	2.34375	100
M	43	128	34	73	21	0	26.5625	57.03125	16.40625	0	100
E	47	134	36	71	24	3	26.9	53.0	17.9	2.2	100.0
M	47	127	37	66	24		29.1	52.0	18.9	0.0	100.0
C	49	128	34	60	30	4	26.5625	46.875	23.4375	3.125	100
E	49	128	34	60	30	4	26.5625	46.875	23.4375	3.125	100
M	49	128	33	64	31	0	25.78125	50	24.21875	0	100
E	50	161.3	44	61.3	54	2	27.27836	38.00372	33.47799	1.239926	100
C	55	125	32	55	27	11	25.6	44.0	21.6	8.8	100.0
E	55	122	32	60	30		26.2	49.2	24.6	0.0	100.0
M	55	122	32	63	27		26.2	51.6	22.1	0.0	100.0
C	63	120	38	58	24	0	31.66667	48.33333	20	0	100
E	63	127	32	68	24	3	25.19685	53.54331	18.89764	2.362205	100
M	63	128	36	70	24	1	28.125	54.6875	18.75	0.78125	102.3438
C	64	132	34	67	31	0	25.75758	50.75758	23.48485	0	100
E	64	132	37	67	27	1	28.0303	50.75758	20.45455	0.757576	100
M	64	124	33	63	27	1	26.6129	50.80645	21.77419	0.806452	100
C	69	128	37	58	21	12	28.9	45.3	16.4	9.4	100.0
E	10	138	34.3	54.9	27.4	21.4	24.9	39.8	19.9	15.5	100.0
M	10	138	34.3	58.3	28.3	17.1	24.9	42.2	20.5	12.4	100.0
E	19	130	38	68	24		29.2	52.3	18.5	0.0	100.0
M	19	136	32	80	24		23.5	58.8	17.6	0.0	100.0
C	22	130	34.5	64	28.5	3	26.53846	49.23077	21.92308	2.307692	100
E	22	133	45	57	28	3	33.83459	42.85714	21.05263	2.255639	100
E	25	114.5	30.6	46	19.3	18.6	26.72489	40.17467	16.8559	16.24454	100
M	25	115.2	31.3	57.3	18.6	8	27.17014	49.73958	16.14583	6.944444	100
E	27	124	32	56	24	4	25.80645	45.16129	19.35484	3.225806	93.54839
M	27	131	33	62	20	16	25.19084	47.32824	15.26718	12.21374	100
C	28	131	33	59	30	9	25.19084	45.03817	22.90076	6.870229	100
E	28	130	32	64	30	4	24.61538	49.23077	23.07692	3.076923	100
M	28	129	33	60	30	6	25.5814	46.51163	23.25581	4.651163	100
M	30	153	36	74	43	0	23.52941	48.36601	28.10458	0	100
C	31	138	33	67	23	15	23.9	48.6	16.7	10.9	100.0
E	31	133	34	67	20	12	25.6	50.4	15.0	9.0	100.0
M	31	133	32	63	38		24.1	47.4	28.6	0.0	100.0

M	32	129	32	69.5	27.5		24.8	53.9	21.3	0.0	100.0
C	40	126	42	59	25	0	33.33333	46.8254	19.84127	0	100
E	45	129	33	72	24		25.6	55.8	18.6	0.0	100.0
C	46	133	32	70	24	7	24.06015	52.63158	18.04511	5.263158	100
E	46	133	34	68	24	7	25.56391	51.12782	18.04511	5.263158	100
M	46	134	34	65	24	11	25.37313	48.50746	17.91045	8.208955	100
C	51	131	36	68	21	6	27.48092	51.9084	16.03053	4.580153	100
E	51	130	35	61	34	0	26.92308	46.92308	26.15385	0	100
M	51	132	33	68	19	15	25	51.51515	14.39394	11.36364	102.2727
C	57	133	32	70	31		24.06015	52.63158	23.30827	0	100
E	57	131	32	56	20	23	24.42748	42.74809	15.26718	17.55725	100
C	59	132	33	75	24		25.0	56.8	18.2	0.0	100.0
E	59	128	33	71	24		25.8	55.5	18.8	0.0	100.0
M	59	132	33	75	24		25.0	56.8	18.2	0.0	100.0
M	61	148.7	34.7	70.7	40	3.3	23.3	47.5	26.9	2.2	100.0
C	62	132	35	75	22		26.5	56.8	16.7	0.0	100.0
E	62	126	35	69	22		27.8	54.8	17.5	0.0	100.0
M	62	132	34	82	16		25.8	62.1	12.1	0.0	100.0
E	68	129	33	71	24	1	25.6	55.0	18.6	0.8	100.0
M	68	130	33	72	24	1	25.4	55.4	18.5	0.8	100.0
E	71	130	33	69	28	0	25.38462	53.07692	21.53846	0	100
M	71	130	33	69	28	0	25.38462	53.07692	21.53846	0	100
C	72	141	44	64	33	0	31.20567	45.39007	23.40426	0	100
E	72	151	44	74	33	0	29.13907	49.00662	21.8543	0	100
M	72	141	36	72	33	0	25.53191	51.06383	23.40426	0	100