



Benchmarking IE Programs: 2005-2015

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Introduction

At the 2005 ASEE conference,¹ I reported on the 101 ABET accredited industrial engineering bachelors programs, asking and answering two questions:

- What do we agree that IE is?
- What are the unique courses we have in our programs?

In this paper, I update the findings of the earlier paper and also describe changes over 10 years. I did not trace the change or continuity in specific programs, but rather looked for overall trends. I found little change in the overall data on industrial engineering curricula, with perhaps a trend away from required courses to electives in engineering courses outside industrial engineering. The average number of faculty members in an IE department has increased and the average number of credits in an IE program has decreased. We still have a strong consensus about the content of an industrial engineering program.

Methods

I followed similar procedures as in the 2005 paper. I started with the 94 programs listed at www.abet.org as having ABET accredited programs in IE. For each program, I recorded:

- The number of faculty members,
- The department name,
- The degree name, and
- The highest level of degree awarded by the department.

In determining the number of faculty I counted the number of regular faculty members, omitting emeritus, visiting, research and adjunct faculty as well as lecturers; I counted faculty members listed as professor of practice, teaching professor, and dean, etc. I could not determine the number of faculty members for all programs.

As stated in the 2005 paper:

For each program, I examined the courses required for the IE degree program. For most courses I could classify the course by its title, but where the title did not give an obvious indication of its content, I looked at the catalog description. I did not look at any course syllabi so I have certainly misclassified some courses. I recorded the number of credits for each course.

I was able to find the required courses and credits for 89 programs. I omitted five programs because they use different units than credit hours or because I could not find credit hour information (Northwestern, Oklahoma State, Oregon State, UTEP, and Worcester).

Web pages

In the 2005 paper, I criticized our web pages, writing:

We all need to work on our web pages. Errors I found included courses listed twice, addition errors in the number of courses in a semester or in a program, spelling errors,

broken links, pages that won't load or won't print, an incredible number of clicks necessary to reach useful information, and so forth.

Perhaps the programs listened; our web pages are much improved, with few errors of the types I described, although I still needed many clicks to get to the useful information. Most programs do now provide (as I asked for in 2005):

a clear, one page, semester-by-semester (or quarter-by-quarter) description of the program, with title, number, and credit hours for each course; that page often contained links to the catalog descriptions of the courses. I salute these webmasters.

Changes in programs

The following changes occurred in the list of programs accredited by the ABET industrial engineering criteria. Seven programs no longer exist, five programs were created, and five programs still exist but are no longer ABET accredited. See Table 1 for the list of programs in these categories.

Table 1. Changes in ABET accredited Industrial Engineering programs 2005-2015.

Programs that no longer exist
University of Alabama
California State Fresno
University of Cincinnati
Cleveland State
University of Nebraska – Lincoln
University of Toledo
Marquette University
New programs
Inter American University of Puerto Rico, Bayamon
Liberty University
Oakland University
Texas A&M, Commerce
Texas State University
Programs that still exist but are no longer ABET accredited
Columbia
Cornell
Florida International
Stanford
University of New Haven

Three of the programs that are no longer accredited are primarily operations research programs (Columbia, Cornell, and Stanford). The 2005 paper reported on 101 programs; the above table is a net reduction of seven programs, leaving 94.

Because some of the changes occurred in programs that had been accredited a long time, the decade of first accreditation shows some changes, as shown in Table 2. The University of Alabama, Columbia, and Cornell were some of the initial programs accredited in 1936.

Table 2. Decade of first accreditation

Decade	Number in 2005	Percent	Number in 2015	Percent
1930s	11	11%	8	9%
1940s	5	5%	4	4%
1950s	19	19%	18	19%
1960s	14	14%	14	15%
1970s	20	20%	17	18%
1980s	18	18%	14	15%
1990s	9	9%	9	10%
2001	4	4%	8	9%
2010s	--	--	2	2%
Total	100	100%	94	100%

Some programs changed the name of the department or the name of the program. Fourteen programs added the word “systems” to the degree or department name; two dropped it (Rutgers and Texas A&M). Western Michigan and Western New England changed from Industrial Engineering to Industrial and Entrepreneurial Engineering and Industrial Engineering and Engineering Management, respectively. The department at Ohio State changed from Industrial, Welding and Systems Engineering to Integrated Systems Engineering.

The St. Ambrose program moved from the Department of Business to the Department of Engineering and Physical Science. Four departments combined with Mechanical Engineering (University of Rhode Island, Louisiana State, NJIT, and Southern Illinois); two separated from Mechanical Engineering (University of Illinois-UC and UTEP). Three universities changed name (University of Alabama-Huntsville added “The,” Cal State Hayward became Cal State East Bay, and SUNY Buffalo became University at Buffalo, SUNY). Wright State moved from quarter to semester system.

The departments at Cal Poly Pomona and South Dakota School of Mines and Technology now offer the Master’s degree. The department at Rensselaer Poly now offers the PhD. I could no longer find the MS degree in the department at the Polytechnic University of Puerto Rico. As shown in Table 3, the distribution of programs by highest degree awarded is almost unchanged.

Table 3. Highest IE degree awarded

Highest IE degree	Number in 2005	Percent	Number in 2015	Percent
PhD	67	66%	63	67%
Masters	24	24%	21	22%
Bachelors	10	10%	10	11%
Total	101	100%	94	100%

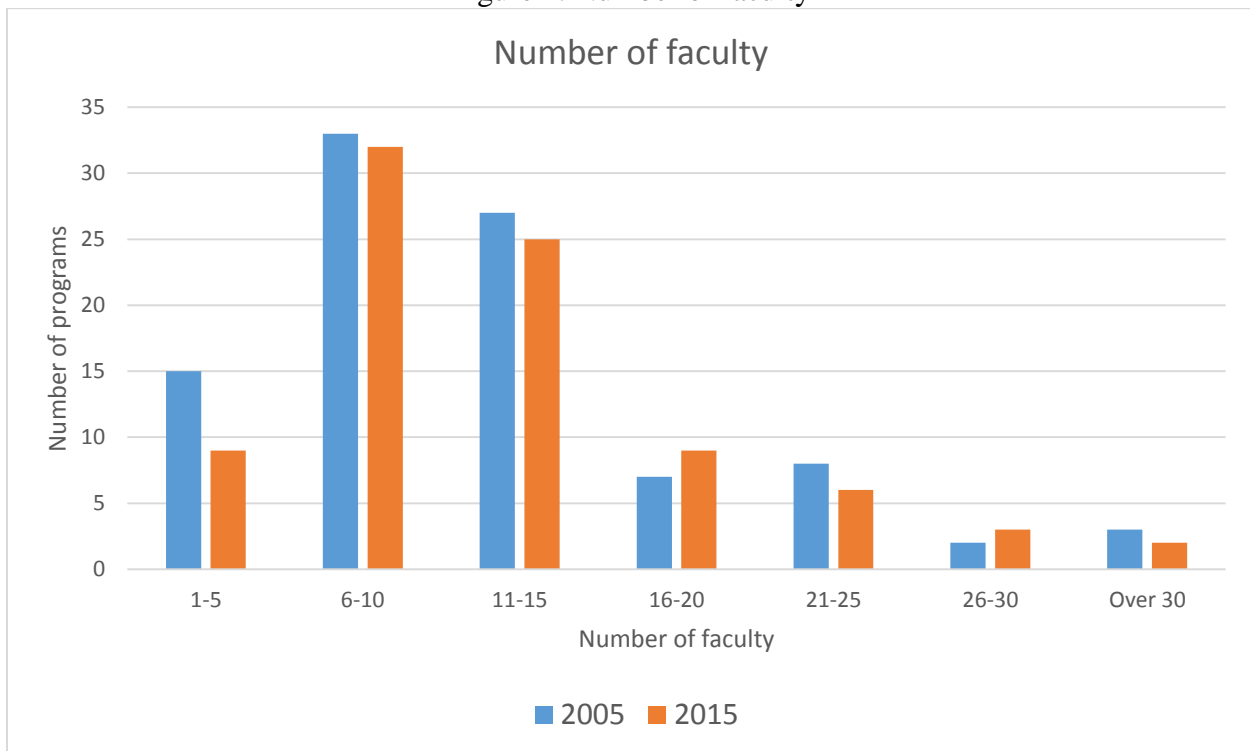
Number of faculty

As shown in Table 4 and Figure 1, the number of programs with only 1-5 faculty members has decreased from 15 to 9. The average number of faculty in an IE program has grown from 11.8 to 13.3. In 2005, three programs had more than 30 faculty members: Purdue with 31, Stanford with 34, and Georgia Tech with 63. In 2015, two programs had more than 30 faculty members: the University of Michigan with 40 and Georgia Tech with 57. Purdue dropped from 31 to 25 faculty and Stanford's IE program is no longer ABET accredited.

Table 4. Number of faculty. Entry gives the number of programs.

Number of faculty	2005	2015
1 to 5	15	9
6 to 10	33	32
11 to 15	27	25
16 to 20	7	9
21 to 25	8	6
26 to 30	2	3
Over 30	3	2
Total	92	84
Average	11.8	13.3

Figure 1. Number of faculty



For 72 programs, I have the number of faculty members in 2005 and in 2015. Some programs had no change in the number of faculty or decreased or increased by only one (30 programs); 27 had a decrease larger than one and 37 had an increase larger than one. Figure 2 is a histogram of

the change in number of faculty. The largest decreases and increases are shown in Table 5. Rensselaer decreased from 24 to 16 and the department changed from Decision Sciences and Engineering to Industrial and Systems Engineering. Rensselaer’s previous department included faculty not in industrial engineering and while I tried to count only the IE faculty, perhaps I overcounted their faculty in 2005.

Figure 2. Change in the number of faculty

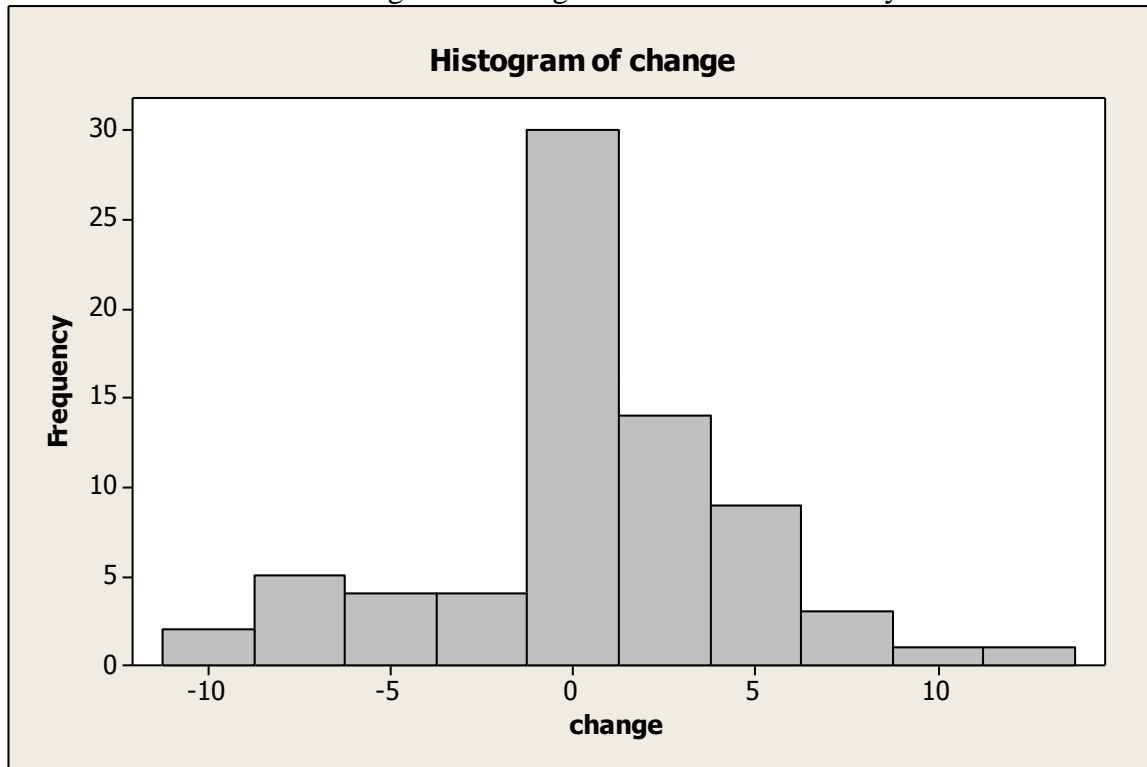


Table 5. Largest changes in the number of faculty

Largest decreases	From	To	Change
Western Michigan	21	12	-9
University of Arizona	20	11	-9
Rensselaer	24	16	-8
Largest increases	From	To	Change
Clemson	7	15	8
University of Florida	6	15	9
University of Michigan	28	40	12

In 2005 I reported that “Over half of all IE faculty members (598 [or 52%]) are in programs with 14 or fewer faculty members.” In 2015 the corresponding number is that 602 or 56% are in departments with 15 or fewer faculty members.

Program content

The information on program content is based on the 89 programs for which I was able to find complete information. As I said in 2005, “[t]hese results depend heavily on my judgment in classifying certain courses as similar” (emphasis in original).

Tables 6, 7, 8, and 9 show the most frequently required courses in four broad categories: mathematics and science, engineering, industrial engineering and other.

Table 6. Required courses in mathematics and science

Mathematics and science courses	Number in 2005	Percent of programs	Number in 2015	Percent of programs
Calculus	92	100%	89	100%
Physics	92	100%	89	100%
Chemistry	90	98%	85	96%
Differential equations, linear algebra, or both	68	74%	60	67%
Science or math electives	20	22%	27	30%

Table 6 shows that we still agree on the basic required courses in math and physics (calculus and physics). The number of programs requiring differential equations, linear algebra, or both has decreased and the number requiring science or math electives has increased.

Table 7. Required courses in engineering

Engineering courses	Number in 2005	Percent of programs	Number in 2015	Percent of programs
Computing	83	90%	82	92%
Engineering mechanics	77	84%	69	78%
Circuits	75	82%	57	64%
Materials	70	76%	48	54%
Technical electives	63	68%	56	63%
Computer graphics	58	63%	51	57%
Introduction to engineering	52	57%	50	56%
Thermodynamics	47	51%	29	33%
Engineering courses outside IE	91	99%	86	97%

While a large majority of programs still require engineering courses outside of IE, the percentage requiring each type of course dropped in every category and the average of such credits dropped from 13.6 to 10.7 credit hours. Notable drops occurring in circuits, materials, and thermodynamics. However, the percent of programs requiring some engineering courses outside of industrial engineering changed little.

Table 8. Required courses in industrial engineering

Industrial engineering courses	Number in 2005	Percent of programs	Number in 2015	Percent of programs
Operations research	92	100%	88	99%
Probability/statistics	90	98%	87	98%
Engineering economics	88	96%	85	96%
Work methods, human factors, or ergonomics	87	95%	80	90%
Simulation	80	87%	79	89%
Quality	79	86%	77	87%
Senior design project	70	86%	83	93%
Production planning and control	68	74%	67	75%
Manufacturing processes	65	71%	51	57%
Facilities, layout, material handling	60	65%	50	56%
Introduction to industrial engineering	43	46%	40	45%
Industrial engineering electives	41	45%	36	40%
Computer aided manufacturing or robotics	38	41%	22	25%
Engineering mgt or project mgt	21	23%	32	36%
Information systems	20	22%	14	16%
Systems analysis and design	18	20%	15	17%
Experimental design	17	18%	14	16%

As shown in Table 8, the only noticeable changes in IE courses are a drop in percent requiring manufacturing processes and an increase in the percent requiring engineering management or project management.

Table 9. Other required courses

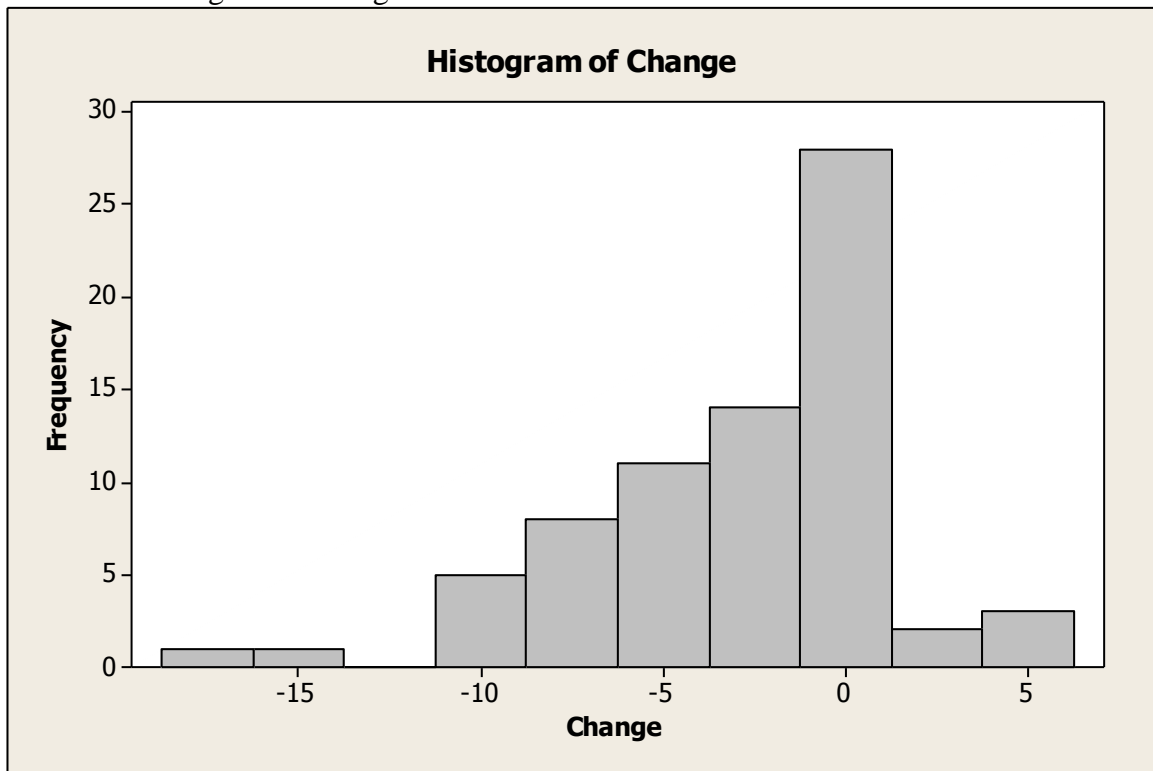
Other required courses	Number in 2005	Percent of programs	Number in 2015	Percent of programs
General education electives	90	98%	89	100%
English	79	86%	72	81%
Economics	38	41%	32	36%
Technical writing	36	39%	31	35%
Speech or communication	37	40%	35	39%
Free electives	26	28%	22	25%
Accounting	24	26%	16	18%
Ethics	17	18%	21	24%

Table 9 shows a notable drop in the percent requiring accounting and an almost equal increase in the percent requiring a course in ethics. With all of these findings, it is important to note that these topics (especially ethics) can be within other courses.

Total number of credits

For 73 programs, I have the number of credit hours in 2005 and in 2015. Many programs had no change in the credit hours or increased or decreased by only one credit (28 programs); of those with a change, only 5 had an increase, and 40 had a decrease in credit hours. Figure 3 is a histogram of the change in credit hours.

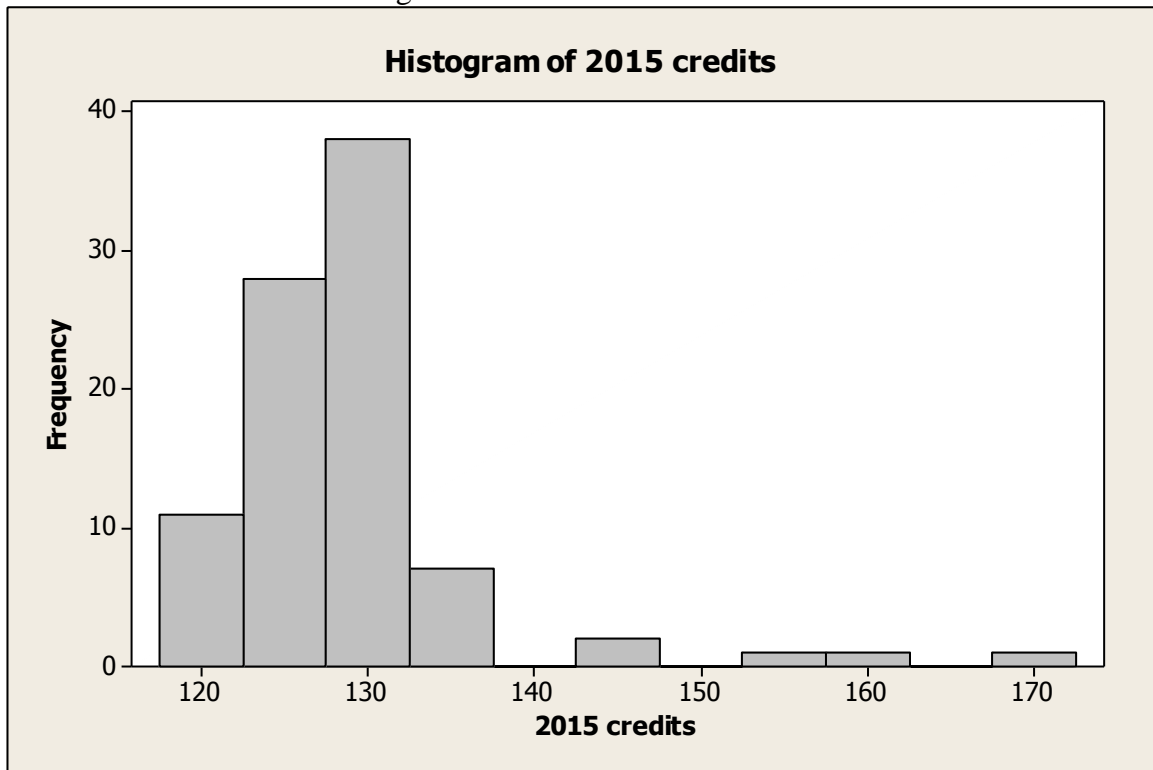
Figure 3. Change in total number of credits from 2005 to 2015



The two programs with the largest reduction in credit hours (19 and 16 credit hours) are the University of Puerto Rico-Mayaguez (from 174 to 156) and the University of Texas-El Paso (from 136 to 120). Other programs at UTEP require more than 120 credit hours (e.g. the BS in electrical engineering), so the change does not appear to have been driven externally, for example, by a state or university mandate. The average number of credits dropped from 129.5 in 2005 to 128.9 in 2015.

For 89 programs, I have the current number of credit hours. Figure 4 is a histogram of the number of credit hours in these programs.

Figure 4. Total number of credits



Programs with a large number of credits include three from Puerto Rico: Polytechnic University of Puerto Rico with 146, University of Puerto Rico-Mayaguez with 156, and Inter American University of Puerto Rico with 169; and two from the US: the University of San Diego with 147, and Kettering with 161. These programs are not different from others in any systematic way except in having a large number of credits in the program. A new program in Puerto Rico at the University of Turabo has only 129 credits.

In the 2005 paper I reported on some interesting unique courses and here I update their status:

- Anthropology is no longer required at Wayne State University
- History of technology is now a “suggested” course at the University of South Florida,
- Business law is still required at Milwaukee School of Engineering,
- Team leadership and facilitation are still required at North Carolina ATSU and Milwaukee School of Engineering,
- Reliability is still required at Cal State Hayward,
- Cognitive engineering is still required at Ohio State University,
- Fuzzy logic is no longer required at SUNY-Binghamton, and
- Entrepreneurship is no longer required at South Dakota School of Mines and Technology, but seems to have been replaced by three 1-credit courses on creativity and innovation, marketing technology innovations, and financing technology innovations.

Other interesting courses I found in 2015 include:

- Several programs include a 1-credit course title “professional practice” or similar.
- Milwaukee School of Engineering requires a junior project.
- Rutgers requires a course on sustainable energy.

- The University of Rhode Island has a course titled Engineering Economy and Project Planning

With its name change to Industrial & Entrepreneurial Engineering, Western Michigan’s program is distinctive in its three semesters of courses titled Entrepreneurial Engineering. For example, Entrepreneurial Engineering II, taken in fall of the junior year, is described as follows: “Topics covered include SWOT analysis, market research, product concept and design, risk analysis for innovative products, with emphasis on product development strategies for new designs and distribution alternatives.” The Program Educational Objectives include “Use engineering skills to support innovative ventures and activities.”

A generic IE program

In 2005, I had created for myself a generic IE program with 121 credit hours, which I did not include in the paper; I find this generic program still describes most of our programs; see Table 10. Indeed the five new programs fit this generic model fairly well.

Table 10. Generic IE program

English	6	Engineering Econ	3
Calculus	12	Operations Research	5
Diff Eq & Lin Alg	4	Manufacturing Processes	3
Chemistry	5	Facilities	3
Physics	10	Production	3
Statics	3	Quality	3
Dynamics	3	Simulation	3
Thermodynamics	3	Work methods	3
Intro to EN	3	Human factors	3
Computers	4	Senior design	4
Circuits	3	Tech electives	8
Probability and Stats	6	Gen Ed	18

Conclusions

The more things change, the more they remain the same. As I reviewed the programs, I saw changes, mostly small, but as shown in the tables above, the overall patterns have changed little. I note some trend away from required courses and toward electives in engineering outside IE. The number of faculty has grown and the number of credits has shrunk, but neither change is large. In conclusion, we still have a strong consensus about the content of an industrial engineering program.

Bibliography

1. Fraser, Jane M. “Benchmarking IE Programs.” ASEE Proceedings 2005.