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Comparison of Engineering Education in the United States versus the United Kingdom

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Introduction

There is debate within history books as to exactly who first made the assertion that "America and Britain are two countries divided by a common language." However, no matter who said it first, the statement is an acknowledgement that despite centuries of common goals and aspirations, as well as historic and cultural ties, the two countries have some very distinctive differences. A recent opportunity to teach for two terms at a major university in the United Kingdom, as part of the Fulbright Visiting Scholar Exchange program, provided an opportunity for one American engineering faculty member to examine the major differences in mechanical engineering education at universities in the two countries. Opportunities to associate with four different campuses in Scotland and England provided an excellent chance to compare and contrast how engineering higher education is conducted within these two nations on opposite sides of the Atlantic Ocean. The object of this paper is to examine significant differences which were found in the areas of course assessment, program assessment, degrees awarded, and educational environment.

Assessment in UK Public Schools

Any discussion of assessment of students in the UK higher education system should begin by looking at the public school system and how the assessment of students in that system forms the basis for admission decisions at UK universities. In the USA, students applying for university admission are generally assessed on the basis of their grade point average (GPA) in their high school classes and by scores on standardized tests, generally the SAT and/or ACT. In the UK, universities look at the number of "A-Levels" that a student acquired during their secondary education career and what subjects those occurred in. The General Certificate of Education (GCE) Advanced Level is commonly known as an "A-Level," and is the most common secondary school completion qualification.[1] A-Levels require studying an advanced level subject over a two year period and sitting for an examination at the end of each year. Most students anticipating university studies, work toward three or four A-Level subjects during years 12 and 13 of their secondary education. A-Levels are recognized by UK universities as the standard for assessing the suitability of applicants for admission to bachelorette studies. It should be noted, however, that the United Kingdom is actually made up of four countries (England, Scotland, Wales and Northern Ireland) operating under one crown monarch. They are allowed to set their own laws and standards. Thus, there is some disparity between how an A-Level is achieved in different parts of the UK. The Fulbright Commission points this out, saying of admissions considerations, "The most competitive universities will expect to see three A-Levels or their equivalent. This could include a minimum of three Scottish Highers, A-Levels alongside the Welsh Baccalaureate, the IB."[2]

In order for this mechanism to be meaningful, there must be consistency in the teaching of, and awarding of, A-Levels across the schools of the UK. Consistency is supposed to be controlled by the OFfice of STandards in EDucation (OFSTED).[3] OFSTED inspects and assesses public

schools. They generally give a school a 24 hour notice before descending on the facility and invading its classrooms, laboratories, and offices. Such a visit is considered extremely stressful by headmasters and faculty, particularly because a rating of "needs improvement" usually results in the removal of the headmaster.[4] There is serious concern about lack of training and consistency of OFSTED evaluators as well as the fact that they serve only as judges handing down assessments without recommendation for improvement and with no follow-up.[4] Nonetheless, this is the system under which assessment of secondary schools and secondary school students is made and which is used for admission decisions to UK universities.

University Degrees

We will now move on, and examine the university system in the UK, particularly in engineering. Engineering degrees awarded in the UK are a bit different from those in the USA. To add to the confusion, there is not consistency across the UK, as again the separation of governance in England and Scotland has led to different systems. During a 2015 Fulbright Visiting Scholar Exchange, the author had the opportunity to teach at an English University and visit three colleges in Scotland. Figure 1 shows the general flow of the four-year curriculum which led to the awarding of degrees of Bachelors in Engineering (BEng) and Masters in Engineering (MEng) at an English university.[5] This plan appears to be fairly typical of engineering programs in England. However, Figure 2 displays one example of a four-year program at a Scottish university. It should be noted, that while this program lasts four years, like the English program, it awards a highest degree of Bachelors in Engineering with Honors (BEngH).[6] Additionally, this program was found to be much less technically rigorous than either the English MEng or American BS engineering degrees. This absence of rigor in terms of higher level math and science skills and advanced engineering techniques results in a student graduating with a skill set quite different than most American institutions would consider applicable for an engineering BS degree. It is more in line with an American Associate of Science degree (AS). However, a second type of engineering degree program exists at some Scottish universities and appears to be much better aligned to the USA degrees, as shown in Figure 3. While it takes five years to complete, it will result in an MEng degree and will contain rigor essentially equivalent to USA programs.[7] Table 1 gives a side-by-side comparison the various programs.

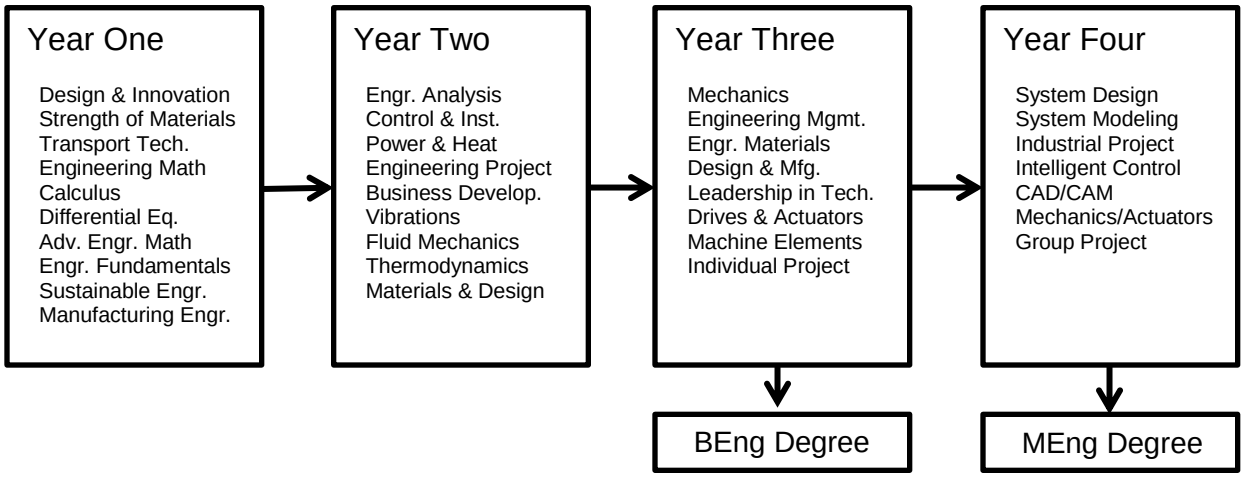

Figure 1: Flowchart of typical mechanical engineering degree program at an English university.

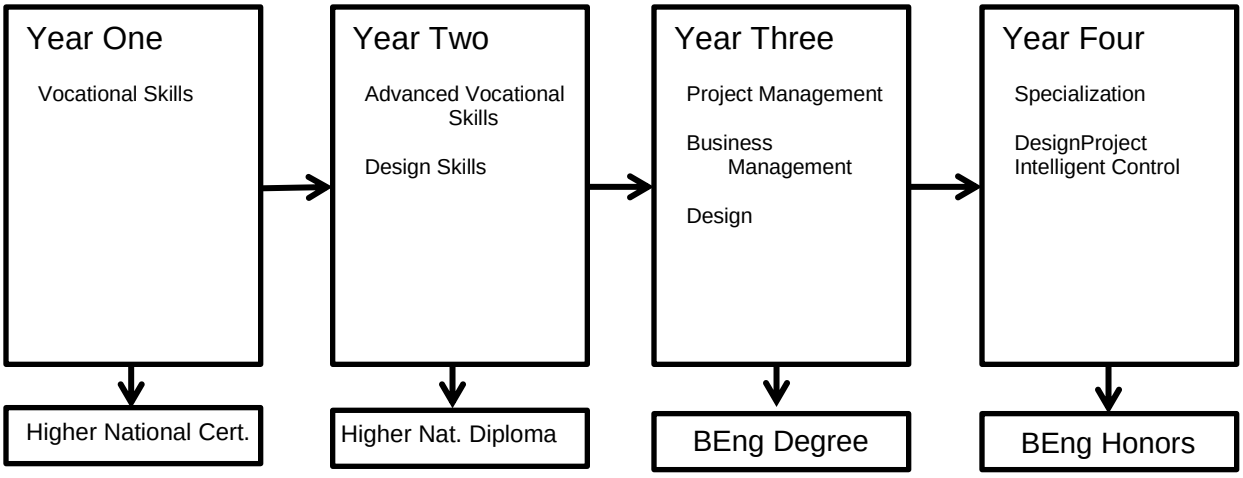

Figure 2: Flowchart of one sample of a mechanical engineering degree program at a Scottish university.

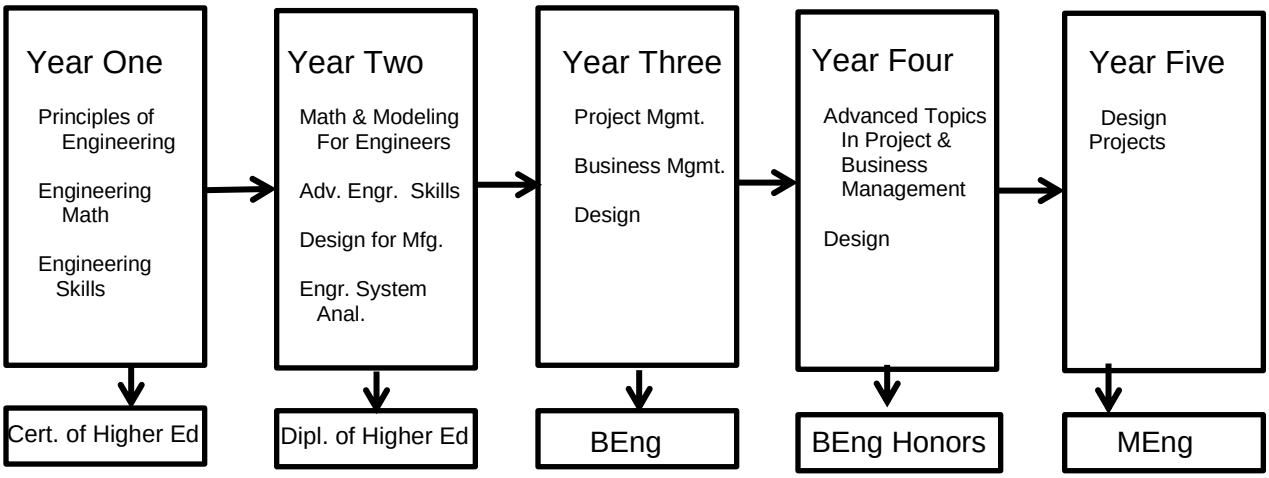

Figure 3: Flowchart of another version of a mechanical engineering program at a Scottish university.

Table 1
Comparison chart of UK and USA mechanical engineering degree programs.

University	Award at the end of year 1-6					
Scheme	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
USA		AS-ME		BS-ME		MS-ME
England			BEng	MEng		
Scotland 1	NHC	NHD	BEng	BEngHon		
Scotland 2	CHE	DHE	BEng	BEngHon	MEng	

Figures 1, 2 and 3 present an overview of the courses taken in a UK program. Note that there are no expectations for humanities, social science, or communication courses, whereas in the USA system, these classes may well account for 15-20% of the plan of study. A USA engineering degree typically has on the order of 50-60% of the plan of study dedicated to engineering courses and around 25-30% of the plan of study dedicated to math and science fundamentals. This indicates a different focus which is worthy of note. Another noteworthy difference is that the UK courses tend to be either lecture or independent project work, whereas the USA courses often balance lecture, lab, recitation, and class related projects all in once course.

Assessment of a Typical UK Course

Regardless of whether visiting English or Scottish institutions of higher learning, the assessment of student work was found to be significantly different than what the author was familiar with in the USA. A typical UK course would have one coursework assignment and one exam and the entire grade for the course was based on those two items. In some project courses, the entire grade was based upon a single assessment of one project. Thus, where a typical American engineering undergraduate course might have ten to twelve homework assignments, with two to four exams, and possibly a project as well, all of the UK schools visited during this Fulbright Experience graded a course on the basis of one to two coursework assignments and a single exam, or in the case of a project course, on a single project report. With a single coursework assignment possible, for an entire course, the American professor might well wonder just how involved the assignment is. The author had the opportunity to co-teach a class and create the coursework for it, and that sample assignment is described herein:

> **Background:**
>
> A new, inexpensive, hand-operated winch system is proposed by as an extension of an existing line of products. The new model, designated the Winchet 2200, is shown in Figure 4, and is detailed in attached assembly-level drawings.
>
> **Assignment Brief:**
>
> Utilizing the drawings which are provided, describe the manufacturing processes which you would select to bring the new Winchet 2200 from concept to production. Include a discussion of materials to be utilized and any restrictive tolerances. Also include a technical risk assessment of the final product, considering and ranking potential failure modes and selecting at least one possible failure mode for which you develop a risk mitigation plan.
>
> Use design and manufacturing technologies which you have been exposed to in this course, are familiar with from existing knowledge, or find during additional research. Detail your selected approaches and include rationale for their inclusion and the role that cost and manufacturing time played in your decisions. Include issues that impacted your thinking, such as the advantages of the processes you selected, benefits, quality of the final product, dimensional capabilities and constraints, as well as any disadvantages to your selection and any compromises made.

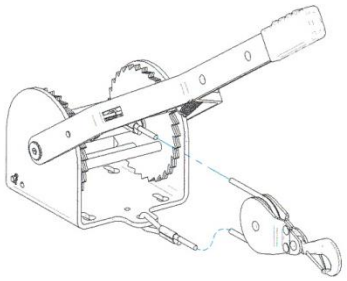

Figure 4: Sample figure used with the coursework described herein.

The rubric for grading such a coursework must be developed and shared with other faculty prior the coursework being assigned. The example given herein was worth 50 points and was assessed on the following basis:

- 15 possible points for an innovative approach to the problem posed
    - Demonstration of an understanding of the current process for manufacturing the product
    - Proposing an innovative approach to the problem that would allow for a method of fabrication to be implemented
- 15 points for technical content
    - Demonstrating a good technical understanding of the proposed design and manufacturing route
    - Sufficient detail to ensure that the proposed method would be considered a viable option
    - Economic/cost considerations
- 10 points for professional skills
    - Demonstration of a range of skills appropriate to a professional engineer.
    - Comparison of skills displayed against the requirements of the UK SPEC for a Chartered Engineer.
- 10 points for the report
    - Logical; report structure
    - Inclusion of sufficient detail for the proposed design and manufacturing process to be implemented
    - Thorough description, including technical data, costs, etc.
    - Clearly written report with correct grammar
    - Appropriate style for a technical report
    - Use of references

As co-instructor for the course, the author also was also tasked with writing one five-part, 25 point, question for the exam. In this case the student was given an example of a component in finished condition and the same component in as-cast, rough condition. The question asked for the following:

1. Discuss how recent advances in manufacturing automation have permitted industries to improve their operations and broaden their potential markets (6 points)

2. Describe two areas where the manufacturing automation has been recently imp[lamented in modern industries (4 points)
3. Compare and contrast why each of the following might be used, and on what type of products: a manual production line, and automated production line, and a manufacturing cell (6 points)
4. Discuss at least two relative advantages of a concurrent design process versus a serial design process (4 points)
5. Describe a typical process plan and routing sheet for the manufacture of the component supplied (5 points).

A marking sheet must be prepared for each exam question by the instructor who wrote the question. This marking sheet indicates how the questions will be assessed during grading, or as UK faculty refer to it, "marking." This marking sheet is done in considerable detail, listing the specific discussion points that would earn the student a point, or as the UK faculty refer to it, a "mark." The next step would seem quite unusual to the average USA professor, who writes his/her own exam, and grades it using his/her own judgment. In the UK environment, the exam question and the marking sheet are shared with other faculty members who are familiar with the class, and are then forwarded to external reviewers who assess them as to whether they are relevant to industry and/or whether they are comparable to similar questions at other universities with similar programs. After the reviewer has passed judgment on the exam and the proposed answers, it is approved for the students to take the exam. After the exam, the principle instructor marks the exam using the rubric. Then, the exam is sent to another faculty member who performs what is known as a "second marking," and the two sets of marks are compared for consistency and any discrepancies are remedied. American faculty members who the author has described this process to are usually quite taken-aback by the process. However, having lived with the UK approach for the better part of a year, the author rationalized this process. If the entire grade for a semester-long course is going to be based on one exam and one coursework, as opposed to multiple exams, assignments and projects in a USA course, then there is less room for error in grading than there is in the USA. Thus, it begins to make sense that more effort will be put into assuring complete, accurate, fair and consistent marking of the UK exams.

Exam Boards and Assessment

The next thing that an American professor will find curiously different about the UK system, is that at the end of each semester an Exam Board is convened. This meeting is attended by faculty from the engineering program as well as multiple external advisors. These advisors may be from industry or from other UK universities, and are generally members of the Institution of Engineering and Technology (IET) which is one of the world's leading professional societies for the engineering and technology.[8] The IET is licensed by the UK Engineering Council and the Engineering Accreditation Board to carry out accreditation assessments. In this regard they function a bit like a combination of the American Society of Engineering Educators (ASEE) and the Accreditation Board for Engineering and Technology (ABET) in the USA.

Exam boards review the results of each course relative to passes and fails. Students failing are often offered a "re-sit" or an opportunity to retake the exam, and possibly even re-submit

courseworks. A student's grade in a course is not final until the first tier exam board says it is. Furthermore, second tier exam boards review student work at the end of their plan of study, and make the determination of whether the student graduates and receives the intended degree. Graduating students in the UK are awarded a First Class, a Second Class (often divided into an upper and lower range, referred to as a 2.1 and a 2.2) or a Third Class passing ranking, or a Fail. This First Class ranking, frequently simply referred to as a "First," is treated as the mark of excellence much the way a GPA of 3.8-4.0 is in the USA. A high Second Class, or a "Two-One" is equivalent to a GPA in the range of an American grade of B. Table 2 shows a comparison of the UK and USA awards system.[9]

Table 2
Comparison UK Class Awards versus USA GPA/Letter Awards at degree completion

Classification	UK Mark	Description	USA Grade
First Class	70%+	Exemplary range and depth of attainment of learning outcomes	A
Upper Second Class (2.1)	60-69%	Conclusive attainment of virtually all intended learning outcomes	B
Lower Second Class (2.2)	50-59%	Clear attainment of most of the intended learning outcomes	C
Third Class	40-49%	Acceptable attainment of intended learning outcomes	D
Fail	0-39%	Deficient attainment of intended 1earning outcomes	F

Accreditation Assessment

In the USA, the normal routine for engineering accreditation assessment is a once-every-six-years visit by ABET. While this visit is rather intensive, it occurs so infrequently that some faculty members are prone to not thinking about it for long periods of time. However, in the UK, external reviewers participate in tier one and tier two exam boards. Their role in these meetings is not merely to aid in the determination of course and degree awards for students. They also present a report, after each exam board meeting, comparing their view of the school's performance, based on what they saw during the Exam Boards, to other universities and to recommended corrective actions from reports produced after previous exam board meetings.

Educational Environment

A number of differences in the educational environment were seen during the author's time in the UK. At the public school level, the dress code for both students and faculty is much more

formal than in the USA, frequently requiring ties and jackets. UK public schools are frequently run by religious organizations even though they are state funded, which could never happen in the USA. There is an early selection of career paths, such that the final years of secondary school begin the training for a college plan of study, or an apprenticeship for a vocational career.

At the university level, dress continues to be much more formal in the UK. This does not appear to be due to any form of regulation and enforcement, but rather is a mindset created after 12 years of dressing well in public school. Students just feel that the formal dress is appropriate. There is little focus on university sports, with numbers of spectators attending very limited. The concept of tens of thousands of people showing up for a university sporting event, as occurs regularly in the USA, is beyond the comprehension of UK students. When UK college students heard the level of expectation for exams, projects, and required homework assignments at USA universities, they were totally aghast at the amount of work required. By contrast, American students would probably have heart failure if they learned that some UK schools give only one exam, and that it may come at the end of the school year, which might be as long as long as 5 months after the end of the classroom sessions for the material being tested.

Conclusions

After his UK teaching experience, the author drew these general conclusions about the comparison between USA and UK mechanical engineering education programs:

- Compared to USA students, UK students seem de-incentivized for regular class attendance or working problems outside of the classroom
    - There are few collected homework assignments in the UK and the course grade is determined, to a great extent, by a single exam occurring at the end of the term, or perhaps even the end of the school year
    - Cramming before exams appears to often become the UK norm rather than performing a series of homework assignments to attain understanding of the material as the course goes along, as in the USA
- The quantity of assessment items (assignments, projects and exams) is much higher in the typical USA engineering program than in a reasonably equivalent UK program.
- Assessment scores for students on these assessment items in the USA tend to be much higher than in the UK.
    - A course average of B in a typical USA engineering class would be awarded for an average of 85%
    - A UK course average resulting in an Upper Second, or a 2.1, which equates roughly to an American grade of B, would be awarded for an average of approximately 65%.
- It is much easier to pass a course in the UK.
    - On a typical UK exam, with a requirement to answer three of an available four multi-part questions, if the student could answer one section completely and 25% of two other sections, an exam score in the mid 40% range could be attained.
    - This 40% would fail in virtually any USA classroom, but would pass in the UK with a Third Class rating

    - A student failing to pass in a UK class is very often afforded the opportunity to "re-sit" the exam, i.e. to take it a second time, whereas in the USA no second chance is generally given.
- Program-level assessments by external reviewers occur more often in the UK than in the USA
    - External reviewers examine the UK program as often as twice per year at exam board meetings
    - USA accreditation reviews occur on an every-six years basis via a visit by ABET

The author's initial impression of the higher education system in the UK was that the assessment of engineering students was much less rigorous in terms of the expectations for mastery and the level of effort required for a course. An additional initial impression was that engineers allowed to graduate at a minimum threshold in the UK were likely to be hired into industry engineering jobs for which they were far less qualified than their American student counterparts. Upon further study and reflection, however, it became clear that UK businesses viewed a Third Class diploma in much the same way a USA employer would view an American graduate with a 2.0 GPA, i.e. as minimally qualified to be a potential employee.

The author's initial impression was that the external assessment of UK engineering education programs was much more rigorous than in the USA, due to the frequent encounters between external reviewers. However, after attending a UK exam board meeting, the author realized that the primary difference was not in the frequency of the visits. Rather, the six year cycle of ABET visits is actually the more intense due to the extensive preparation required for the self-study document. The relationship between the reviewers and the faculty is short-lived and can be adversarial. On the other hand, in the UK, a long-running and positive relationship can be built between the faculty and the reviewers because they see each other frequently, come to understand each other, and can follow up on changes and improvements that occur year to year.

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