Work in Progress: I Didn't Know You Did That: A Case Study of Learning Outcomes Across Multiple Engineering Disciplines Compared to Biological and Agricultural Engineering.

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Abstract

Biological and Agricultural Engineering is a diverse discipline that encompasses skills which transcend across multiple fields of engineering. In addition to the base competencies that all engineering curricula demand from students, Biological and Agricultural Engineering (BAEN) students gain additional in-depth knowledge from a variety of core sciences. Unfortunately, there are still many misconceptions about the field and students' knowledge and skills, making it difficult for students to market themselves to companies. When it comes to hiring at career fairs, many companies do not realize that the attributes they seek from alternative disciplines, are also at the forefront of the BAEN knowledge base. This case study compares the curriculum and knowledge areas across multiple engineering departments at a university to those of the BAEN department. Knowledge gained from the study is then used to survey organizations which have employment positions which fit knowledge, skills and abilities (KSA) that BAEN students possess. This is a work in progress; however, we anticipate that from this work we will develop a more concrete narrative of the field of BAEN to provide students and recruiters with in identifying their KSAs.

Background

Anecdotal evidence from students in BAEN disciplines shows that undergraduates often face scrutiny from companies looking for hirees from 'more traditional' engineering majors such as mechanical, chemical, etc. Common complaints include being confused with other majors like biomedical engineering or agricultural sciences, being deterred from application cycles by lack of mention to BAEN on job listings and being generally disregarded in favor of more obviously related majors. Part of this frustration can be attributed to industry or company representatives lacking needed information about the BAEN degree [1]. Recruiters are sometimes given specific

instructions on what roles need to be filled. These same recruiters also make the first decision on who can be considered a qualified applicant. Due to misinformation about the breadth of the BAEN degree, it is possible that recruiters do not know to include BAEN students in their searches or signage [2]. Of course, this means that problem begins higher in the recruitment chain of command. There is room for improvement of communication to visiting companies on BAEN programs. Additionally, college students share responsibility to market themselves to employers - a skill universally needed for job seekers - regardless of major or job title [3]. Employers generally hire qualified applicants. We need to expand the understanding on all fronts of what it means to be qualified as a BAEN graduate. There is also a severe lack of peer reviewed studies on BAEN students' responses and feelings about their difficulties.

Methods

Misunderstandings about BAEN from industry

This study utilized standardized, open-ended interviews in order to facilitate an adaptable approach which collected the same information from each respondent [4]. Each interview was conducted in person at a university hosted career fair. The recruiters were chosen at random on the spot and participated voluntarily.

In order to better understand what misunderstandings, if any, companies may hold about BAEN students, we interviewed seven companies at a large career fair held by the engineering department at the university being studied. The recruiters were asked open ended questions regarding three categories of information: 1) major targeting, 2) previous information about the hiring pool, and 3) recruiter experiences or extra information. Major targeting questions encompassed answers about which, if any, major(s) companies specifically looked to hire or not hire at the career fair. These questions held basis in the fact that company profiles for the career fair website included a list titled "Majors Hiring" [5]. Questions under 'previous information' included answers about any information the recruiters had about the major or students before visiting the university. This information could come from the university itself, digitally or hardcopy, through word of mouth or from first hand experiences. The final category, recruiter

experiences, comprised a catch all of pertinent information not relayed by the other two; this included questions about relevant qualifications, alumnus/a status and student behavior or interactions at the booth. In addition to these open-ended questions, multiple survey-like questions on a 10 point Likert scale similar to the one used by Diop et. Al [6] were introduced for a clearer understanding of the aforementioned answers. These questions were grouped by construct as recommended by Davis and Venkatesh [7]. This grouping was more convenient for the interviewees and has no carryover effects [6] [7].

Table 1 Recruiter Interview Questions: the questions within each construct were asked together in an order benefitting the flow of conversation.

Construct	Items	Wording	Question Type
Major Targeting	HMT1	Do you target recruits by major or department?	Y/N
	HMT2	Who in your company decides what majors you should target?	Open ended
	HMT3	Is a student within the targeted major more likely to receive an interview?	Y/N
	HMT3a	How likely would they receive an interview?	Likert
	HMT4	Are majors outside of the target group less likely to receive an interview?	Y/N
	HMT4a	How likely would they receive an interview?	Likert
	HMT5	If you use an automated resume sorter, does it sort out by major?	Y/N
Previous information about the majors and hiring pool	PI1	What information, if any, did you receive from the university about the students, their respective majors, and skills?	Open ended
	PI1a	What information would you have liked to receive?	Open ended
	PI3	Why do/don't you list Biological and Agricultural Engineers as a major you are hiring?	Open ended
	PI4	Have you hired students from this university before?	Y/N
	PI5	Which department do most of your applicants come from?	Open ended
Recruiter experiences	RE1	Are you an A&M graduate? What degree?	Y/N
	RE2	Do students outside the target major approach the table?	Y/N
	RE3	Do you accept the Fundamentals of Engineering exam as a mark of qualification?	Y/N

*Coding of each question were designed as follows: HMT – H Major Targeting, PI – Previous Information, RE – Recruiter Experiences. Each code is followed by a number, for the question in that construct and sub/follow-up questions and indicated with a number and letter

Comparison of Learning Outcomes

This project offers a thorough comparative analysis of learning outcomes between all engineering majors offered at a large public engineering institution in the Southeast. All information was collected from the most recent published degree plan from that major [8]. Only mandatory curricula were counted toward the comparison as we understand any student may achieve mastery of other topics through elective courses. Additional criteria for the comparison limited learning objectives to those covered in the 2nd and 3rd years, aside from the common engineering core and foundational LOs as required by ABET standards and met by each discipline. Thirteen distinct engineering majors were identified: Aerospace, Biological and Agricultural, Biomedical, Chemical, Civil/Environmental, Computer Science, Electrical, Industrial, Materials Science, Mechanical, Nuclear, Ocean and Petroleum [9].

For the purpose of this comparison, engineering core and foundational topics included statics, dynamics, thermodynamics, materials science, multivariate calculus, differential equations, basic programming, physics (mechanics), and chemistry. These topics are covered primarily in the first year but are continually built upon in subsequent classes.

Morning Session
Same questions for all examinees per exam
Average of 2 minutes per question
Topics covered and percentage of questions:
- Mathematics, 15%
- Engineering Mechanics (Statics), 6%
- Engineering Mechanics (Dynamics), 4%
- Engineering Probability and Statistics, 7%
- Strength of Materials, 7%
- Chemistry, 9%
- Material Properties, 7%
- Computers, 7%
- Fluid Mechanics, 7%
- Ethics and Business Practices, 7%
- Electricity and Magnetism, 9%
- Engineering Economics, 8%
- Thermodynamics, 7%

Afternoon Session
Choose one of seven discipline modules:
- Chemical
- Civil
- Electrical
- Environmental
- Industrial
- Mechanical
- Other Disciplines

Figure 1 FE Exam Session 2013 Specifications. [12]

The ten LO categories were consolidated from a list of twenty-two learning outcomes identified by engineering faculty as important skills students should have acquired by the completion of their taught class [10]. These categories align well with the Fundamentals of Engineering Exam sections and topics covered throughout all seven discipline specific exams [11]. The FE exam is well known and accepted as a measure of engineering knowledge as its passing is required for any licensure track engineer in the United States and her territories by the National Council of Examiners for Engineering and Surveying (NCEES) [11] [12]. We recognize that an individual major is

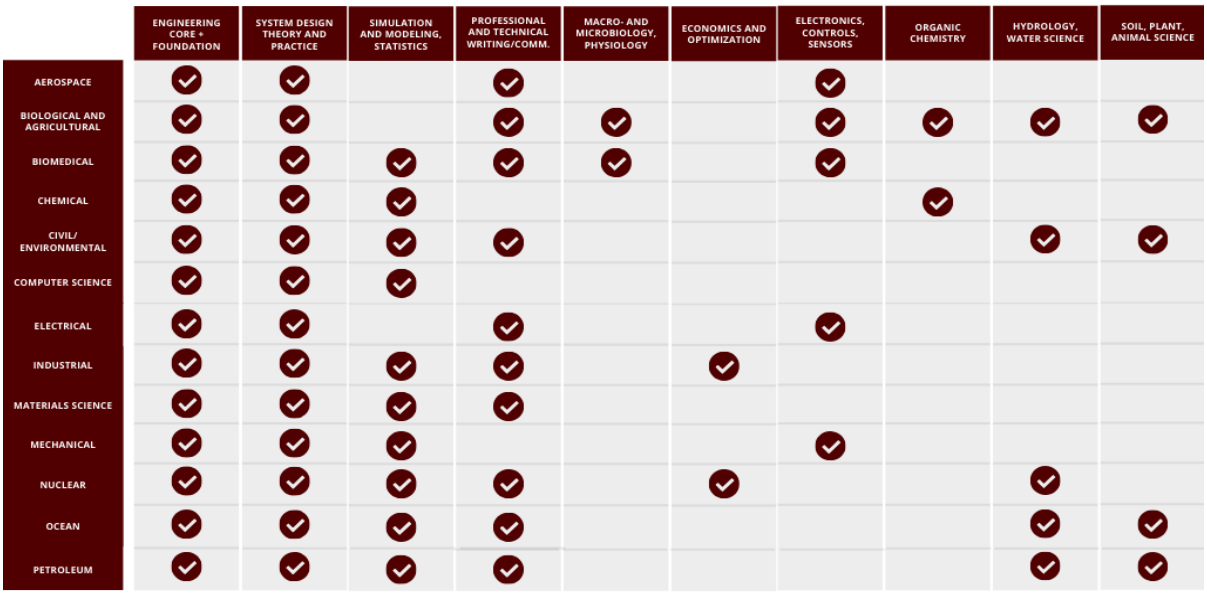
trained to succeed at its respective FE exam. Therefore, it is reasonable to assume that a competent civil engineer, for example, should do as well as a competent mechanical engineer provided that each is taking his or her discipline's exam. As there is no BAEN specific exam, the 'Other Disciplines' exam is used here as a stand in; however, BAEN students have been known to excel at other FE discipline exams [12].

Results

The 10 Learning Outcome (LO) areas identified were:

1. Engineering Core + Foundation: as defined above
2. System Design Theory and Practice: defining structure, architecture, and data of a system to satisfy specified requirements
3. Simulation and Modeling, Statistics: mathematical simulation and predictive modeling, statistics
4. Professional and Technical Writing/Communication
5. Macro- and Microbiology, Physiology
6. Economics and Optimization
7. Electronics, Controls, Sensors
8. Organic Chemistry
9. Hydrology, Water Science
10. Soil, Plant, Animal Science

Figure 2 Learning Outcomes (LOs) fulfilled by major during the 2nd and 3rd year.



These LOs directly prepare students with the knowledge covered on the non-discipline specific sections on the Fundamentals of Engineering exam as outlined in Figure 1. The BAEN LO competency is validated by the Other Discipline exam which spans the breadth of each box checked [11]. Specifically, the FE knowledge sections align like so (titles shortened):

LOs	Core	Sys. Des.	Stats.	Writing	Bio.	Econ.	Elect.	Chem.	Hydro.	Soil Sci.
FE section	1,8-13,15	4	2	5	2,6	7	4,14	3	6	6

It follows that these LOs also demonstrate and are supported by the ABET criterion 3 student outcomes (1-7) [13]. ABET outcomes 1-4 and 6 are directly satisfied by multiple of our identified LO, while 5 and 7 are met through in class activities and general training throughout the curricula [14]. We know that these LO support the ABET outcomes because this BAEN is an accredited program, thus providing additional validation.

Table 2 ABET criterion 3 student outcomes (1-7) [13]

1. ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

The interview data supported our claims that the FE exam is a valid comparative tool to predict student qualification for employers. The responses also show a link between what we identify as learning outcomes and what employers perceive as relevant knowledge, skills, and abilities (KSAs). Many recruiters agreed that students needed to have the correct, relevant curriculum in order to possess the KSAs the company was looking for in a candidate. However, recruiter knowledge of the actual curricula was mainly limited to assumptions based on personal experience (his or her degree) or perception (interns, general knowledge base).

Table 3 Interview Responses by Category

Major Targeting							
Company	**HMT1**	**HMT2**	**HMT3**	**HMT3a**	**HMT4**	**HMT4a**	**HMT5**
1	y	Recruiters	y	10	y	1	n
2	n	HR	y	n/a	y	n/a	n
3	y	Senior Staff	y	10	y	2	n
4	y	Recruiters	y	10	y	1	n
5	y	Senior Staff	y	10	y	2	y
6	y	Corporate	y	-	y	-	n
7	y	Recruiters	y	9	y	2	n

Previous Information					
Company	**PI1**	**PI1a***	**PI3**	**PI4**	**PI5**
1	n	none	Curriculum doesn't match	n	Petroleum
2	n	none	All engineers are well suited	y	Computer Science
3	n	none	Assume students have no interest	y	Civil
4	n	none	Specialized work	y	Civil
5	n	none	Not qualified	y	Civil
6	n	none	Little to no knowledge of BAEN	y	Mechanical
7	n	none	Curriculum doesn't match	y	Civil

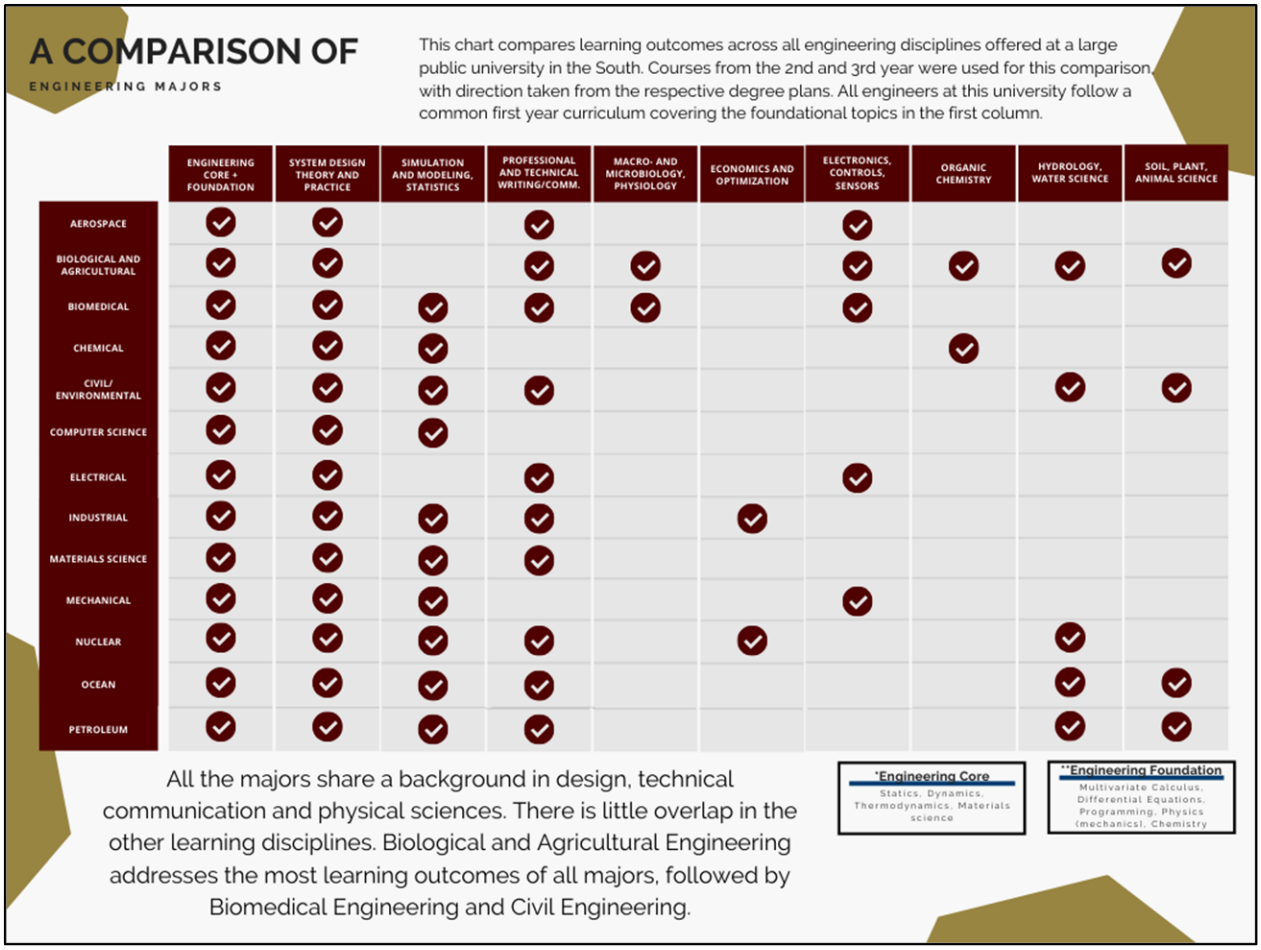
Recruiter Experiences			
Company	**RE1**	**RE2**	**RE3**
1	n	n	y
2	n	n/a	y
3	y	n	y
4	n	y	n**
5	y	y	n**
6	y	y	-
7	y	n	Y
**Required master's degree as minimum qualification			

Discussion

As made evident by the major comparison in Figure 2, BAEN curricula spans most LO areas touched on by other majors. Not only are BAEN students competitive, they have the widest breadth of knowledge mandatory of all majors offered [15] [9]. Biomedical engineering required the second most areas. This confirms that BAEN students possess the training requisite for even jobs that do not target them. It also complements the FE exam scores from 2019. During the administration of July-December 2019 'Other Disciplines' FE exams, examinees self-identified as agricultural or biological (non-biomedical) engineers had a pass rate of 84% and 80% respectively, compared with an average pass rate of 73% for other disciplines [11]. Both agricultural and biological engineer pass rates are up to 30% higher than the pass rates for other FE exam specialties.

In our interviews with the companies, we found that 86% of the companies do target specific majors while recruiting and that those majors alone were rated as extremely likely to receive an interview. All other majors outside the target group were rated as not at all likely to receive an interview. For recruiters, the major title is "a factor of just getting inundated" [16]. The recruiters relied on primarily first-hand experiences to discern the abilities found within each department, as the university provided no information about the different departments or the students therein. This is a critical area for strengthening communication to the company representatives. It is also a major opportunity to improve education. At the end of each interview, the recruiter(s) was shown an infographic incorporating the same chart as in Figure 2:

Figure 3 Infographic displayed to recruiters.



Each of the recruiters commented that not only was that information interesting and helpful, but also that it challenged long held beliefs about KSAs of each major. One company representative is quoted as saying the chart was “definitely helpful” and that “we’ve been kind of one-track mind” about the recruitment process. Most of the recruiters were repeat visitors to the university and approximately half were alumni. It is important to note that even as the university or the fields of engineering changed, since none of the recruiters ever received any clear information about the majors, their perceptions of the departments have not changed over the years. To illustrate this, I offer the example of a recruiter from a prominent civil engineering firm who debated me on the existence of discipline specific FE exams. That same recruiter denied BAEN as a major they would hire until being shown Figure 2. He then went on to say, “actually I’ve hired several of those [BAEN students] because they had to do a lot of GIS and hydraulics drainage. I’ve hired about 3 or 4 of them.” When presented with clear, organized information

about the majors, this recruiter was able to better remember and understand BAEN students as the asset they are to his company.

Conclusions + Recommendations

We conclude that not only are BAEN graduates are just as competitive as their peers in the knowledge, skills, and abilities they hold, but also that there is a severe lack in understanding that fact. This gap in understanding comes both from misinformation to hiring companies and from students discouraged or unable to explain their value as a new hire. This project further established the need for increase in communication between all parties. We have shown that learning outcomes selected by faculty members bolster BAEN breadth of knowledge. Additionally, we support our claim that our major comparison is backed by the standard for aspiring professional engineers, the Fundamentals of Engineering exam. Through first person interviews with actively recruiting company representatives we found a disconnect between the reality of the major curricula and the perceptions of those majors. These recruiters are the first line of defense against misinformation for the companies about students they meet at career fairs. In order to better overall understanding of BAEN students' abilities we recommended infographics much like Figure 3 be sent to company representatives before career fairs. These graphics should be up to date and include a comparison to all majors, as BAEN students will be compared to peers in other departments. Additionally, BAEN students should have access to discipline specific training on self-marketing. These trained students will make excellent combatants against misunderstandings. We were unable to conduct and cursory interviewing of BAEN students present at the same career fair. We recommend further research efforts to the experiences of these students as they navigate the job search process and how they fare after graduation. Though we expect BAEN students to succeed even in jobs for which they have not been targeted, those specific data are not available for this study. In future work with this subject we plan to collect more interview data with recruiters from a variety of STEM university career fairs. This data will be from companies both targeting, and not targeting BAEN students. This will lead to further insight and better generalization on the issues.

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