The Development of Mechanical Engineering Education at the University of Virginia and Virginia Tech

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

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Spring 2025

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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I. Introduction

In engineering education today, institutions use different means to teach students and future engineers. These institutions utilize means such as lecture-based classes, laboratory classes, and hands-on experiential learning opportunities to educate their engineering students. Some schools provide spaces for hands-on experiential learning opportunities, while others provide opportunities for hands-on learning directly as a part of their curriculum (Connor & Malzahn Kampe, 2002, pp. 7.563.1-7.563.2; Feigenoff, 2012, p.1). So why is it that these engineering schools don't use the exact same curriculum and deliver it in the exact same way? Why do some schools teach engineering topics in different ways and through different means?

If engineering schools teach their students through different means, could this have an impact on the skills that graduates may have? With the cost of a college education being relatively steep, it is important for students to understand what they will get from their respective engineering programs. There is roughly a $10,000 difference in yearly price for first year students at Virginia Tech and U.Va.'s engineering schools (University of Virginia Student Financial Services (n.d.); Virginia Tech Enrollment Management University Scholarships and Financial Aid (2024)). There is also roughly a $5,000 difference in starting salaries among mechanical engineering graduates from these two schools (UVA Career Center (n.d.); Virginia Tech Career and Professional Development (n.d.)). These factors might be what steers a prospective student towards one school or even causes them to pursue another career path.

In this paper, I argue that Virginia Tech and U.Va.'s undergraduate mechanical engineering programs have each been uniquely developed by different social groups. I argue that Virginia Tech's program has been shaped more by employer feedback and faculty implementation, while U.Va.'s program has been shaped more by accrediting bodies and student feedback, resulting in distinct programs. This claim and research question were supported through a social construction of technology (SCOT) analysis. Relevant social groups' roles in the development of each program were determined through interviews and surveys. The three social groups that will be analyzed will be students, those developing the programs (faculty and accrediting bodies), and employers. Each of these groups has previously been determined to have some sort of impact on the development of engineering programs, as seen in Connor & Malzahn Kampe (2002), Feigenoff (2012), and Froyd et al. (2012). The goal of this analysis was to understand how these relevant social groups have helped shape these programs and to see any possible differences in the programs that may have resulted.

II. Supporting Argument No. 1

In a mechanical engineering curriculum specifically, there are many key subjects that are taught, such as thermodynamics, statics, and fluid mechanics. A key culmination of such topics is the design of the engine and more specifically, the four-stroke engine (Radcliff, 1997, pp. 9, 107-109). The four-stroke engine uses many of these key mechanical engineering principles and is the powerhouse behind most all consumer vehicles today (Colwell, 2019, p.3). This may be covered in a survey mechanical engineering course. A mechanical engineering student may also be able to learn about this through hands-on projects, whether that is fixing their own personal vehicle, or if their school offers it, through working with a motorsports-related club. The point is, there are many different educational means for students to learn about important engineering subjects, such as the four-stroke engine.

At U.Va., the School of Engineering and Applied Science (SEAS) has supported the growth and implementation of these hands-on, "experiential", learning opportunities. A direct result and impact of this was the building of the Ann Warrick Lacy Experiential Learning Center (at Lacy

Hall), which is home to many experiential learning organizations. This building gives organizations such as Virginia Motorsports and Hoo's Flying their own space to work on projects. At the time, this demonstrated experiential learning as "an essential part of the student experience at the University of Virginia's School of Engineering and Applied Science" (Feigenoff, 2012, p.1). This effort was brought on by George Cahen Jr., a former professor and director of experiential learning, as well as Linwood A. "Chip" Lacy Jr. a U.Va. graduate and generous donor. Cahen notes that opportunities such as this give students experience aside from textbook readings and lectures.

In the early 2000s, Virginia Tech's College of Engineering experimented with implementing hands-on opportunities as a part of every freshman engineering student's curriculum as a part of their Engineering Fundamentals program (EF 1015 and EF 1016). This effort was brought on by students and industries, making it known that Virginia Tech's College of Engineering should implement shift methods of instruction. This is in response to engineering education shifting away from experimental learning and shifting more towards theoretical, lecture-based instruction over the last fifty years (Connor & Malzahn Kampe, 2002, pp. 7.563.1-7.563.2). Virginia Tech even has a Department of Engineering Education that studies such, in hopes to develop an engineering curriculum that suits the needs of modern society (Gonsalves, 2024, p. 5).

These two examples show how different social groups can have different impacts on engineering education styles, thus helping to create distinct programs. In the case of Lacy Hall, alumni and faculty have been key in emphasizing the importance of experiential learning at U.Va.. Conversely, in the Virginia Tech example, students and industry have been key in their curriculum's shift towards more hands-on classes.

Although this paper hopes to examine mechanical engineering curriculums at these schools, these trends in varied educational methods can also be examined at other institutions and other degrees. Some universities have examined the feasibility of offering a fully online undergraduate mechanical engineering program to better suit full-time workers (Fisher et al., 2007, p. 12.739.2). Software engineering programs have examined many different teaching methods that are utilized such as project-based learning and flipped learning (Aničić & Stapić, 2022, p. 76). David Harris, of the Department of Engineering at Harvey Mudd College highlights some of the positive and negatives of project-based, laboratory courses in computer engineering (Harris, 2001, pp. 367-368). He notes that engineering is more effectively taught by integrating theory into hands-on projects. He also notes that technical difficulties within these laboratory courses were a main downside. Nevertheless, different institutions, different programs, and different professors all approach teaching engineering in distinct ways for different reasons.

This same methodology can even be applied to non-engineering programs such as architecture. I know of architecture students who have chosen to spend their summers during college in various ways. Some chose to take summer internships, one chose to study abroad, and one even spent the summer working for himself. The point is the same general logic applies: students develop and are taught in many different ways. Educational institutions could have a strong impact on this (study abroad), or it could be left completely up to the student (summer internships and personal projects), each of which will create differences within students.

All students will exit an undergraduate mechanical engineering program with the same thing: a Bachelor of Science degree in mechanical engineering. So why don’t institutions teach the exact same curriculum and teach in the exact same way? These different educational backgrounds can produce students with very distinct skillsets. With potential employers looking for employees with certain skills, this may lead to different full-time positions following graduation that may have drastically different salaries. If these differences can all be tied back to an engineering school, why wouldn't they try to all mimic each other? Or could these differences be attributed to another group?

With the price of a college education being very steep, it is important for students to understand any potential costs and consequences of their college choice. The estimated cost of attendance for a freshman, in-state engineering student at Virginia Tech is $41,670 (Virginia Tech Enrollment Management University Scholarships and Financial Aid (2024)). Meanwhile, the cost of attendance for a similar engineering student at U.Va. is $51,160 (University of Virginia Student Financial Services (n.d.)). This is a significant difference in cost for two public, accredited engineering schools in the state of Virginia. Similar differences are shown in starting salaries of mechanical engineering graduates from Virginia Tech and U.Va. The most recent data from Virginia Tech shows that the median starting salary for mechanical engineering graduates was $76,000, while the average starting salary for U.Va. mechanical engineering graduates was $81,037 (UVA Career Center (n.d.); Virginia Tech Career and Professional Development (n.d.)). Again, this is a significant difference that can be tied back to engineering programs and their students.

In my work experience thus far, I have been able to work with engineers from many different institutions, with the majority of them in Virginia. These work experiences have also left me with the impression that engineers from varying institutions are better fit for different engineering roles, or at least that engineers from varying institutions tend to be currently in different types of roles. An engineering unit manager that I previously worked with noted how engineers from U.Va. and Virginia Tech are more likely to follow different engineering careers paths. This manager mentioned that Virginia Tech engineers are more likely to take on more technical engineering roles while U.Va. engineers are likely to take on management and leadership positions. On the contrary, I have also worked in positions where I have had Virginia Tech engineering graduates as my supervisors, or higher-ups. Nevertheless, this shows that this is a common understanding within engineering firms, at least in my experience.

Engineering programs, and mechanical engineering programs specifically, have surely changed and developed over time. These programs have developed their curriculum into what they are today, whether that is one that emphasizes theoretical, lecture-based learning, or possibly even a completely online curriculum. As previously mentioned, each of these undergraduate mechanical engineering curriculums is unique in their own way. This is why a SCOT analysis was performed: to understand each program's influences. SCOT claims that relevant social groups view technology in a different way, and that these groups must negotiate until a consensus is reached on how the technology will be developed (Klein & Kleinman, 2002, pp. 29-30). This SCOT analysis hopes to better understand why each of these curriculums is unique and who played a role in developing these mechanical engineering programs. The impact of the relevant social groups will also help to identify the cause behind any differences in the two engineering programs that are being examined. As mentioned previously, to keep the scope of this analysis narrow and relevant, only two large mechanical engineering undergraduate programs in the state of Virginia were analyzed: Virginia Tech and the University of Virginia.

III. Supporting Argument No. 2

A SCOT analysis was utilized to answer the research question of the impacts of different social groups on Virginia Tech and U.Va.'s mechanical engineering programs (Klein & Kleinman, 2002, pp. 28-34). As its name suggests, SCOT deals with the social shaping of technology. A key part of this framework is the idea of relevant social groups, each of which will hold a different interpretation or embodiment of the respective technology. They will each have individual wants and demands for the technology that will all impact its construction. The framework claims that although these groups may have different interpretations or wants for technology, they must all reach a consensus on how technology should be developed. This consensus may not be a fair consensus, however. Some groups' opinions may have greater importance than others in the consensus that is reached.

In this paper, the technology that will be examined will be undergraduate mechanical engineering programs at Virginia Tech and the University of Virginia. The involved social groups are split into those participating in the engineering program (students), those directly developing the programs (faculty and accrediting bodies), and those who indirectly benefit from the programs (any form of employer). Each group plays some sort of role in the process of becoming an engineer and has a different interpretation of these engineering programs. Examining each of these social group's impacts will help to identify the reasoning behind differences in these engineering programs.

There is not necessarily any explicit research that has examined these three social groups and their impact on engineering programs all together. However, prior literature on engineering education did separately identify these social groups as all playing some sort of role in engineering programs. One piece of literature describes the engineering faculty at Harvey Mudd College implementing new teaching methods and looking to students for feedback (Harris, 2001, pp. 367-369). Another piece of literature shows that industries and students have also had an impact on the development of first-year engineering education at Virginia Tech specifically (Connor & Malzahn Kampe, 2002, pp. 7.563.1). These separate examples show how relevant social groups have had an impact on the development of engineering programs, resulting in differences among programs. In the first example, faculty member David Harris' emphasis on project-based learning has led to questioning on why design is not implemented more into engineering classes. The second example shows that both industry and engineering education's feedback have led to Virginia Tech implementing more hands-on learning opportunities for first-year engineering students. This research took a similar approach, however by analyzing all relevant social groups together, the varying levels of impact upon engineering programs by different social groups can be examined.

In order to reach these social groups, surveys and interviews were conducted. Surveys were used to reach a large population of students and form a consensus opinion for student bodies. Interviews were utilized to reach faculty members at Virginia Tech and U.Va. The faculty members that were interviewed were those who would have the most impact on the development of their undergraduate programs or would have the most information regarding the development of their program. The employer that was interviewed was a former hiring manager who had many interactions with engineering graduates. The questions used for the surveys and the interviews were created with SCOT and the development of these engineering programs in mind. The focus of these questions was to see each social group's wants and demands for their respective mechanical engineering programs, as well as the extent to which these wants and demands were implemented in programs. The goal of the latter was to see the compromises that the different social groups took in the development of the mechanical engineering programs. The questions that were asked can be seen in Table 1 below.

Table 1

Different Questions Asked to Relevant Social Groups

	Students	Faculty	Employers/Researchers
1. Background	Do you have relevant experience in your field? Internships, research, TA, etc.	What is your role and what does that entail?	What does your group do? Where are the majority of your hires from (university)?
2. Demand	What do *you* want to gain out of your time in your engineering program? Hard skills? Soft skills? Research experience? Internships?	What do you hope that students leave your program with/what are the main things you trying to instill in students during their time in your program (hard skills, soft skills, etc.)?	What skills are you looking for in engineers? Are these skills you hope engineers have prior to employment or skills that are learned in the workplace? Do you notice a difference in skills among engineers from different schools?
3. Feedback	Have you had any opportunities to provide feedback to the university regarding their program? What was it? And did you see it implemented?	What feedback have you gotten regarding your program? Have you implemented any changes as a result? And if so, how?	Have you had any opportunities to provide feedback to the university regarding their program? What was it? And did you see it implemented?
4. Random	What have you enjoyed about your engineering program? Anything you haven't liked? Anything else you feel like sharing about your program?	Anything else you might like to share?	Anything else you might like to share?

Following their completion, responses to surveys and interviews were compiled. The level of impact of the three relevant social groups would then be recorded. Levels of impact from relevant social groups were also clarified by faculty members that were interviewed, as they had the most direct impact on the development of their respective programs. These responses would then be compared to see if different social group's impacts could be tied to any differences between the two programs.

The SCOT analysis allows for the impacts of multiple groups to be understood. At a higher level, universities are impacted by many groups, such as state governments, donors, or faculty. Nevertheless, universities and their programs are extremely complex systems, each of which are unique and shaped differently. Analyzing a few of these different social group's impacts together allows for a better understanding of how these engineering programs within these complex universities are shaped.

IV. Supporting Argument No. 3

U.Va. Mechanical Engineering

Following an interview with Natasha Smith, Professor and former Director of Undergraduate Mechanical Engineering as well as survey responses from U.Va. undergraduate mechanical engineering students, I made a few conclusions regarding the development of U.Va.'s program.

The first conclusion I made was that students' opinions are heavily considered in the development of the program. As a student at U.Va., I will say that we do receive semesterly course evaluation forms, as well as other opportunities to provide the department feedback. From survey responses, many students noted that they did not see any of these changes implemented during their time at U.Va. However, Professor Smith was actually able to provide examples of changes that had been implemented as a direct response to students' feedback. She did note that they do not like to implement curriculum changes in the middle of a student's time in the program, which would explain why students had not seen any of their feedback implemented. Some of the changes she noted were regarding not having enough hands-on opportunities, 2nd year Science, Technology, & Society (STS) courses, advising experiences, and committees on engineering-related clubs. Surveys responses from students did suggest that two main skills that students were looking for during their time in U.Va.'s program were hard skills and professional development. A direct result of this was the department revising their lab courses as an opportunity to improve hands-on opportunities and hard skills.

The second conclusion I made was that accrediting bodies, in this case the Accreditation Board for Engineering and Technology (ABET), has a large impact on U.Va.'s program. The majority of all engineering programs are accredited and must follow specific guidelines from ABET, however it seems as if U.Va. follows these guidelines very strictly. When asked about her main goal for the program, Professor Smith noted the seven specific ABET outcomes for an engineering program. Some of these outcomes include lifelong learning, communication, and problem-solving skills. Furthermore, she also noted the department has had to make some smaller, internal changes to some of their courses as per request of ABET. Again, most all engineering programs are overseen and reviewed by ABET, yet it seemed as if U.Va. was very adherent to these guidelines.

Virginia Tech Mechanical Engineering

An interview with Scott Huxtable, Associate Professor and Associate Department Head of Undergraduate Studies in Virginia Tech's Department of Mechanical Engineering as well as survey responses from Virginia Tech undergraduate mechanical engineering students led me to draw one main conclusion. I concluded that Virginia Tech's Department of Mechanical Engineering is heavily influenced by employers, and more specifically industry.

It’s important to note that both U.Va. and Virginia Tech’s departments have some form of advisory boards. However, it seems as if Virginia Tech’s advisory board spans more industries than U.Va.’s. This could be due to many different reasons. Professor Smith suggested that larger universities, such as Virginia Tech, will have more graduates end up at certain companies. A strong alumni network at a certain company may lead a company to be more willing to participate in a university advisory board, hence the difference in advisory boards between U.Va. and Virginia Tech.

I believe it is also important to note that it seems as if universities receive their industry feedback mainly through advisory boards, as opposed to individual employers or hiring managers. However, I am sure that this information from hiring managers is somehow relayed to employees of that company that participate in an advisory board. An interview with Scott Niedzialek of BWX Technologies led me to conclude this. He mentioned that in his former role as a section manager, he never had any opportunity to provide feedback to the universities that he hired engineers from.

Professor Huxtable also mentioned that Virginia Tech’s program highly encourages students to get some sort of industry experience. Their advisory board made it clear that they would like to see some sort of prior industry experience before hiring their program’s engineering graduates. Huxtable mentioned a bridge experience that they are implementing into their program. Students can fulfill this requirement by participating in undergraduate research, senior design, or internships. It seems that this bridge experience provides students with an opportunity to gain engineering experience, outside of the typical classroom setting. Virginia Tech even has industry sponsors for their senior design courses. This is something that U.Va. does not do, although I have heard talks of bringing in industry sponsors for senior design courses at U.Va.

Differences Between Programs

It also seems as if there are some larger factors that play into the differences between these two programs and the students they educate. To start, Virginia Tech and U.Va. are in very different locations. U.Va. is in the city of Charlottesville, Virginia, just about two and half hours south of Washington, D.C. Virginia Tech is in the town of Blacksburg, Virginia, about 45 minutes west of Roanoke in southwest Virginia. Although both of these schools are in the same state, and do attract students from many of the same areas, this surely still creates a difference in demographics among students.

Professor Huxtable also brought up an interesting point that highlighted some of the differences between engineering programs now, and engineering programs in decades past. He mentioned how growing up on a farm in New York, he was able to gain lots of hands-on, tinkering experience through working on various farm equipment. I concur with this; as someone who also spent a lot of time around farms as a kid, I was able to gain lots of hands-on experience, whether that was through building things or fixing equipment. The point here is that not all prospective engineering students have these kinds of opportunities any more. Professor Huxtable mentioned how many students these days gain tinkering experience through coding or working with Arduinos. What I believe this shows is a possible shift away from hands-on experiences in engineering and a shift towards more software, or computer-based engineering experiences.

Professor Smith also noted the different ethos of the two universities. As a university founded by Thomas Jefferson, there is a sense of U.Va. being a liberal arts school. Although U.Va. is much more than a liberal arts school, students, including engineering students, are still encouraged to gain a well-rounded and diverse education. This can be seen directly through U.Va. Engineering's Department of Science, Technology, and Society, where engineering students are exposed to topics and issues that are outside of a typical technical engineering education. Engineering students at U.Va. also have the opportunity to take any class outside of the School of Engineering and Applied Science for credit towards their degree. The official name of Virginia Tech, is Virginia Polytechnic Institute and State University. It would make sense that a school with polytechnic in its name would place an emphasis on technical education for their students.

I believe that the different ethos associated with these universities as well as their different locations lead these schools to attract different students. This in turn will also lead to differences among these two programs. As this paper suggests, students play a viable part in the development of these mechanical engineering programs, which is why I believe that these two reasons have also led to the two distinct and different programs at U.Va. and Virginia Tech.

So, what does this all mean? Clearly these programs are different, but what difference does that make? Scott Niedzialek mentioned that in his time hiring engineering graduates he saw a small difference between U.Va. and Virginia Tech engineers. He mentioned that a U.Va. graduate might have a bit more of a theory-based background, while a Virginia Tech graduate might have a bit more of a hands-on background. Nevertheless, he noted this wouldn't make an impact on who he hires, unless he is explicitly looking for someone with one of those backgrounds. At the end of the day, the main skills he looked for in engineering graduates did not seem to be tied to any specific school. These skills were communication, problem solving and planning. He noted that many of the technical skills that an engineer would need would be learned on the job.

V. Conclusion

This paper argues that Virginia Tech and the University of Virginia's mechanical engineering programs have been uniquely formed and impacted by different relevant social groups. Accrediting bodies (ABET) and students have had a profound impact on the development of U.Va.'s mechanical engineering program, while industry has had the most impact on the development of Virginia Tech's program. Input from relevant social groups involved in U.Va.'s program helps to show the impacts that accrediting bodies and students have had on the development of their program. It also shows some of the direct changes that have been implemented into U.Va.'s program such as changes to hands-on lab courses as well as changes to the advising experience for students. Input from relevant social groups involved in Virginia Tech's program helps show similar impacts, although mainly due to industry feedback. This impact can be shown through the bridge program that has been implemented at Virginia Tech. The impact has been mainly shown through Virginia Tech's emphasis on industry experience within their mechanical engineering program. Although these social groups have been shown to have created a difference among these programs, this does not seem to make a measurable difference among engineering graduates in the workforce.

The findings of this paper could be used to help prospective students better understand engineering programs and what they might be able to expect from them. Similar methods could also be applied to different schools and different programs to see who has helped to shape them and if they will have any long-term effects on graduates.

The main limitation of this argument and paper are the lack of social groups that data was gathered from and overall small sample size. Obviously, a larger sample size would have benefitted this paper. However, after interviewing faculty members, I can confidently say that they speak well for the majority of these social groups, as they are the ones with direct oversight and the most direct control of the development of the mechanical engineering departments.

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