Prioritizing Experiential Learning in the Classroom

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On my honor, as a 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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Introduction

Over the last half century, the world of engineering and technology has drastically shifted towards computer aided design (CAD) and manufacturing (CAM) because man has realized that a computers speed and computing power can be much more efficient than the human brain. Note the word "can" in the previous sentence. While computers might be able to solve complex integrals or matrices in less than a second, their abilities lack in areas that the human brain excels, such as being able to retain and analyze information from all five senses simultaneously. For technological breakthroughs to continue, engineers not only need to learn the foundations of engineering, like material science, electrical properties, force and stress relationships, etc. but they also need to learn how to implement current technologies to solve complex engineering problems. According to *The Importance of Supporting Engineering Education,* written by Frank Baldesarra,

> When students have access to better teaching methods, more information, and new technologies or tools - they improve their creative and learning potential. Creative engineering students at all levels, and particularly in postsecondary institutions, develop astonishing breakthroughs while still in school. Professors and teachers usually work closely with these students to refine their ideas and bring them to fruition. Universities are well-known hotbeds of innovation. A significant number of life-changing advancements are either developed in colleges and universities or began there. Some of these ideas lead to startup companies that become household names - Microsoft, Facebook, Dell, and Google, to name a few.

This prospectus serves to inform individuals about the importance of modern educational techniques and the direct relationship it has not only on university recognition, but more importantly, recent graduate success in the workforce. This research will also report on the significance of engagement in engineering clubs and societies for gaining practical hands-on experience with projects like building racecars, planes, robots, and more.

Technical Discussion

With the rapid growth of technology, many recent mechanical engineering graduates that do not participate in collegiate engineering clubs or have prior engineering internships have a hard time finding a well-paying job because of their lack of knowledge in one or more of the following:

1. Computer Aided Design (CAD)
2. Computer Aided Manufacturing (CAM)
3. Computer Programming
4. Finite Element Analysis (FEA)
5. Computational Fluid Dynamics (CFD)
6. Vibrational Analysis
7. Thermal Analysis
8. Fatigue Analysis

and this is only the bare minimum of a decent mechanical engineer. While there are Universities that have successfully adapted to more modern teaching styles, while also complying with ABET curriculum requirements, the number is few.

Within the Mechanical Engineering Department at The University of Virginia (UVA), there is only one, one credit required lab devoted to CAD and is taught using Autodesk Inventor

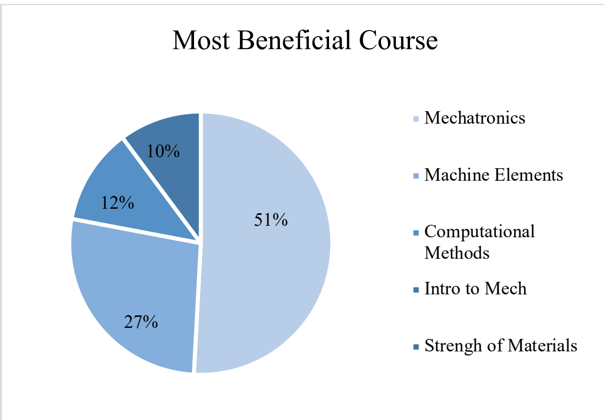
(The University of Virginia School of Engineering and Applied Science [UVA Engineering], 2022). While it is better than nothing, this class is structured in a way that almost all assignments are accompanied with step-by-step instructions for making models, which any good engineer knows, is not the right way to teach CAD. It also uses a software that is not commonly used in industry ("Introduction to Mechanical Engineering", 2022). On the contrary, the university provides students with a free Solidworks license yet rarely uses it in coursework, even though it is industry standard. Another required class within the Mechanical Engineering Department that deals with more hands-on education is Mechatronics, which "surveys basic electronics, electromechanical actuators, analog and digital signals, sensors, basic control algorithms, and microcontroller programming" ("Mechatronics", 2022). This class is recognized by many students in the department as one of the most relevant "real-world" courses and is extremely beneficial, but realistically, most mechanical engineering students would benefit more from a course of the same complexity and incorporate similar teaching styles, focusing rather on design, simulation, and manufacturing. This is not to discredit the course in any way, because in our current day in age, an understanding of electronics is key to any engineer's success, but to understand wiring and electrical components at a higher level than CAD as a mechanical engineer, is a cause for concern.

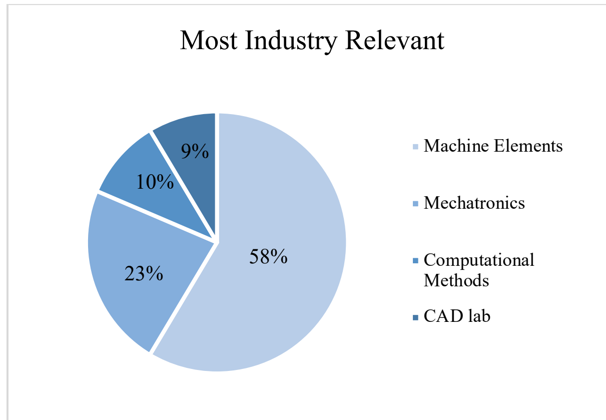
Figure 1 below contains data obtained from a Mechanical Engineering (ME) Curriculum Survey given to 32 fourth year mechanical engineering students. This survey was written and distributed by me and is not published online. The chart shows the four highest rated courses for two different categories:

1. Most overall beneficial required mechanical engineering course with Mechatronics ranking the highest at 51%.

2. Most relevant for gaining industry knowledge and skills with Machine Elements and Fatigue in Design ranking the highest at 58%.

Figure 1. *Mechanical Engineering Curriculum Survey Results (Created by Author)*





Based on the ME Curriculum Survey, Mechatronics ranked number one for being overall the most beneficial required course within the department (). A condensed list of learning objectives is as follows:

1. Fundamentals of electricity
2. Binary numbers and how computers work
3. Analog and digital input and output
4. PWM and motor control
5. Peripheral devices
6. ADC and sensors

The ME Curriculum Survey shows that this course was extremely beneficial because of the hands-on weekly laboratories that involved both hardware and software (ME survey). Students were able to control motors, create LED light displays, make video games, and as a final project, use techniques learned throughout the semester to improve a manufacturing method.

Machine Elements and Fatigue in Design ranked number one for being the most beneficial for gaining industry knowledge and skills (ME survey). Some key course objectives include buckling, shock and impact, reduction factors, shafts, gears, bearings, springs, and more. Students emphasized that the curriculum is extremely beneficial, but the teaching style is old-fashioned. In-class lectures and homework's had not been updated in years and the professor did not capture the student's interest well (ME survey). There were a handful of projects that incorporated CAD and it was optional to do FEA, but students claimed that it was very basic and not very beneficial.

Engineers must possess good problem-solving skills and be able to understand complex systems. Courses like calculus, physics, thermodynamics, strength of materials, etc. do in fact help weed out individuals that don't possess characteristics of good engineers and these should still be taught in a traditional way using hand-written numerical methods. I believe that after successfully completing these "weed out" courses, students should be allowed and encouraged to use a variety of computing methods when doing assignments and examinations. For example, rather than requiring students to solve complex partial differential equations by hand, spend a small amount of time explaining the theory and derivation, then allow students to write their own script to solve the problem. This not only saves a student over 75% of the time it would take them to do it by hand, but it also aids in their programming skills, which most employers find substantially more beneficial (Baldesarra, 2017). In fact, many companies now look for some level of programming experience when recruiting mechanical engineering graduates.

Based on the ME Curriculum Survey, computational methods is one of the highest rated courses for potential to be the most relevant course in the department because it "introduces numerical modeling concepts used in engineering simulation tools like computational fluid dynamics and structural mechanics analysis software" ("Computational Methods", 2022). Unfortunately, the way it is taught, is still tailored to understanding the mathematics behind these analyses. The course does not reach its full potential by not providing learning tools and engaging projects for complex softwares. Figure 2 shows some of the most commonly used software in industry for mechanical engineers, according to MechaniCalc, Inc.

Figure 2. *Most Used Software for Mechanical Engineers*

MathCAD	Nastran
Solidworks	Microsoft Excel
Unigraphics NX	Visual Basic for Applications (VBA)
CATIA	MATLAB
Ansys	Python

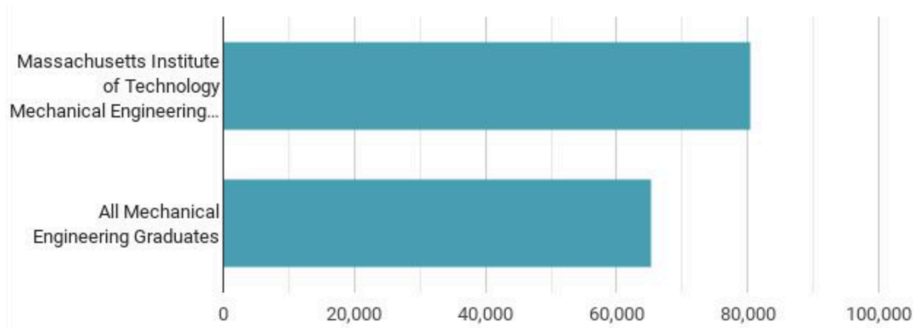
According to both students and industry professionals, mechanical engineers should be encouraged to learn how to use design and simulation softwares alongside the curriculum. In addition to Computational Methods being ranked highly for most potential, Machine Elements and Fatigue in Design also ranked highly because the course curriculum is extremely important, but the teaching style is very textbook oriented which students dislike (ME Curriculum Survey). Both courses can easily implement more involved programming, CAD, FEA, and more.

STS Discussion

The goal of this research is to determine which accredited universities provide mechanical engineering students adequate education on industry software and practices and obtain student feedback on these departments. The methods I will use to gather information are generic research from scholarly articles and academic conferences along with interviews and surveys with students and faculty at select universities including UVA. I would like to see the differences in some of the United States' most prestigious engineering schools and how they are either similar or different from UVA's mechanical engineering department. Not only will I relate required course curriculum for mechanical engineering, but I will also look at what electives are available and look more in depth into how professors teach ABET required courses (and if they allow more modern problem-solving methods). According to multiple sources including Edurank, US news and World Report, and Best Accredited Colleges, Massachusetts Institute of Technology (MIT) has the best mechanical engineering department in the United States (College Factual). It also lies in first place for being the most innovative university in the nation, which is why I will be focusing my research primarily on student and faculty feedback from their mechanical engineering department (College Factual). Additionally, MIT's post graduate income analytics are in favor of my theory that universities that emphasize the importance of hands-on experience and innovative teaching methods, result in increased average post graduate income. Figure 3, obtained from the article *Mechanical Engineering at Massachusetts Institute of*

Technology, shows MIT's mechanical engineering graduates' average salaries versus a pool of mechanical engineering graduates from universities across the nation.

Figure 3. *Salary for Mechanical Engineering Majors with Bachelor's Degrees*



The last issue I wish to address in my thesis is the importance of out-of-classroom hands-on projects and how they also directly influence job opportunities for new graduates. Not only do students get to design and manufacture components and work on their technical skills, they develop more soft skills from working with their peers, engaging in administrative work for clubs and organizations, and much more. Students should learn how to use engineering software in the classroom and easily transfer that knowledge to projects that spark their interest.

Conclusion

The world we live in is developing very rapidly, and engineering students should be learning about evolving technology and not solely the foundations of technology that have been developed over the last 5 centuries. While it is important to learn a base foundation of one's area of study, most engineers work in a very specific sector where they only require an in depth understanding of a select few topics. This directly relates to employers hiring process.

Nowadays, employers using automated resume screening methods to look for keywords. These keywords often include specific software that company uses, or “experience in” the area they are applying for. If a student has an exceptional educational background and good personality and work characteristics, there is a good chance their application doesn’t even get read by a real person due to a lack of experience in certain areas. There is no correct way to train the engineers of the future, but there are certainly ways to provide them with enough education and resources to be able to bring their ideas to life and make technological breakthroughs. This prospectus serves as a starting point for further research on the direct impact that more modern teaching styles and experiential learning have on recent graduate success, which goes hand in hand with the success of the universities engineering department.

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