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A survey to assess the importance of analysis in an undergraduate Mechanical Engineering curriculum

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Abstract

Among mechanical engineering (ME) educators, there are often competing views about the role of analysis in undergraduate ME education. Some educators think that the goal of a B.S. in ME is mastery of a set of analytical techniques. However, alumni returning from industry to the authors' institution often share that they conduct very little analysis in their work. Other educators recommend that students should spend more time on practical training with design and manufacturing activities. Too much focus on these "hands-on" activities, however, can also lead students to be unprepared for traditional engineering roles. This study will present the development of a survey to gather perspectives from industry representatives on the importance of engineering science and analysis in undergraduate ME education.

Keywords

Curriculum development, mechanical engineering, industry perspective

Introduction

The role of engineering science and analysis in engineering education has been debated for many decades. In a review of the history of engineering education, Seely[1] states that there was a shift away from apprenticeship training to formal university training soon after the civil war. He goes on to list how competition from other countries led U.S. universities to focus more emphasis on engineering science and analysis in the first half of the 20th century. Froyd et al.[2] lists this shift to engineering science and analysis as 1 of the 5 major shifts in engineering education between 1912 and 2012. Both of these works emphasized that there has been a lot of resistance to this shift.

Today many faculty, students, and industry representatives continue to debate the value of a heavy emphasis in engineering science and analysis. Some criticize that engineering education is not well aligned with industry needs. In the authors' experience, many engineers do not practice advanced analytical techniques as part of their regular job responsibilities. Even those that do practice advanced analytical techniques often require additional training in industry to master such skills. Danielson et al.[3] surveyed students, university department heads, engineers, and engineering supervisors about the strengths and weaknesses of engineering graduates. Industry representatives were more concerned with graduate weaknesses in practical and critical thinking than with technical knowledge.

While there are many opponents to a heavy emphasis on science and analysis in education, there are some who continue to support it. A report[4] by the National Academy of Engineering lists analysis as one of the attributes of engineering that has enduring value for engineers. This study will survey engineers in industry in the southeastern region of the U. S. to determine the direct and indirect benefits of training in engineering science and analysis.

Method

A survey has been developed which includes questions related to the value of training in engineering science and analysis for engineering jobs. Engineers from a variety of industries in the southeastern U.S. will be approached for completing this survey. The survey is focused on three major areas:

1. Direct use of advanced engineering science and analysis techniques
2. Communicating with engineering analysts, specialists, and/or contractors about advanced engineering science and analysis techniques
3. Making engineering decisions based on a working knowledge of engineering science and analysis concepts.

For each of these focus areas, a list of questions were developed based on the content covered in the mechanical engineering curriculum at the authors' institution. All questions, other than the general information section, will use a sliding scale.

Survey

The questions that will be used in the survey are listed below.

<u>General respondent information:</u>

1. What level of education do you have?
2. What is your major?
3. What industry do you work in?
4. What is your title?
5. How much experience do you have?

<u>Direct use of advanced engineering science and analysis techniques</u>:
In the last 5 years how much of your time has been focused on complex engineering analysis and/or design in the following areas?

1. Material selection (material parameters: yield strength, compressive strength, thermal properties, fatigue properties, magnetic, corrosion)
2. Determine factor of safety for mechanical failure structural components
3. Mechanical component sizing and selection (shaft, gear, bearing, spring, etc.)
4. Heat exchanger sizing / selection
5. Piping network system analysis and design (pump selection)
6. Power Generation Component selection and design
7. Electric motor sizing / selection
8. HVAC sizing / selection
9. FEA / CFD
10. CAD
11. Programming
12. Quality and reliability - statistical analysis

<u>Communicating with engineering analysts, specialists, and/or contractors about advanced engineering science and analysis techniques</u>
In the last 5 years how important have the following skills been to your work?

13. Communicating well with an engineering analyst about analysis results related to a project.
14. Communicating well with an engineering specialist to help with a design decision.
15. Running simple calculations to check detailed design and/or analysis work of contractors.
16. Communicating clearly with contractors about detailed design and/or analysis of mechanical components.

<u>Making engineering decisions based on a working knowledge of engineering science and analysis concepts.</u>
In the last 5 years how often has a working knowledge of the concepts listed below been helpful in making engineering decisions?

17. Work, power, heat, and/or energy conservation
18. Energy, temperature, pressure, and/or entropy
19. Balances of forces and/or moments
20. Power Cycles: Rankine, Brayton (gas turbine), otto cycle (IC engine)
21. Refrigeration and/or HVAC cycles
22. Mechanical advantage and/or speed ratios
23. Gear, cam, and sizing and/or linkage design
24. Shaft, spring, bearing, and/or clutch design
25. Principles of heat treatment
26. Modulus of elasticity, yield stress, and/or ultimate strength
27. Stress and strain
28. Fatigue failure
29. Static failure (Tresca or Von Mises)
30. Heat transfer: conduction, convection, and/or radiation
31. Transient response of systems: Time constant, natural frequency, resonance, free and forced response
32. Fluid system design: major and minor losses in flow networks, pump and/or fan design/selection
33. Heat exchanger operation and design
34. Vibration isolation
35. PID control
36. Optimization

Summary

Through this study, the authors hope to provide some guidance on the value of engineering science and analysis in mechanical engineering programs. It is our consensus that programs should strive for an appropriate balance between technical/industrial skills and foundational knowledge and understanding. Through the course of this study, we hope to comment on best practices in achieving this balance.

References

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