Engineering Education Goals; Building Tomorrow's Leaders

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Abstract

The goal of any education program is to provide the student the tool set, or tool box, to perform the objective of the intended training. For some training curriculum, this is a straight forward task. You perform task ABC, and get XYZ.

The challenge for engineering training is the definition of an engineer.

1. One who is trained or professionally engaged in a branch of engineering,
2. A person who uses scientific knowledge to solve practical problems,
3. One who operates an engine,
4. One who skillfully or shrewdly manages an enterprise,
5. A person who harnesses resources for betterment of mankind and his environment.

An engineer can be a person who develops, manages or optimizes a process to safely produce a product at the most reasonable cost. A humorous quote is - an engineer is someone who make for ten cents what any fool can make for a dollar.

Involved in the required engineering tool set is scientific knowledge, analysis tools, optimization tools, economic tools, and personnel management skills. The goal of engineering education is to build tomorrow's enterprise leaders. It is very important to look at the qualities that we wish to have in tomorrow's leaders and instill them in our engineering education today – the correct attitude as well as aptitude.

Introduction

The education of engineers must be a multi-frontal effort. The basic fundamentals of engineering must be instilled into the student. The economics of how to manage an enterprise must be taught and the practical method of problem solving must be applied.

One of the key phrases is "the betterment of mankind". This definition of engineering is now used as a yard stick in reputable engineering schools to grade PhD theses. Any new technology must be commercialized and used by consumers before it can be valuable to society and any new technology that is not utilized for betterment of mankind is not valuable to society. This definition will improve the way engineering is taught at the bachelor and post-graduate level.

Many of today's leaders are engineers. A list of Prime Ministers, Presidents and CEOs will contain many engineers. What are the qualities that we wish to have in tomorrow's leaders? Most people will agree engineering education is the best training to nurture thinking and the thought process. Therefore, how do we tune our engineering education to produce the best cognitive thinking? What is the best way to tap the resources of both sides of the brain; left and right- neurolinguistic and programming? How to remove the filters that alter our responses to conditions and pre conditioning – be able to realize a paradigm shift. To be extroverted and introverted at the same time – to be the best whether in a big community or among the private few. Command the ability to think and yet feel, to judge and yet perceive, to make decision in both regimented and chaotic situations. Our current engineering education already contains many such elements.

One who is trained or professionally engaged in a branch of engineering

The first tool in the required set of tools is scientific knowledge, the fundamental basics of engineering – fundamental principals and laws. These must be taught and understood. An engineer should be able to perform higher-level math and science correctly due to the decision-making he or she will be required to make in the job duties. Many times calculations performed will have an impact on personnel, and these calculations have to be accurate.

When you drive over a bridge or sit down in an airplane seat, you are trusting that an engineer performed the calculation correctly. As engineering educators, it is our main task to instill the engineering fundamentals. A second task is to instill integrity. When you drive over a bridge or sit down in an airplane set you trust that engineer has faithfully performed the calculations.

Before 1800, the study of engineering was by apprenticeship, which led engineering students into specific areas like mining and bridge design. At West Point in the early 1800s, there was mechanics and military engineering, which then translated to our more formal form of civil engineering.

Next, the automobile era arrived along with mechanical engineering. Then the airplane era arrived along with aerospace engineering. Next humans wanted to go to space and came up with aerospace engineering. Along the way came other needs - electricity, computers and chemicals, which all were economically driven and thus the formal teaching of engineering was established.

Engineering is reaction process that formalizes the obvious in mathematical terms to the public. Presently, biological chemical engineering and nona engineering are being studied do to market demand.

The educational institutions must keep abreast of the needs of society in terms of the new demands. The breakdown of engineers required at different stages of country development also varies. In a developing country, graduating aerospace engineers might not be optimal if water, sanitation hygiene or basic necessities were not resolved first. In a developed country graduating 50%, agricultural engineers may not be the optimal.

The current employability of engineers in the field of engineering is rather surprising. Many graduate engineers never get to practice engineering but only apply the expertise gained to contribute in their respective different career paths.

Numbers of employability also tells a story:

Ease of Employability Courses	
Course	**Percentage**
Architecture & city planning	**100**
Medicine & dentistry	**100**
Law	**69**
Engineering	**62**
Computer science & IT	**46**
Economy & business	**33**
Science & similar	**28**
Arts & similar	**24**
Technical & similar	**20**
Pure science	**19**
Arts & humanity	**16**
Agriculture & related	**0.7**

The system is producing more engineers but only 62% are employed in engineering, therefore another 38% look at other economic growth areas. The question is not having the right number but the right type of engineering background. Therefore, part of the debate should be on how to tally the supply-demand. Future plans should decide where education emphasis should be concentrated.

A person who uses scientific knowledge to solve practical problems

The key of engineering education is scientific knowledge. Engineering education should not be modified to align with the current and latest fashions. Engineering fundamentals do not change and have to be instilled in the young engineers.

Having said this, engineers can and should serve the society. They should learn business and public administration after their engineering education, or they should seek partners who are purely trained in these disciplines. Leaders capitalize on their strengths and seek partners to make up where they are weak.

One who operates an engine

Many engineers today operate very complex engines. Common names include chemical plants, automobile manufacturing, and power generation. At engineering colleges, the instructors will put tools into the students toolbox. On the job, the engineering manager instructs the new engineer how to utilize his tools, based on the type of engine that the engineer is operating. The engineer manager will arrange on the job training that utilizes the engineer's set of tools for a peculiar industry.

Given the rapid advancement of technology, specific job training will not prepare engineers for an entire career, therefore engineers should not be trained for specific jobs, but educated in the basic engineering skills and be prepared for lifelong learning.

Many factors are influencing the engineering industry and are changing the work place environment. Some of the factors include;

- Increased use of teams – Industry and academe will need to support the development of professional skills.
- Globalization – Engineers will be interfacing with colleagues and clients in other countries. When doing so they must protect their employers' intellectual assets. They must also demonstrate that their contributions are worth their labor costs.
- Growth of small business – More engineers will work for smaller employers in environments that require an even broader range of skills and knowledge.
- Scientific advances – As new technologies are developed, engineers will need to retool more frequently.
- High throughput techniques and speed-based R&D – As the means of developing new products and processes change, so will the responsibilities and job scope of engineers.
- Economic uncertainty – Job market fluctuations will require engineers to have increased flexibility and mobility. Engineers will need to allow for opportunities outside their geographic areas and be prepared to relocate as necessary. Maintaining skill sets and institutional knowledge will become more of a challenge for employers as engineers relocate.

One who skillfully or shrewdly manages an enterprise

The engineer progresses from someone who barely knows how to take his or her tools out of the tool box to a master craftsman. They become a manager of an enterprise. The manager has several roles. They must train the new engineers, must operate the engine correctly, and they must review the economics of the enterprise. They must have technical, economic and people skills – not a commonly found combination. It is easily to find two of the three; it is difficult to fine all three skills in one person.

To have successful careers, engineering will need to

- Be masters of their discipline
- Recognize the risks inherent in a changing industry
- Develop critical thinking skills

- Demonstrate the ability to learn
- Pursue lifelong learning
- Embrace the emergent technologies
- Look for rewarding and stimulating opportunities
- Be curious (play 'what if…')
- Find mentors and be a mentor
- Be effective communicators
- Be goal-oriented, but flexible
- Understand the strategies to improve corporate performance (operational excellence, product leadership, or customer service) and align personal development strategies appropriately
- Determine how to contribute to success of company
- Be responsible and exercise caution with new materials and technologies
- Be committed to leverage science against the needs and wants of our society

A person who harnesses resources for betterment of mankind and his environment

What type of person can harness resources for the betterment of mankind? Meyers and Briggs has a 16-type system where they rate personalities based on answers to a questionnaire. People are either;

1. Introverted or Extroverted
2. Sensing or Intuition
3. Thinking or Feeling
4. Judgmental or Perceiving

Most engineers are rated Introverted - Sensing - Thinking and Judgmental (ISTJ).

Extroverted people are outgoing and get their energy from others, and they feel comfortable with and like working in groups. **Introverted** people are not normally good at public speaking therefore, they should select the correct media to communicate their agenda. For example, the incoming CEO of a Fortune 500 Company was a very reserved person. Therefore, he set up an internal blog site to communicate his ideas and reach out to all employees. In the blog site's forum, employees can voice anything anonymously. Anything he promised on the forum itself is executed. This is how he communicates and displays his accountability - despite not a charisma speaker.

Sensing people describe object and situations with direct output of five senses.
Display skills by hands-on execution of work.
This is the traditional strength of an engineer.
Intuition people work from the big picture to the facts. They place great trust in insights, symbols, and metaphors and less in what is literally experienced.

Feeling types of people believe that being tactful is more important than telling the "cold truth".
Thinking people believe telling the whole truth is more important than being tactful.

Thinking is not just to solve a problem and an engineer, who solves a problem, has solved only one problem. Today and tomorrow we need strategists - an engineer, who fore sees a problem and solicited resources to resolve the situation before the problem evolves, therefore eliminating the issue. The strategist put the first engineer out of job but reduced the cost of a product/service for the benefit of consumers. This may sound ironic but the first engineer is a cost, an expense, and a liability to the society.

Perceiving people sometimes focus so much on adapting to the moment that they do not settle on a direction or plan. **Judgmental** people create systems to judge, regulate, audit and improve. The motivation must be improve and create value, therefore do not judge if does not create value. This is the greatest weakness of many engineers is that they diminish value for sake of correctness, and again society does not gain from this type of engineer.

Conclusions

To meet the challenge of employability or marketability the engineer will still be judged by what tools he or she has in their toolbox. In the future engineers, as well as other people, will need to have more skills to stay employable. Today in developed countries as much as 25% percent of the population has 16 or more years of education.

The question for individual engineers is what are they intending to contribute as an engineer. They then therefore must better equip themselves with technical know how or risk being phased out. As a manager, their toolbox must include

materials such as business and public administration.

Many factors have the potential to reshape or redirect the engineering world. In the event of a crisis, drastic changes are likely to occur. However, the world will continue to evolve at an increasingly rapid pace even without the impact of unpredictable events. The significant changes in responsibilities and expectations for engineers that have occurred over the last ten years will continue during the next ten years. Given the rapid advancement of technology, specific job training will not prepare engineers for an entire career - they will need a solid foundation of basic engineering fundamentals along with the ability and desire to continue learning.

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