What's in an Iron Ring?

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Abstract

What do you get out of an engineering education? Is it technical knowledge, a peer network, or a way of thinking? Much of our work goes into teaching the technical skills. But the real value in engineering comes from our structured thinking.

In Canada, an engineering degree means that graduates are academically qualified to be engineers. Yet it takes at least another four year of apprenticeship to become a professional engineer. Engineers Canada expects us to teach engineers the fundamentals of engineering, and the skills for them to independently acquire the knowledge required for professional practice.

So what is the purpose of engineering education? Is it technical competence, a structured way of thinking, or a set of principles? Do we focus on theory, design or ethics?

Each of us has a different answer to these questions. This presentation will challenge you to think about what it means to be an engineer and how we convey our common principles to young engineers.

1 Introduction

Natasha McCarthy of the Royal Academy of Engineering writes that “Engineering is taking the possibilities that are revealed by scientific research and turning them into practical products”. [1]

For many of us, engineering is about more than just turning out products; it's also about serving humanity, exercising professional judgement, and taking responsibility for the work we oversee.

The Iron Ring is an internationally recognized symbol of engineering. Wearing it is an affirmation of where you came from and an acceptance of the professional responsibilities engineers have.

Engineering schools are the precursors to professional practice. And as such, have an obligation not only to teach technical skills but to produce graduates who understand what it means to be a professional engineer.

2 Professional Practice

In design no one hands us you book with all the right answers. If they did, it would not be engineering. You can build a house or a garage by following the building code. It is a compilation (and codification) of the relevant engineering knowledge. But when you want to create something new and unique, when you want to go beyond the code, then you need an engineer.

2.1 Professional Practice in Canada

Engineers Canada defines professional practice as applying engineering principles in projects that affect the wellbeing of others.

“The "practice of professional engineering" means any act of planning, designing, composing, evaluating, advising, reporting, directing or supervising, or managing any of the foregoing, that requires the application of engineering principles, and that concerns the safeguarding of life, health,

property, economic interests, the public welfare or the environment.” [2]

This definition is important because it makes some very particular distinctions about engineering practice in Canada.

The words “*planning, designing, composing*” describe using our technical knowledge to create products. While “*advising, reporting, directing*” emphasize the role of communication in our work. Finally, “*supervising, or managing... or safeguarding*” underscore our roles as leaders who are responsible to the public.

From this definition we see professional engineering as involving technical skill, communication, and responsibility to the public. It demonstrates that engineering is about stewardship protecting the community and lives of those around us. It goes hand in hand with our code of conduct [3], and legal obligation to protect the public.

Wearing the iron ring is a public declaration of your commitment to be honest, fair, and accountable in your work. It is a statement of your character.

2.2 Engineering skills for new graduates

In 2006, the Royal Academy of Engineering [4] surveyed 8000 engineering companies in the UK. As part of this work, the respondents rated seven critical skills of new graduates.

These seven skills were then divided into defining and enabling skills. The “defining skills” were those seen as unique to engineering, while “enabling skills” were business skills critical to performing engineering work.

Defining skills:

- **(29%) Practical application:**
Knowledge of standards, policies, and equipment used in industry
- **(20%) Theoretical understanding:**
Knowledge of the mathematics and underlying principles of how things work
- **(19%) Creativity and innovation:**
Being able to apply theoretical knowledge to real world problems
- **(14%) Technical breadth:**
Broad exposure to engineering concepts

Enabling skills:

- **(required) Communication:**
Reading, writing, listening and speaking

- **(15%) Team-working:**
Working in multidisciplinary teams
- **(3%) Business skills:**
Commercial awareness, how businesses work, finance, and project management

Upon graduation, engineering students are hired for their technical expertise. Yet their ability to work within the organization is quite important. In [5], UK engineers felt that communication skills were a prerequisite for being hired. While business skills in general were expected to be developed on the job. Similarly, in the US [6], practicing engineers reported communication (62%) and teamwork (53%) were essential components in their jobs.

“We want them very good technically but we want them to have this wider ability to work in a team” [5]

2.3 Moving into industry

Throughout Canada, the UK, and the US, graduates need to be technically competent and able to communicate. They also need to be able to adapt. As the Canadian Academy of Engineering wrote in 1999:

“Remarkably few engineering graduates are actually practicing what would be remotely recognisable as what they were being taught, or even connected with it.” [5]

“I think for some of them [graduates] it’s a bit of a shock, because they expected us to be engaged in slightly more specialist engineering, than we are...” [5]

In 2010, these statements still ring true. As students move from school to industry, they have to adapt to a new environment -- One full of meetings, ill defined problems and customers. Their technical expertise allows them to get the job -- their ability to function and contribute allows them to keep it. [6] [7]

“But with technology changing so rapidly and the roles of engineers being so diverse, acquisition of the skills of self directed learning may be even more important as a preparation for life after leaving the university” [8]

2.4 What our graduates need

In order to be employable, our graduates need to combine both technical and communication skills.

Once they are in industry, they will learn business skills and their professional responsibility.

Industry expects our graduates to be well grounded in mathematics and engineering science. [5]. [9] [10] Yet they also must be familiar with current technology. They need to understand digital logic, but also be able to recognize a ball grid array integrated circuit.

Companies want engineers who can move their designs forward. That means new engineers have to have the technical breadth to understand how their portion of the product works and how it impacts the rest of the design. For example, poor coding can cause brake failures in a vehicle, or the bad choice of a CPU can result in overheating. Engineers need to understand not only their technical specialty, but also the broader scope of electronics, thermodynamics, statics, and manufacturing.

But as useful as their technical knowledge is, our graduates also need strong communication skills. In most companies today, engineering is done by multidisciplinary teams with sales, engineering, and customers all coming to the table. [5] [6]

Young engineers need the ability to ask the right questions, defend their work, and contribute effectively to teams. Without these skills, they will have great difficulty doing their work. This was true in the past, and it will continue to be true in the future.

3 Education

Although we can emphasize what engineers do in practice and proclaim that school should prepare you for work in industry. The reality is that developing good curriculum is challenging.

Through the Canadian Engineering Accreditation Board (CEAB), Canadian engineering institutions are mandated in relative weighting of science, math, design, and non-technical content.

Additionally, departments have to deal with issues like institutional policy, teaching effectiveness, and student retention.

3.1 Changing reality

Over the last 15 years, there has been a growing concern that our engineering education system is not working.

Literature from Canada [8] [11], the UK [4] [5], and the US [9] [12] [13] all focus on industries need for engineering education to more closely align with professional practice. The feeling is engineers need a broad education base – technically grounded, but more driven by design. The consensus is that more hands on work, design projects, and practical applications are needed in school to create competent problem solvers.

“One failing of universities now is that some of the theory never gets translated into reality” [4]

In 1999, Engineers Canada recommended that the “broadening aspects of engineering knowledge coupled with the continual expansion of technical knowledge requires a re-examination of the context in which Canadian engineers are educated.” [8]

In 2008, this recommendation was put into practice. At this time, the new CEAB accreditation requirements were changed to include more design experience and to evaluate programs by learning objectives. By 2014, all engineering programs in Canada must meet the following minimum standards:

- **A total of 1950 academic units (AU)¹**
- **Mathematics and natural science 420 AU**
- **Engineering science and design 900 AU**
- **Complementary studies 225 AU**

From these new criteria, design has to have a minimum of 225AU, giving it a much more significant place (11%) in the engineering curriculum.

3.2 The role of design

Mastery of scientific fundamentals is essential to engineering yet not what defines it. The defining characteristic of engineering is the mindset and ability to transform what is into practical products. [1] [6] Unlike science which studies natural phenomena, engineering is about taking those phenomena and *creating* new life.

“It is design which distinguishes engineering from science” [8]

In order to build students confidence and competence in making decisions and defending them in the workplace - design should be incorporated into **each term** of engineering, not left until a single capstone course. Doing so will awaken your student’s curiosity, encourage them to look beyond the textbook and ultimately come face to face with design failures. The lab is a safe place to fail; it doesn’t cost you your job.

¹ An Academic unit is 1 hour of lecture or 2 hours of lab.

“Exercising creativity and inventing are why I become an engineer.” [6]

If you wait until a capstone course, then your students believe right or wrong, that engineering is all about the equations and the math. Putting off design teaches students to look for one right answer and to double check their calculations against the author. In the field, you need to find your own mistakes and verify your work is correct without the help of a readymade answer.

Yet in the real world, the “right” answer is not always right. Laws, risk, and codes all constrain our work. Customers will do things like push for tighter deadlines, ask you to assume responsibility, or even change the plans mid-design.

Help build your students ability to solve poorly defined, contextual problems. Have them refer to the appropriate codes. Think about regulations, life span considerations, and handling risk.

“Engineering is a professional faculty with special responsibilities for developing professional attitudes and habits.” [8]

Putting off design, sabotages the very spark and responsibility young engineers need.

4 New Challenges

The reality in our classrooms is that expectations of our students have evolved with technology. Having grown up in the information age, today’s students expect their education to be interesting, engaging, and interactive. [12] [5] [14] Large lecture style courses are in direct contrast with the personal and highly interactive nature of video games, cell phones, and the internet. Today’s students believe information is easy to obtain, and can often be found looking up information on the internet during class.

If we want to connect with these young engineers, then we need to tap into their sense of value, wonder and fun. Like effective marketers, we need to get them to buy into our product.

“Students are driven by passion, curiosity, engagement, and dreams. Although we cannot know exactly what they should be taught, we can focus on the environment in which they learn and the forces, ideas, inspirations, and empowering situations to which they are exposed.” [7]

Once they have bought in, we need to inspire them to go beyond learning for the test. We need to inspire

our students to learn and imagine this profession as their own. We need to help them take pride and ownership in what they are accomplishing.

5 Going Forward

Much work is being done to update our engineering programs, to realign education and professional practice. However, as we do so we need to remember our students are our products. And that they will operate in the real world – one that requires them to be technically competent; able to communicate, and most importantly accept the obligations of our profession.

Over the next four years, our engineering schools are going to undergo a fundamental change. As engineers, it is important that we support this process. As educators, it is important for us to put our student’s needs first. Our graduates will move into companies that expect technical competence, but more so expect communication, leadership, and accountability from their new hires.

The technical skills of our graduates let them get interviews. Their communication skills let them get jobs.

6 Conclusion

Each of us has our own perspective on what is important about engineering. But generally we agree - a solid technical foundation, good communication skills, and an aptitude for design are hallmarks of our profession.

As you finish reading this paper, ask yourself – what’s in my iron ring?

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