How to Train an Engineer

A Proposed Model

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***Abstract*—*This paper explores the difference between an employable engineer and a graduate engineer and proposes a model to reduce/ eliminate the disconnect between the two.*

The Industry operates in a fast-paced, dynamically changing environment. Universities are steeped in academic tradition and although they may be amenable to change, inertia is high and change is a slow process. Industry and Academia are two very different worlds who do not share a common language.

This paper proposes a training model, which involves the introduction of a layer between these two worlds, a communication and feedback medium that can help bridge the divide.

The focus is on a symbiotic relationship between Universities, Technical Finishing Schools (who can cater to the vocational training of an Engineer), and the Industry.

Keywords—engineering; education; technical; finishing schools; colleges; industry; employability; communication; feedback.

I. INTRODUCTION

In a world that is increasingly driven by technology, there is barely any realm that remains untouched by Engineering. From medical science to household appliances, from space exploration to the lone hiker, from pure science to pure entertainment, technology and engineering products are everywhere.

As the job of an engineer grows more varied and more specialised, the skills demanded of an engineer have changed over the years. As the introduction to the book "Educating Engineers" aptly says:

"Amidst complex challenges of unprecedented scale and urgency, the profession of engineering has new global significance—and responsibilities. Undergraduate engineering programs, the source of the professional degree, struggle to transmit a base of technical knowledge even as it grows exponentially, leaving little room for students to develop the skills and professional identity necessary to meeting the responsibilities of engineering in this new century." [1]

The technical base itself is a challenging task as disciplines merge and the lines between the various branches of engineering grow increasingly fuzzy. Is an Embedded systems engineer a product of Computer Science or Electronics engineering? Is an Automotive engineer an Electronics graduate or a Mechanical graduate? The answers are, a Computer science graduate who has learnt electronics or vice versa and a Mechanical engineer who has learnt electronics or vice versa. The required on-the-job knowledge is increasingly multi-disciplinary in nature, so where do we draw the boundaries?

"Although engineering schools aim to prepare students for the profession, they are heavily influenced by academic traditions that do not always support the profession's needs." [1]

All are in agreement that a gap does exist between the required skills of the employable engineer and the skills of the graduate engineer.

This paper explores that gap and proposes a model to reduce/eliminate it.

II. THE GAP

Drawing on personal experience, I would summarise the required knowledge, skills and attributes of an ideal employable engineer as:

1. Strong Technical base

   (Good understanding of fundamental principles, Subject knowledge, Broad theory base, Full System perspective …)

2. An Engineering Approach

   (Strong analytical skills, Problem solving approach, Ability to ask the right questions, Capability to decompose a problem, Logical thought flow, Technical writing skills, Self-learning ability, Curiosity, Creativity, Effective communication skills, Ability to work in a team, Process-oriented…)

3. Professional Values

   (Ethics, Accountability, Initiative, Integrity, Social Responsibility, Commitment, Ownership…)

In addition, a couple of value-added skills would be:

1. Relevant domain knowledge
2. Appropriate tool expertise

The current prime focus of Colleges and Universities is on setting the technical knowledge base.

"A jam-packed curriculum focused on technical knowledge is the means for preparing students for a profession that demands a complex mix of formal, contextual, social, tacit and explicit knowledge." [1]

The other two aspects (An Engineering Approach; Professional Values) are not part of the course curriculum and, in truth, some of it cannot be taught. However they are an essential part of what makes a good engineer and should be considered in the training of an engineer.

There is a growing disconnect between an employable engineer and a graduate engineer. This is, in part, due to the fact that there is no tangible feedback path between Industry and Academia. The dialogue between the two is fragmented and inconclusive.

III. Proposed Model

The ideal (and much talked about) scenario is for Engineering colleges to completely revamp their curriculum and teaching methodology to map onto the requirements of the Industry.

"Redesigning undergraduate engineering education will demand an enormous effort on the part of faculty. It will involve more than learning about, designing, and implementing integrated curricular structures and active pedagogies. It will involve fundamentally rethinking the role and even the makeup of the faculty." [1]

Redesigning undergraduate engineering education overnight is both impractical and unrealistic. It calls for a massive one-time effort, which, even if it does happen, will be rendered obsolete in a few years.

The need of the hour is to establish an effective communication path between the two spaces of Academia and Industry. Change should trickle in and contribute to a constantly evolving process, such that the two spaces remain tightly united while retaining their individual identities.

This paper proposes the introduction of a layer between the University and the Industry. An entity that serves as a communication and feedback medium between the two, in addition to adding value to the quality of Engineering input to the Industry.

It suggests the creation of Technical Finishing Schools that are carved out of the training organisations of companies. This close link to Industry will ensure that it understands the needs of the companies. The fact that it is a training organisation ensures that it shares a common language with Academia.

The goal of a Technical Finishing School is to serve as a bridge between Academia and Industry.

It should be a school where the employees of tomorrow make the leap from thinking like students to thinking like engineers. A place where personality is developed, skills are taught and attributes are honed.

Imparting relevant technical knowledge and skills is the core premise, but it should be packaged in such a way that the competencies of design, practice, professionalism, ethics and communication are integrated into a seamless whole.

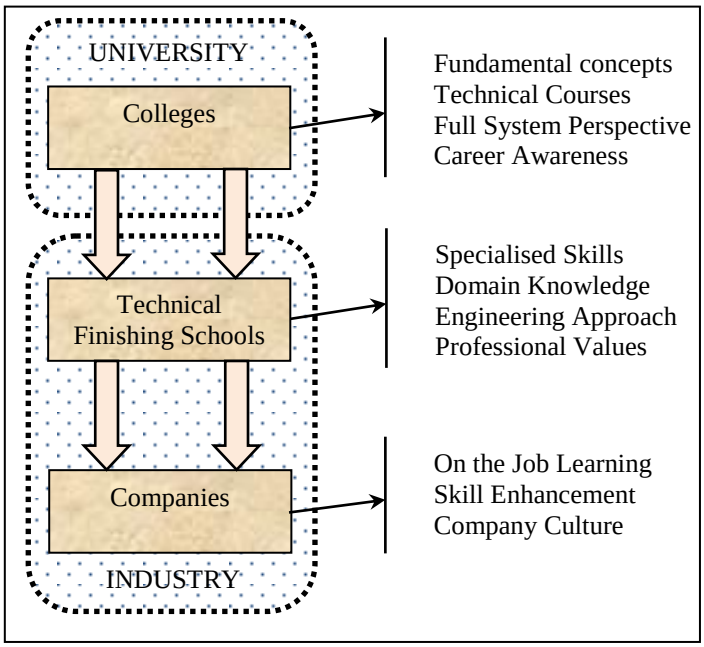

Fig. 1: The Proposed Model

This model proposes minimal radical changes in the two established sectors of the University and the Industry. It suggests the setting up of a practical feedback path that can result in slow, incremental improvements over a long period of time.

At the college level, the model stresses that they should continue doing what they do best – impart technical knowledge. Universities should set a base of strong fundamentals in science, math and engineering for technical finishing schools to build upon.

The change called for at the college level is two-fold:

1. Expose the students to a full system perspective in their respective field

   (Eg: An Electronics engineer should understand a basic system-on-a-chip architecture and all its constituent parts; An Automotive engineer should understand the complete system of at least one type of automobile.)

2. Introduce a Career Awareness program

   (Students should have a basic understanding of the various job profiles that are available to them as a result of their engineering degree. This will enable them to make an informed choice about the specialisation that they can opt for at a Technical Finishing School.)

This will then set the stage for the Technical Finishing Schools to take over and mould an employable engineer.

This paper does not propose that all graduates of engineering schools should be employed as engineers. On the contrary, it states that it should be a reducing pipeline as you move from University to Industry. This selection and elimination process will, given time, improve overall quality.

The Technical Finishing Schools will have an input screening process and all relevant feedback on candidate selection, evaluation and performance will be shared with the respective colleges.

A similar feedback path will exist from companies to the Technical Finishing Schools. All Finishing school graduates will not find a slot in the Industry. They will have to meet stringent criteria established by the hiring teams.

The feedback path is the crux of this model. It gives both Finishing schools and colleges valuable information on what aspects of training they need to focus on and improve.

Feedback from Industry to Technical Finishing Schools can be broadly classified into the following areas:

1. Quality of the certified professionals
2. Required job profiles
3. Required on-the-job skills
4. Gaps in training
5. Knowledge share (New domains, latest trends in R&D, industry practices, etc.)
6. Technical consultants from Industry (in the roles of Guest faculty, Subject matter experts, Members of the board, Reviewing members, Advisory members, etc.)

Feedback from Technical Finishing Schools to Colleges can be broadly classified into the following areas:

1. Quality of the students
2. Pre-requisite courses
3. Gaps in training
4. Knowledge share (New courses, tools, methodologies, etc.)
5. Technical consultants from Technical Finishing schools (in the roles of Guest faculty, Subject matter experts, Members of the board, Reviewing members, Advisory members, etc.)

Motivation to change is an inherent aspect of this model as an outcome of the selection process.

It is in the interest of Technical Finishing Schools to improve their input student quality and they will have the time and ability to inspire incremental change at the undergraduate college level. Similarly the companies and their selection criteria and feedback will drive change in the curriculum and teaching methodologies of the Technical Finishing Schools.

Technical Finishing Schools will function as vocational training centres. They will train engineers in the required on-the-job skills. Their focus will be on imparting relevant domain knowledge, specialised skills, tool training, an engineering approach to problems and inculcation of professional values in their students.

Technical Finishing schools should strive for and develop core competencies in various engineering domains. For example, in the VLSI domain, the output of an undergraduate program would be an Electronics engineer, whereas the output of a VLSI Technical Finishing School would be an Analog design engineer, an Analog layout engineer, a Digital Design engineer, a Verification engineer or a Physical Design engineer and so on.

The final block in the model, the Industry, is the driver for change. They are the end users, the ones who determine and define the requirements. Technical Finishing Schools and Colleges should evolve to meet those requirements.

The proposed model for the training of an effective, employable engineer requires the three entities (University, Technical Finishing Schools and Companies) to work with and support each other. All three stand to benefit from this interaction.

The companies will save on cost of hiring, as they only need to approach the relevant Technical Finishing Schools to get the required talent for their teams. They will also save on the initial training cost and have a support system in place for future on-the-job training.

The Technical Finishing Schools will have their charter defined for them by the Industry. An effective interaction with colleges will ensure that they get the required input student quality to turn out the engineers of tomorrow.

Engineering colleges can work in tandem with Technical Finishing schools to ensure relevant student education. They will receive the support and expertise needed to upgrade their curriculum and keep it current.

IV. An Example

Sandeepani, the training division of CoreEL Technologies (I) Pvt. Ltd. is an example of a Technical Finishing School with a vision that aligns with this proposed model. The school runs four to six month Professional Development Courses in VLSI and Embedded Systems for B.Tech and M.Tech students. The challenge faced in making these truly vocational in nature is that the students enter with poor fundamentals and a significant portion of the course duration is spent in strengthening the basics.

Sandeepani is actively working with colleges to strengthen the curriculum and teaching methodologies at the university level. The proposition is to do this via two modes:

1. Establish an Industrial Centre of Excellence at the college and host relevant courses with external faculty.
2. Aid the improvement of the regular curriculum courses by providing the support of Subject Matter Experts (SMEs) who will review and strengthen the course.

V. Conclusion

This model proposes a realistic way to bridge the Industry and Academia. It suggests a practical approach to establishing effective communication between the various links in the chain.

The spine of this model is the communication and feedback path, hence a request goes out to all Universities and Companies to partner with existing Technical Finishing schools and to drive for the creation of more such schools to fill the void between the Industry and Academia.

References

[1] S. D. Sheppard, K. Macatangay, A. Colby and W. M. Sullivan, Educating Engineers: Designing for the Future of the Field (Winter 2008), Carnegie/Jossey-Bass.

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