

Contextualising engineering education to 21st century - MBA style education for engineering

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Abstract

The skills required in an engineer of 21st century are not limited to technical understanding. The engineering field has been become more multidisciplinary and evolved than before. Moreover, the generation Z is characterised by different traits from its previous generations such as fast learning and shorter attention span. In view of these, pedagogical changes needed are discussed in this paper which not only address the needs from the engineers today but also suit the current generation. The suggested pedagogical changes are discussed with respect to delivering content and also evaluation methods. Some of the methods discussed are inspired from those practiced at business institutes.

Keywords: engineering education, pedagogy, distributed learning, flip teaching, evaluation methods

1. Introduction

The role of engineers today is not just limited to the engineering domains. The society is increasingly absorbing them in a variety of non-engineering fields [1-3]. Thus, the survival skills for engineers not only include core engineering acumen but also interpersonal skills, versatility and life-long learning skills. Moreover, the engineers from premier engineering institutes are increasingly taking jobs which are in line with those offered to or meant for graduates from business schools. The engineer's skill set is increasingly approaching one that is expected of a graduate from business institute. In light of these, the present system of engineering education needs a fresh look. This paper targets to bring out the learnings from the pedagogical practices in an MBA education which can prove to be useful in engineering education, regardless of the engineering discipline.

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An education system comprises of three components – curriculum, pedagogy and academic environment [4]. Generally, the modifications in the curriculum and academic environment can take longer time, given an institute's autonomy and management. On the other hand, changes in the pedagogy can be implemented almost instantaneously and most of it depends on the educator. However, the importance of regular revision of curriculum and efforts towards building a conducive academic environment cannot be undermined.

This paper discusses changes needed in pedagogy to begin recreation of engineering education for 21st century. Pedagogy comprises of two main aspects – delivering information and evaluation. Considering the evolving attributes and capabilities of the newer generations, the ways of delivering information and evaluation need to be revisited. The Indian engineering education institutes have been conservative with experimenting on both – delivering information and evaluation methods. There are some rare examples of innovation in pedagogy but they remain limited. Of course, this also demands a certain degree of academic autonomy to the colleges and flexibility to the teachers.

Another important point to consider is that today's generation, generation Z in specific, has witnessed a world very different from what the previous generations have seen. Being born in the so-called digital age, they have not seen a world without 24x7 connectivity and internet. While they have been exposed to a globalized world right from the beginning, they are not unaware of some of the global issues such as terrorism, global warming, and economic crisis at a very early age. They are predicted to spend their young adult years in a time of economic and social renewal. They are also living in an era of changing household structures, and are the students of today and university graduates, employees and consumers of tomorrow [5]. There are specific attributes which characterise the generation Z. These include – extremely fast learning, versatile, unsettling. Also the increased dynamism needs from them skills and approaches different from the previous generations.

It is difficult to keep them focussed in a classroom unless the lectures bring the dynamism which can synchronise with their agility. On the other end, traditional-style of examinations held in most engineering colleges are not enough to evaluate the various kinds of skills discussed above. The crux is that contextualisation of engineering education is necessary to build an Effective Engineering Ecosystem (3E).

Education should not only preserve the innate strengths of students of generation Z (Gen-Z) but also lead way to utilise these strengths while training them to overcome the weakness. This paper elucidates learnings from business education systems across the world both in terms of delivering information and evaluation of a learner's performance. This paper discusses needs for 21st century engineers and attributes of Generation Z and further proposes the changes in pedagogy with respect to delivering content and evaluations strategies.

2. Needs of 21st Century Engineering and Gen-Z

Engineering today is much more evolved, globalised, multifaceted and innovation-design oriented than ever [6]. The various engineering disciplines have evolved with need of the hour and the growing available-knowledge base. Today a look at the plethora of branches (Figure 1) in engineering certifies that the boundaries between various disciplines are fading [1, 2, 3, 4, 7]. Thus the technical development in the future would need stronger networks and global activity. Engineers are not just responsible for designing and building today but also for constantly innovating as per the needs of the society. They need to optimise economically, environmental impact, serve people's need and most importantly compete in the market. The skills needed for such dynamic profile of engineers are vastly different from the ones normally with the previous generations.

The generation Z is also different from the previous generations. The Gen-Z has the following characteristics [5, 8]-

- Tech savvy (omnipotent smart phone users)
- Instant experts (easy access to information & databases on-line)
- Capable in multitasking
- Speaks in rapid fire
- Plugged into social networks
- Open to diverse cultures
- Concerned about sustainability issues
- Open to entrepreneurial pursuits

Current workplaces have a mix of generations including - millennial, gen X and baby boomers. A study conducted by Ernst and Young including over 1200 professionals in various roles revealed that Millennials are tech-savvy, but aren't great team players. Gen X-ers are entrepreneurial-thinking, but rank low on executive presence. And last, but not least, Boomers are team players and loyal, but don't adapt so well. [9]

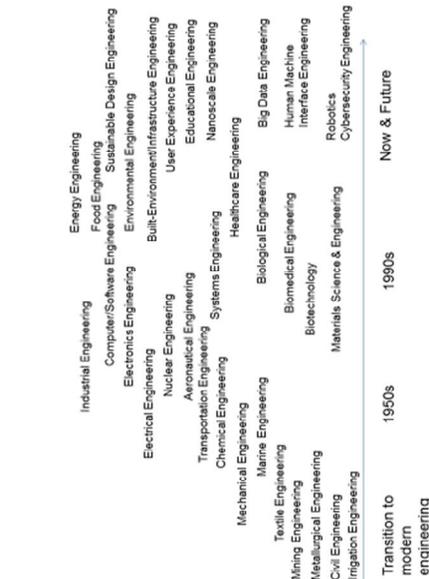


Figure 1. Dynamic nature of engineering field [4]

The variation in performance, strengths and weaknesses between generations supports that academic training has to be an evolutionary process which bridges the gap between their attributes and the skills needed from them. Figure 2 shows the skills required from the generation today in the inner circle and the additional skills required from an engineer in the outer circle. A 21st century engineers not only needs technical knowledge but also innovation, creativity, adaptability, interpersonal skills. The need is to produce global engineers.



Figure 2. Skill set for generation

today in the core circle and skills needed on top by engineers in the shell

The pedagogical changes needed are discussed below in two respects – methodology to impart knowledge and evaluation techniques.

3. Pedagogy – delivering content

An educator in an engineering classroom today faces the following problems –

- a) Lack of sustained concentration by the gen Z students and
- b) Ever-increasing number of students in the classroom
- c) Evolution and development of technical and technological knowledge

The current forms of teaching practices in engineering involve lecturing, laboratory practical, and industry training. Traditional methods of lecturing do not seem to be effective in such a situation. Need is to instead evolve the lecturing into a dialogue, where the educator and student get involved in discussions and share knowledge. This helps in maintaining interests and bring fresher ideas to the classroom. Some of these methods are discussed here.

Distributed teaching is a form which allows the student to learn in multiple sessions and also involves non-face-to-face learning. Students may be assigned various topics, on which they are asked to prepare and teach in the class. This actively involves students, brings in fresher ways to teach and also brings in possibility to introduce topics of current importance in the class.

Experiential learning involves case studies based learning. An example could be - for teaching material failure, popular cases of titanic, space missions may be discussed. Such an approach proves relevance of the course in day-to-day life and connects the students more to the course and also society.

Flip teaching is another which involves giving out information in form of notes, video lectures, online content and so on and the students are expected to go through these before the class session. This then allows discussions, problem solving and interactions in the class room which enhances learning. The idea is to flip the content of a class work and home work [10]. Such a learning unlocks more freedom to the learner giving him flexibility with respect to when and where to learn [11]. This enhances thinking as well gives time to clarify doubts.

Cohort teaching– This involves students (as an individual or in a group) to prepare a topic or subject related to the course in their own way and share with the class. This breaks monotony of the class room where one instructor covers all the content. This method not only keep the students involved effectively and also boosts their confidence, interpersonal, public speaking skills and so on.

The techniques discussed here are only a few amongst the several forms of delivering information and teaching. However these forms of teaching are widely practices in business education institutes. These techniques offer advantages in several ways and a few are the following -

1. Gen Z is interactive, learns quickly and needs dynamism in the class to maintain attention.
2. More time can be spent on applied learning and problem solving rather than rote learning.
3. More case studies and topics can be covered in the class which would result in adaptive learning.

The requirement from teachers in engineering is not merely to impart technical knowledge and understanding but to also make them ready for the world. A combination of teaching practices may be practiced.

4. Pedagogy - Evaluation

Unfortunately, learning and teaching in most courses is governed by evaluation. Often the motivation to learn or know a content for a student is merely to do well in an exam. The fault lies in the pattern of examination conducted and its routine and predictable nature. Examination currently are wrongly focussed on judging the knowledge and not skills or understanding. Different skills may be evaluated by varying evaluations techniques such as viva-voce, written exam, presentation and so on [12]. Table 1 compares certain different evaluation strategies (non-exhaustive), which are commonly used in the MBA schools, across various skills that are required for the today's engineers. A written exam may judge technical knowledge or memory but is incapable of judging one's leadership skills. A practical laboratory examination may be useful to test practical understanding and problem to some extent but its effectivity is going down as the practicals are becoming more and more standardised and the act of examination is being reduced to merely replication of a previously done activity. A special emphasis is needed on group activities such as group projects, presentations which naturally brings out leadership, team work and understanding. Communication skills can be tested by a presentation while presence of mind may be evaluated in a viva-voce.

As is evident from the table, no single evaluation technique is suitable to test all the necessary skills and hence a carefully chosen bundle of techniques should be employed. The choice of techniques to include in the bundle could vary depending on the content/ curriculum and academic environment and hence an educator should wisely choose from the tools available. The emphasis should be on evaluating a variety of skills so as to produce more versatile and dynamic engineers.

5. Conclusion

With paradigm shift in both – the expectations from an engineering graduate and the evolving traits of generations, the pedagogy needs a relook. This paper tries to bring out the learnings from MBA education and ways to implement in engineering education. The learnings are emphasised in two

domains of pedagogy – teaching and evaluation. It has been discussed in the paper how different forms of teaching can enhance learning leveraging on the strengths of the current generation. Various evaluations methods have been compared with respect to the skills that are actually put to test in each of them and it is revealed that best is to devise a combination evaluation strategy.

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Table 1: Comparison of evaluation strategies across skills required for today's engineers

Skills	Written Exam	Practical	Presentation	Viva voce	Class participation	Field - project	Take-home assignments
Technical Knowledge	✓	✓	✓	✓	✓	✓	✓
Understanding/ Application ability/ Subject confidence	(to some extent)	(depends on the design of the practical)	✓	✓		✓	(may be)
Problem solving skills/ critical thinking	(may be)	(may be)	(may be)	✓	✓	✓	(may be)
Imagination/ Innovation/ Invention/ Out of box thinking	(rarely)	(may be)	✓	✓		✓	
Risk Taking					(may be)	✓	
Self-motivation/ Inquisitiveness			✓		✓	✓	(may be)
Versatility			✓	✓	✓	✓	
Prompt thinking/ Spontaneity	(may be)	(depend)	✓	✓	✓		
Stress and time management	(may be)	✓	✓	✓		✓	✓
Decision making and Leadership		✓ (group practical)	✓ (group presentation)		✓	✓ (team project)	
Communication skills	✓ (written)		✓	✓ (oral)		✓	
Life-long learning/ self-learning/ ability to improve		✓	✓	✓	✓	✓	

Bio

Dr. Mudrika Khandelwalis a PhD from University of Cambridge and currently an assistant professor at IIT Hyderabad in the Department of Materials Science and Metallurgical Engineering. She has done her B.Tech and M. Tech at IIT Bombay. Apart from her professional interest in materials science, she taken very keen interest in engineering education and pedagogy. She has been active at devising new teaching methods and evaluation techniques.



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