Critical and innovative thinking skills in engineering students

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Objectives

• To identify, formulate, and solve **defined and undefined** engineering problems.
• To design and **innovate**
• To **evaluate and mitigate risks**
• To understand professional and ethical responsibility.
• To be tomorrow's **enterprise leaders**.
• To **communicate** effectively
• To understand the impact of engineering solutions in a global, economic, environmental, and societal context.
Employability skills of engineering graduates

• “Thinking skills such as logical and analytical reasoning; problem solving; capacity to identify access and manage knowledge and information; personal attributes such as imagination; creativity and intellectual rigor; values such as ethical practice, persistence, integrity and tolerance, problem solving, team working, communication, leadership” (Chaita 2016).

• “Not only a computer engineer or a mechanical engineer but a technical graduate with a perfect hold on his dealings with the professional world and hence can be a good leader and a motivator (Hargis 2011).

• Critical thinking and innovation: essential employability skills
Innovation

Innovation is:

anything that is
new, useful, and surprising

CREATIVITY IS THINKING UP NEW THINGS.

INNOVATION IS DOING NEW THINGS.

INNOVATION IS A STATE OF MIND
Critical thinking

• Do not accept any information presented as fact
• Dealing with new or unfamiliar ideas, opinions, and situations.
• See things in an open-minded way and examine an idea or concept from as many angles as possible.
• Look past views of the world and better understand the opinions of others.
Challenges: Engineering education

• How to teach critical thinking and innovation?
• Is it possible?
• How to assess CT and innovation skills?
• How to motivate my students?
• How to promote life-long learning?
• How to create the engineers of the future?
Critical thinking and innovation skills – engineering education

it is important for engineering students to develop the skills:

• For effective scientific and technical communication.
• To assess claims and data
• To criticise their own assumptions and inferences,
• To communicate and argue their own knowledge.
Critical thinking and innovation

• The Framework are the “4Cs” that make up Innovation Skills

• Critical Thinking development leads to innovation skills development
Can we teach critical thinking and innovation?

"We cannot solve a problem by using the same kind of thinking we used when we created them."

- Albert Einstein
Can we teach CT and innovation?

• Numerous debates say NO but maybe the don’t want to change and follow a new technological Evolution that we live

"Often the Biggest Barrier to Innovation Is Our Own Way of Thinking."
How to teach critical thinking and innovation

- Some universities have introduced a course
- Not recommended as it serves the need of understanding but not applying
- Embed the critical thinking and innovation requirement in multiple course can provide better results
- Teaching validation methods for each project can also help
The curriculum tells you "what", not "how." The "how" is the artistry in education.
Strategies in teaching critical thinking and Innovation

Inductive (alternative) teaching approach rather than deductive (traditional) which means:

• Inquiry learning (starting with questions)
• Problem based learning
• Project based learning
• Case based teaching
• Walking the talk – Socrates (peripatetic learning)
• Future – based learning (imaginary future environment, request for solutions)
• Innovation games (can be online or virtual)

Prince and Fletcher, Inductive learning and teaching methods
How to teach CT and Innovation: Concepts

- Teach concepts not facts
- Use Project Based learning and don’t use just projects
- Use and assess skills not only knowledge
- Reward innovation: Add column in the rubrics
- Use Teams not only groups
- Be innovating in the class
- Research – based
- Evidence – based
- Student centered
- Technology based

*Imperial college: Innovating teaching*
Assessment design

• Open ended assignments
• Case studies
• Reflections
• Discussions
• C.T. Question of the week

These important skills for the engineering professional are rarely part of the regular technical courses, where the students are graded rather by their performance. The examinations focus on the application of technical knowledge, not on its actual communication or validation.

"This really is an innovative approach, but I'm afraid we can't consider it. It's never been done before."
Assessment design

• Questions that promote evaluation and synthesis of facts and concepts
• Questions that start or end with words or phrases such as “explain,” “compare,” “why”

Questions to Ask

• What do you mean by ...? • How did you come to that conclusions? • What is the source of your information? • What assumptions led you to that conclusion? • What are the implications if you are wrong? • Why did you make that inference? • What is an alternate explanation for this phenomenon?

Peter Jeschofnig, 2014
Engineering School of Bahrain Polytechnic

strategies

Work integrated learning
- Industry projects, work experience, simulations

Problem based learning
- Well-designed work related problems stimulate learning to ensure students develop technical knowledge & skills plus employability skills

Employability skills
- teamwork, problem solving, communication, initiative & enterprise, planning & organisation, self-management, learning & technology
What the engineering students should be able to do

- Understand engineering problems
- Precisely describe the problem
- Develop possible solutions
- Effectively solve problems
- Design good products and processes
- Validating their solutions
- Provide alternative designs and evaluate results
Are our Engineering Students innovative and critical thinkers?
Thank you for your attention
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