

# Undergraduate Engineering Student's System Thinking of Their Teaching and Learning about Indian Accreditation

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**Abstract – Engineering faculties across India are experiencing substantial pressure from industry, the professional body and their own institutions to contextualise and embed generic graduate attributes in undergraduate programs. Responding to this pressure is proving challenging in India with three inter-related problems evident in the Indian engineering education literature: Innovative teaching and learning of graduate attributes tends to be isolated and short-lived; rigorous evaluation of impact on student learning is rare; and contextualization of institutional graduate attributes statements tends to be limited. In India and internationally, greater discourse, research and development are needed to embed engineering design-relevant meta-attributes (eg. reflective practice, creativity, social justice, systems thinking) in undergraduate engineering. The focus of this paper and our research is the teaching, learning and assessment of the meta-attribute systems thinking.**

**Keywords: Teaching, Learning, Accreditation, Higher Education**

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## 1. INTRODUCTION

Education plays a vital role in the development of any nation. Therefore, there is a premium on both quantity and quality (relevance and excellence of academic programmes offered) of higher education. Like in any other domain, the method to improve quality remains the same that is, finding and recognizing new needs and satisfying them with products and services of international standards.

Accreditation is a process of quality assurance and improvement, whereby a programme in an institution is critically appraised to verify that the institution or the programme continues to meet and exceed the norms and standards prescribed by the appropriate designated authorities. The Indian accreditation guidelines for all graduates of any higher education programs are expected to have identified technical/functional, generic and managerial competencies which signify Graduates as;

- To make the institute/department aware of the weaknesses of the programme offered by it and act on suggestions for improvement.
- To encourage the institute to move continuously towards the improvement of quality of its programme, and the pursuit of excellence.

- To facilitate institutions for updating themselves in programme curriculum, teaching and learning processes, faculty achievements, and students' skills/abilities/knowledge.
- To excel among stakeholders. (Peers, students, employers, societies etc.)
- To facilitate receiving of grants from Government regulatory bodies and institutions/agencies.
- To attain international recognition of accredited degrees awarded.
- To facilitate the mobility of graduated students and professionals.

The Indian accreditation guidelines implicitly and explicitly mandate the teaching and learning of systems thinking relating to engineering design and operational environments as well as the broader context of engineering work. In brief graduates require:

- To the solution of complex engineering problems.
- Analyze complex engineering problems reaching substantiated conclusions

- Design solutions for complex engineering problems and
  - Design system components or processes that meet the specified needs
  - Conduct investigations of complex problems
  - Prediction and modeling to complex engineering activities with an understanding of the limitations.
  - Consequent responsibilities relevant to the professional engineering practice.
  - Societal and environmental contexts for sustainable development.
  - Commit to professional ethics and responsibilities and norms of the engineering practice.
  - Function effectively as an individual, and as a member or leader
  - In diverse teams, and in multidisciplinary settings.
  - Communicate effectively on complex engineering activities with the engineering community
  - To manage projects and in multidisciplinary environments.
  - Ability to engage in independent and life-long learning in the broadest context of technological change.
4. Identify, formulate, evaluate and solve complex engineering problems.
  5. Knowledge of uses of modern tools of engineering.
  6. Broad education necessary to understand the impact of engineering solutions in a global and societal environment.
  7. Design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, manufacturability, health and safety.
  8. Understanding of ethical responsibility in practice at all times in function on multi-disciplinary teams also.
  9. Use of techniques, skills, and modern engineering tools necessary for engineering practice individual as well as in team management.
  10. Communicate effectively using oral, written and graphic forms.
  11. Handling contemporary issues related to engineering management and related fields.
  12. Engage in life-long learning to acquire other knowledge for continued education and learning in various elective streams.

## 2. METHODOLOGY

The research reported here was part of a broader study which used qualitative and quantitative measures to evaluate students' experiences of the teaching, learning and assessment of systems thinking in undergraduate engineering. In the broader study, we used different stakeholder's (student, alumni, employer and parent) data collection mechanisms to triangulate the findings consideration of following twelve skill of system thinking;

1. Applying knowledge of basic mathematics, science, and engineering.
2. Conducting experiments, as well as to analyze and interpret data.
3. Design & development of system and processes

## 3. DATA COLLECTION

A survey instrument with six basic questions followed the phenomenographic approach by using second order questions aimed at eliciting the lived experience of the individual, reported from the individual's own perspective. A three point scale was used for student responses such as [Excellent-3 Good-2 Poor-1] as well as word description and short answer.

Table No. 1

S.N.	Questions for Student	1	2	3
1	How <b>useful</b> are the twelve skill of system thinking for your future career?			
2	How well have you <b>learned</b> about the twelve skill of system thinking during your undergraduate degree?			
3	Have you been <b>assessed</b> on the twelve skill of system thinking during your undergraduate degree?			
4	Please give an example of teaching that helped you to learn one of the systems thinking skills			
5	Please given an example of an assessment task that allowed you to adequately demonstrate one of your systems thinking skills (mention in Q4 above)			
6	Do you have any suggestions for us on how we could improve our work based learning program for other students?			

Table No. 2

S.N.	Questions for Parents	1	2	3
1	How <b>useful</b> are the twelve skill of system thinking for your wards future career?			
2	How well have your ward <b>learned</b> about the twelve skill of system thinking during your undergraduate degree?			
3	Have you been <b>assessed</b> on the twelve skill of system thinking during your undergraduate degree?			
4	Please give an example of teaching that helped your ward to learn one of the systems thinking skills			
5	Please given an example of an assessment task that followed by your ward to adequately demonstrate one of your systems thinking skills (mention in Q4 above)			
6	Do you have any suggestions for us on how we could improve our work based learning program for other students?			

Table No. 3

S.N.	Questions for Alumni	1	2	3
1	How <b>useful</b> are the twelve skill of system thinking for your future career?			
2	How well have you <b>learned</b> about the twelve skill of system thinking during your undergraduate degree?			
3	Have you been <b>assessed</b> on the twelve skill of system thinking during your undergraduate degree?			
4	Please give an example of teaching that helped you to learn one of the systems thinking skills			
5	Please given an example of an assessment task that allowed you to adequately demonstrate one of your systems thinking skills (mention in Q4 above)			
6	Do you have any suggestions for us on how we could improve our work based learning program for other students?			

Table No. 4

S.N.	Questions for Employer	1	2	3
1	How <b>useful</b> are the twelve skill of system thinking for your future career?			
2	How well have you <b>learned</b> about the twelve skill of system thinking during your undergraduate degree?			
3	Have you been <b>assessed</b> on the twelve skill of system thinking during your undergraduate degree?			
4	Please give an example of teaching that helped employee to learn one of the systems thinking skills			
5	Please given an example of an assessment task that followed by employee to adequately demonstrate one of your systems thinking skills (mention in Q4 above)			
6	Do you have any suggestions for us on how we could improve our work based learning program for other students?			

#### 4. FINDINGS

This paper primarily reports on the stakeholder's survey research. We provide only a summary of the quantitative. We collected data from students in chemical engineering (strongly systems oriented)

- We surveyed second year students (n=76), third year students (n= 76) final year students

(n=68), providing some grounds for comment on possible development.

- We surveyed second year students parents (n= 67), third year students parents (n= 75) final year students parents (n=61), providing some grounds for comment on possible development.
- We surveyed final year students who completed graduation degree (n=82), providing some grounds for comment on possible development.
- We surveyed employer who play also major in development of institutes (n= 27) providing some grounds for comment on possible development.

A summary of the demographic data is shown following tables 5 to 8;

Table No. 5 summary of the demographic data of student

Sex	Age	Year	Major	Language at home		
Female	39	<18	152	2 <sup>nd</sup> 76	Chem. 203	English 11
Male	191	21-23	68	3 <sup>rd</sup> 76		Other 192
		24 Above	00	4 <sup>th</sup> 68		Both 57
Total	220	-	220	-	220	-

Table No. 6 summary of the demographic data of parents

Sex	Age	Year	Major	Language At Home		
Female	153	<35	00	2 <sup>nd</sup> 67	Chem. 203	English 11
Male	50	35-60	187	3 <sup>rd</sup> 75		Other 157
		60 Above	16	4 <sup>th</sup> 61		Both 57
Total	203		203	-	203	-

Table No. 7 summary of the demographic data of alumni

Sex	Age	Completion Year	Major	Language At Home	
Female	37	2012 - 2016	24 Above	Chem. 82	English 07
Male	45		-	-	Other 75
					Both 11
Total	82			-	-

**Table No. 8 summary of the demographic data of employer**

Sex	Age		Year	Major		Language At Home		
Female	11	<24	00	2012 - 2016	Chem.	27	English	00
Male	16	25-60	27		-	-	Other	27
		60 Above	00				Both	00
Total	27		27	-	27	-	-	

**Table No. 9 summary of the quantitative data**

Program	Year	Useful	Learned	Assessed
Chemical	2 <sup>nd</sup>	18	38	20
	3 <sup>rd</sup>	21	41	14
	4 <sup>th</sup>	17	47	04
Parents	-	153	27	23
Alumni	-	37	45	00
Employer	-	18	07	02

## 5. DISCUSSION

An overview of the quantitative data generated from the survey is interesting (Table 9) and provides an introduction to the qualitative results. The percentages shown are the sum of those students who indicated a positive response on the usefulness, learning and assessment questions against the systems twelve thinking skills. Note that 76.7% of students see the skills as useful for their future careers, with a slightly higher value for the final year chemical engineering students. The focus on work related skills is likely to have contributed to this. It is possible that students focused on specific skills rather than these being examples of the use of systems thinking.

There was a significant difference between students' scores on questions for 'useful' (question 1) and 'learned' (question 2) and 'assessed' (question 3). This suggested that systems thinking skills are perceived by students to be well learned or assessed as they should be, given the high proportion of students rating these skills as useful or essential for their future careers.

The learned and assessed scores were significantly different across all other stakeholders. As expected, final year students who indicated a positive response (proportion who answered 4 or 5) measured higher proportions on 'learned' and 'assessed' than second year and third year students with students normally being exposed to more of these skills by final year where design and capstone experiences feature more prominently. However, only in the case of chemical

engineering students did the scores differ significantly. In the case of mechanical engineering students the scores appear higher for third and fourth year students compared to second year students however the numbers in these groups were lower and so the error margin was greater.

The summary data shows that all groups of stakeholder saw the systems thinking skills as important (76.6% on average). There was a small year bias, suggesting there may be an improvement in perceived relevance and learning of systems thinking through the programs surveyed with final year students feeling more capable in these skill areas.

Given the quantitative results showed that students' perception of the usefulness of systems thinking match their experiences of being taught and assessed these skills, we now present the qualitative findings. These findings provide insights into how we might improve or increase students' experiences and perceptions of learning systems thinking.

## 6. CONCLUSION

In summary, systems thinking skills are critical competencies for contemporary and future engineers for particular emphasis on Complex Engineering Problems and Complex Engineering Activities Surveyed students from Chemical saw the development of a range of professional skills as useful to their future careers. They also noted that they getting enough teaching of these skills, enough authentic assessment opportunities to fully demonstrate mastery of these skills. The study reported here addresses that assumption and begins to answer questions as to what the best teaching methods might be for developing this complex thinking skill.

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