Challenges and Opportunities in the Engineering Profession
The Unnat Maharashtra Abhiyan

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Organization of the talk

- What is Engineering
- Engineering in India and key problems
- The government viewpoint
- The Unnat Maharashtra Abhiyan
- A new university and its curricula and research
Students: Why are you here?

- My parents sent me here.
- I have always wanted to be an engineer.
- I liked Physics and Maths in School.
- I want a good job.
- I want to do something for society.
- I like making things.

Two Questions!

- What is science and what is engineering?
- What are the prospects for engineering in India?
What is engineering?

and how do we measure it?

- Number of scientific instruments in schools.
- Number of buses per 1000 people.
- Number of liters of water per person per day?
- Number of factories. Number of manufacturing jobs.
- Length of roads per 1000 people.
- Units of electricity per person per year.

*material well-being of society*-sustainable, equitable and efficient
## Sectors and employment

### Sector-wise GDP

<table>
<thead>
<tr>
<th></th>
<th>Agriculture</th>
<th>Industry</th>
<th>Services</th>
<th>Per capita (in USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>India</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDP (2012) (%)</td>
<td>17.4</td>
<td>25.8</td>
<td>56.9</td>
<td>4K</td>
</tr>
<tr>
<td>Employment (%)</td>
<td>51.1</td>
<td>22.4</td>
<td>26.6</td>
<td>-</td>
</tr>
<tr>
<td>GDP China</td>
<td>10</td>
<td>44</td>
<td>46</td>
<td>9K</td>
</tr>
<tr>
<td>GDP S. Korea</td>
<td>3</td>
<td>40</td>
<td>57</td>
<td>30K</td>
</tr>
<tr>
<td>GDP Germany</td>
<td>1</td>
<td>28</td>
<td>71</td>
<td>43K</td>
</tr>
</tbody>
</table>

### Top Formal Employers

<table>
<thead>
<tr>
<th>Industry</th>
<th>Food</th>
<th>Textiles</th>
<th>Metals</th>
<th>Apparel</th>
<th>Non-metals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wages (Rs. lakhs)</td>
<td>0.70</td>
<td>0.80</td>
<td>1.35</td>
<td>0.67</td>
<td>0.69</td>
</tr>
</tbody>
</table>
### Engineering Placements 2013 (IIT Bombay)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Engg.</th>
<th>Finance</th>
<th>Consulting</th>
<th>IT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Super-GG</td>
<td>25 (27.7)</td>
<td>10 (35.0)</td>
<td>8 (49.6)</td>
<td>41 (52.1)</td>
</tr>
<tr>
<td>GG</td>
<td>116 (7.9)</td>
<td>82 (11.7)</td>
<td>110 (9.6)</td>
<td>102 (10.0)</td>
</tr>
<tr>
<td>IG</td>
<td>52 (6.5)</td>
<td>19 (7.2)</td>
<td>11 (5.8)</td>
<td>28 (7.2)</td>
</tr>
<tr>
<td>GI</td>
<td>24 (9.3)</td>
<td>10 (14.2)</td>
<td>10 (5.2)</td>
<td>5 (9.3)</td>
</tr>
<tr>
<td>II</td>
<td>64 (6.5)</td>
<td>13 (9.5)</td>
<td>8 (5.8)</td>
<td>22 (7.9)</td>
</tr>
</tbody>
</table>

Table: Numbers by sector and profile and average annual salary in Rs. lakhs

**So, why are IIT graduates not doing engineering?**
Placements in Engg.

Engineering/MBA/MCA/Pharmacy-Course vs Intake/Enrollment/Passed/Placement for the academic year: 2015–2016
Effects!

Steel consumption.

<table>
<thead>
<tr>
<th>Country</th>
<th>Steel Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>57</td>
</tr>
<tr>
<td>China</td>
<td>477</td>
</tr>
<tr>
<td>Other Asia</td>
<td>69</td>
</tr>
<tr>
<td>Japan</td>
<td>506</td>
</tr>
<tr>
<td>Egypt</td>
<td>95</td>
</tr>
<tr>
<td>USA</td>
<td>306</td>
</tr>
<tr>
<td>UK</td>
<td>145</td>
</tr>
<tr>
<td>Netherlands</td>
<td>200</td>
</tr>
</tbody>
</table>

Year-round drinking water availability.

<table>
<thead>
<tr>
<th>Year</th>
<th>Rural</th>
<th>Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012 (69th NSSO), per 1000</td>
<td>858</td>
<td>896</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>745</td>
<td>931</td>
</tr>
<tr>
<td>2008</td>
<td>862</td>
<td>911</td>
</tr>
</tbody>
</table>

Find out about Milk, Electricity, Cooking Fuel.
And this is how we are ...
And this is how we are ...

Data from Census 2011
Conclusion

- Very slow progress in meeting development needs.
- Poorly functioning industry sector. Poor productivity, inability to attract best talent.
- Increasing need in key areas and unmet demand!
- **How can engineers deliver better value?**

**4 Questions**

- Why is this mis-allocation happening?
- Where and which sectors are the jobs going to be?
- How are these jobs going to be created?
- How do I prepare for these jobs?
Some Answers

Focus on big-company engineering. More theory, less practice.
Less freedom, over-qualified. No comprehension of value.
More loyal than the king.
Output: Service sector!
### Table 3. Number of papers with phrase in the title and with at least one author from India (Scopus)

<table>
<thead>
<tr>
<th>Topic (phrase)</th>
<th>All years preceding 2003</th>
<th>2003–09 (TEQIP I)</th>
<th>2010 onwards (TEQIP II)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neural network</td>
<td>692</td>
<td>1818</td>
<td>2467</td>
</tr>
<tr>
<td>Fuzzy logic</td>
<td>110</td>
<td>327</td>
<td>759</td>
</tr>
<tr>
<td>Wavelets</td>
<td>96</td>
<td>905</td>
<td>1846</td>
</tr>
<tr>
<td>Genetic algorithms</td>
<td>262</td>
<td>989</td>
<td>1373</td>
</tr>
</tbody>
</table>

### Table 4. Number of papers with phrase in the title and with at least one author from India (Scopus)

<table>
<thead>
<tr>
<th>Topic (phrase)</th>
<th>All years preceding 2003</th>
<th>2003–09 (TEQIP I)</th>
<th>2010 onwards (TEQIP II)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water supply</td>
<td>84</td>
<td>74</td>
<td>87</td>
</tr>
<tr>
<td>Sanitation</td>
<td>30</td>
<td>51</td>
<td>63</td>
</tr>
<tr>
<td>Groundwater models</td>
<td>11</td>
<td>29</td>
<td>70</td>
</tr>
<tr>
<td>Public transport</td>
<td>5</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>Power grid</td>
<td>12</td>
<td>56</td>
<td>288</td>
</tr>
</tbody>
</table>
How does GoM or GoI see it

- Where will jobs come from?
- How will we fix basic services?
- Who will strengthen small enterprises?
The development challenge

Other Metrics as well

- Year-round access to DW-74%.
- droughts, chulhas, public transport, small manufacturing etc.
- missing: institutions, community and private sector- knowledge
Urban water Availability and Jobs

2012 Data - Person employed vs Water availability

Employees per 1000 vs Water availability
Better Amenities $\Rightarrow$ More jobs
New Knowledge, New Professions $\Rightarrow$ Better Amenities

**Conclusion:** New jobs will begin in the development sectors!
New and hard applied research. Student and faculty Interest.
New Mechanisms. Understanding how is value created!
What does GoM want

- Governance and Job Description
- Research and Curricula
- Development Outcomes
Unnat Maharashtra Abhiyan

Started by Govt. of Maharashtra in January 2016.

Objectives:

- align higher education with demands of regional development
- create avenues for students, faculty members and institutions for participation
- through curricula and research, create new professions and new professionals of the future
The basic argument

Better Outcomes
Water, Public Transport, SME, Energy

Need for Knowledge, New Practices, New Research
New Job Profiles, Avenues for Professionals.

The role of University and Higher Education
Knowledge Structures. Key Areas.

Mechanisms for a Partnership
Can Universities help?
A unique and welcome GR(15/6/2015) from Water Supply Dept.

- Every new PWS must undergo 3rd-party assessments.
- Every CEO-ZP to identify college to perform these assessment. 1% of capital costs to be paid.
- Selected college must form an inter-disciplinary cell, prepare success criteria, advise on good practices!

<table>
<thead>
<tr>
<th>District</th>
<th>Palghar</th>
<th>Thane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of schemes</td>
<td>19</td>
<td>12</td>
</tr>
<tr>
<td>Sanctioned amount</td>
<td>Rs. 28.2 Cr.</td>
<td>Rs. 6.4 Cr.</td>
</tr>
<tr>
<td>Major Issues (Design)</td>
<td>7/19</td>
<td>9/12</td>
</tr>
</tbody>
</table>

Learnings
- Bad practices and issues identified. New research generated.
- Rs. 34 lakhs to colleges but... Positive returns already for GoM.
The Unnat Maharashtra Abhiyan (13/01/2016)

Objectives

- Align teaching and research in engineering with state’s development agenda. **Understand value and outcomes.**
- Mechanism for select regional colleges to access funds and data.
- Support the **Right To Know** for communities.

Features

- **Project Areas.** Water, Sanitation, Electricity and Energy, Public transport, rural and household enterprises.
- **Programs.** e.g., Jalyukta Shivar, Thakkar Bappa.
- **At the college.** Technology and Development Cell.
- **Nodal Agency.** District Collector, DPC and District Innovation and departmental M&E funds.
- **Mentored by CTARA at IIT Bombay**
More GRs

- Planning, 7th April, 2016. Source of funds.
- HTE, 15th June, 2016. Topics and guidelines.
- Planning, 20th July 2016. Images from MRSAC for govt. projects.
- Planning, 22nd July 2016. IIT Bombay as 3rd party overall evaluation of programs and projects.

The Future

- Planning. DPO as nodal office for UMA. Periodic clarity on funds.
- GAD/Planning. Support for UMA in 3rd party assessments.
- UMA as a network of trusted institutions

Needed

Reform. Field-work, social context, inter-disciplinary, curriculum and R&D reform. Trust.
<table>
<thead>
<tr>
<th>Broad Area</th>
<th>Type of service</th>
<th>Case study</th>
<th>Fees</th>
<th>Possible Core Departments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural Electricity</td>
<td>QoS analysis</td>
<td>Rural electricity stress assessment for a feeder/village cluster</td>
<td>4-8 man months</td>
<td>EE, CSE</td>
</tr>
<tr>
<td>Assessment and</td>
<td></td>
<td>Soci-economic and technical analysis of agricultural feeders</td>
<td>4-8 man months</td>
<td>EE</td>
</tr>
<tr>
<td>analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture pumping</td>
<td></td>
<td>Techno-economic feasibility of implementing energy efficiency and renewable</td>
<td>4-8 man months</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td></td>
<td>energy/hybrid solution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural household</td>
<td></td>
<td>Techno-economic feasibility of implementing energy efficiency and</td>
<td>4-8 man months</td>
<td>All</td>
</tr>
<tr>
<td>Assessmen and</td>
<td></td>
<td>renewable energy/hybrid solution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Feasibility study, assessment and</td>
<td>Network components and design for reliability and QoS</td>
<td>1-2% of project cost</td>
<td>EE, Mechanical</td>
</tr>
<tr>
<td></td>
<td>design</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## UMA Areas

<table>
<thead>
<tr>
<th>Resources</th>
<th>Description</th>
<th>Duration</th>
<th>Departments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logistics and planning</td>
<td>Groundwater utilization and regulation for a specific situation</td>
<td>4-8 man months</td>
<td>Civil, Mechanical, Chemical</td>
</tr>
<tr>
<td>Feasibility assessment and design</td>
<td>Assessment and design of watershed programs such as JYS or IWMP</td>
<td>1-1.5% of plan cost</td>
<td>Civil, Env. Sci. and Engg.</td>
</tr>
<tr>
<td><strong>Irrigation</strong></td>
<td>Feasibility assessment and design</td>
<td>Assessment of regional and sub-taluka minor irrigation systems</td>
<td>4-12 man months</td>
</tr>
<tr>
<td>Feasibility assessment and design</td>
<td>Water use efficiency of irrigation systems</td>
<td>4-12 man months</td>
<td>All</td>
</tr>
<tr>
<td>Feasibility assessment and design</td>
<td>Assessment and improvement of distribution systems</td>
<td>4-12 man months</td>
<td>Civil, Env. Sci. and Engg., Agriculture</td>
</tr>
<tr>
<td>Third party audit</td>
<td>Water use and socio-economic analysis</td>
<td>4-12 man months</td>
<td>All</td>
</tr>
<tr>
<td><strong>Rural industries</strong></td>
<td>Feasibility study and assessment</td>
<td>Standardisation of processes for specific rural industries</td>
<td>4-12 man months</td>
</tr>
<tr>
<td>Logistics and planning</td>
<td>Technological and business support to regional industrial clusters</td>
<td>4-12 man months</td>
<td>All</td>
</tr>
<tr>
<td>Feasibility study and assessment</td>
<td>Use of cold storage supply chains for food processing</td>
<td>4-12 man months</td>
<td>All</td>
</tr>
<tr>
<td>Research and Design</td>
<td>Improvements in productivity of poultry industry</td>
<td>4-12 man months</td>
<td>All</td>
</tr>
</tbody>
</table>
The Big Picture - What used to be

People
- State, district, taluka, GP
- CEO, Collector

serve

University

support

Government
Companies

employees

What we now need...

People
- State, district, taluka, GP
- CEO, Collector

support
- advise, plan, assess

University

serve

Government
Companies

employees
- new job descriptions
- knowledge products
UMA work in pictures

Plastic road (KBP Satara)  Cleaning of Krishna River (BVP Pune)  Irrigation at Sinnar (CTARA, IIT-B)

Solar Dryers (SSVPS Dhule)  Camlin Pencil Sorter (PVPIT Budhgaon)
UMA Colleges at work
The New Engineer

- Identify a *societal problem* and a *stakeholder!*
- Analyse the problem and separate it elementary subproblems
- Solve, Synthesize and Deploy the complete solution.
- The true engineer is *inter-disciplinary*

**The True Engineer**

**Design**
- Civil
- Econo.
- Maths.
- IT

**Modelling**
- Analyse
- Identify Problem
- Synthesize
- Deploy

**Domain Knowledge**
- Creative Skills
- Societal Skills

Society
# The Regional Engineering Framework

<table>
<thead>
<tr>
<th>Department</th>
<th>Last-mile areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSE</td>
<td>Public Transport, PDS logistics</td>
</tr>
<tr>
<td>Economics</td>
<td>District Economic Plan, GP development plan</td>
</tr>
<tr>
<td>Civil Engg.</td>
<td>Taluka DW plan, Low-cost housing</td>
</tr>
<tr>
<td>Elec. Engg.</td>
<td>Household efficiency, Agricultural Feeders</td>
</tr>
<tr>
<td>General Engg.</td>
<td>Urban Local Body, Bus Depots, Irrigation Systems</td>
</tr>
<tr>
<td>Planning</td>
<td>Electricity, Water, Sanitation, Energy</td>
</tr>
</tbody>
</table>

- **Development Engg.**: an inter-disciplinary course.
- More field-work, more space for electives. Project based learning.
- Interactions with regional agencies. **Systematic interaction with people.**
- **Case-studies.** Planning.
Composite Skills-Academic Framework

**The Case-study**

- Preparing the Bio-diversity register for a GP. Forest plans.
- Computing the agricultural GDP in a taluka. Recording farmer narratives.
- Preparing a village sanitation and waste disposal plan.
- Preparing ideal time-tables for city public transport system.
- Guiding municipal corporations in energy efficiency.
- Visiting a Poha Factory. Designing a *haldi* cooking machine.

**Exciting -Comprehension and Delivery**

- All areas of knowledge.
- Soft-skills, data, maps and quantification, analysis, scientific temper, reporting, documentation.
The concrete cycle-1

- Energy bill reduction through the use of solar dish.
- Conversion of Istry from electricity to steam.
- How to make leaf-plate making more efficient.
- Supply chains for bio-mass power plants.
- Temperature regulation in poultry farm.
The concrete cycle-I
The concrete cycle-I

- Power quality meter-3-phase, voltage, power factor, harmonics
- Measurements at irrigation pumps
- Mapping of taluka grid.
Analysis of a failed rural regional (RR) Water supply scheme. Designs for many other.
Sample Projects

Rooftop solar plan for a complete gram-panchayat (Kerala).
Sample Projects

Irrigation plans for your district or taluka.
Is there policy space? Plenty

Objectives of University [4.6]

extend the benefits of knowledge and skills for development of individuals and society by associating the university closely with local, regional and national problems of development

Powers and duties of university, inter alia, [Sec 5.17]

to make provision, wherever feasible, in the university departments, colleges, institutions, recognized institutions and schools, for survey and collection of statistics, data and other particulars relevant to various developmental activities including State and National plans, evaluation of the developmental schemes with the participation of the students as a part of their curricular activities”
Powers and duties of university, [5.74]

*to identify skills to which students need to be exposed to, by taking into account the local needs, training facilities available, emerging needs and new employment opportunities*

Powers and duties of the Board of Research[Sec 60 (I)]

*to identify problems and issues related to the region within the jurisdiction of the university and to take special initiative to address such issues through systematic research*
The functions and duties of the Commission[Sec. 77.1]

(m) to prepare programmes in the various subjects in the sphere of higher education, keeping in view the overall priorities, perspectives and needs of the society and expectations from higher education

(zf) to review the approach and methods adopted by the colleges and universities, both public and private, for integrating education with social development and to study the impact of such an approach on social development and suggest ways and means to make it more efficient and effective
(5) "The university shall initiate a time bound programme to prepare an annual plan every year for the location of colleges and institutions of higher learning, in consonance with the perspective plan and shall publish it before the end of academic year preceding the year in which the proposals for the opening of new colleges or institutions of higher learning are to be invited."

(6) The University shall undertake the systematic field survey within the geographical jurisdiction of the University every five years regarding the requirements of the facilities of Higher Education, types of skills needed for the local industries, trade and commerce, aspirations of youth of the region...... The university shall use the findings of such field survey and develop the scientific database while preparing the perspective plan of the university.
Jadhav Committee Recommendations

University Perspective Plans: **Broad Objectives**

- Importance of R&D, policy, objectives, incentives and measurements.
  - Its utility in teaching and infrastructure
- The need for composite skills.
  - Each teacher to develop one. Importance of teacher training.
  - 2-3 case-studies for every student. Related to course-work.
  - Building overall competence and delivery of value.
- Address rural-urban divide and social back-wardness
  - stress on uniformly good quality, access and equity
  - address basic amenities, jobs and relevance
Detailed Guidelines

Curricula and Research

- Prepare manpower for future needs. Enable learning of composite and inter-disciplinary skills. Innovative programs.
- Make research topical and useful.
  - Consult regional agencies, DPC, DIC and society in general.
  - Decide on areas of research, incentives, metrics.
  - Set up Regional Research Cell at university and college level for industry and society to access.
- Evolve partnerships with local industry. Training and Entrepreneurship support. Engage and understand research needs.
- Invest in Teacher Training Cells.
- Enhance the social role and responsibility of the University.
Links and References

Sites:

- www.ctara.iitb.ac.in: CTARA, a center of IITB devoted to technology and development. Also see TDSL in Academics at CTARA, for a variety of case studies.
- www.ctara.iitb.ac.in/tdsc: Our Technology and Development Cell.
- www.ctara.iitb.ac.in/tdsc/uma: Documents on Unnat Maharashtra Abhiyan.

Talks on youtube:

- https://www.youtube.com/watch?v=G71maumVZ1A: On the role of engineers in development.
- See https://www.youtube.com/watch?v=fc5WsQBJqcs for placements in engineering, esp. IITs.
Thanks