Recommendations Towards Development Engineering
Implementing the UBA
Second Meeting of All India Board of Under Graduate Studies in Engineering and Technology
17th September 2016, New Delhi
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Today’s Agenda

- Demand Side: Status of today’s engineering and of development indices
- Supply Side: How are the institutions doing?
- Reasons and how to overcome
- One step: UBA
- Recommendations
- Does it fit overall policy frameworks
- How to implement it

References are provided at the end.
Economy: Sectors and Employment

- Sector Wise GDP (World Bank database)

<table>
<thead>
<tr>
<th>India</th>
<th>Agriculture</th>
<th>Industry</th>
<th>Services</th>
<th>Per capita (in USD)</th>
</tr>
</thead>
<tbody>
<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 (Labour Bureau, Govt of India)

<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>

Usual formal vs. Informal—low technology, poor conditions
Other Indices

- Steel Consumption (World Steel Association)– points to lack of virtuous cycle in railways, roads, infrastructure

<table>
<thead>
<tr>
<th></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>

- Year Round Drinking Water Availability (NSSO, Census)
Severe Stress in Key Areas
Our engineering teaching and research infrastructure

- Teaching—layered institutions—centrally funded, state, private
- Curriculum—Many changes from Thomson College (state engineering) to COEP, Madras to IITs and RECs
- Focus on abstract scientific and less on practical and empirical systems
- JEE GATE as key norms for measuring high school science and engineering education outcomes!
- Research: DST and other GoI agencies. Very little at the state level. Very little at the application level, e.g., MDWS or MORD or MOUD.
- Little accountability of R&D or engineering education to end-user. NO systematic data.
AICTE and its Role

- Maintaining standards– institution and curricula
- Admissions of students and measuring performance of institutions
- Curriculum design for meeting societal needs
- Guidance on the conduct of research and development
India produces 1.5 million engineering graduates every year, as opposed to 95,000 in the US
The number of engineering colleges was 3,345 in 2014–15
Needs of the informal sector are not being met
IT continues to be the most attractive sector
TEQIP, NBA and NAAC

TEQIP
- Much in governance and administration, little in technical content
- Push for globalization, no regional push
- Centers of excellence, publication in international fora
- Tepid outcomes

NBA/Ranking
- Accreditation based on model curricula
- ABET but without the "Body of Knowledge" handbooks
- Led to stress on GATE

IITs remain at the top and as role models
Role of elite engineering institutions (such as IITs)

The elite and model educational institutions, such as the IITs, are best positioned to lead the way in defining new ways of conducting engineering education. This is enshrined in their objectives as well, such as—

- To provide research and development consultancy which will promote contact with and be of service to industries and to government and Civic Organizations.
- To organize quality improvement programs for faculty members from various engineering colleges.
- To provide leadership in curriculum design and development.
- To organize short intensive courses, conferences and seminars on current technological developments which will be of benefit to the surrounding community.
Table: Numbers by sector and profile and average annual salary in Rs. Lakhs

<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>
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<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>

So why are IIT graduates not doing engineering?
Placement (AICTE website)

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

Total

Values

0k 100k 200k 300k 400k 500k 600k 700k 800k 900k

Chemical Engineering  Civil Engineering  Computer Science Engineering  Electrical Engineering  Electronics a…  MBA  MCA  Mechanical Engineering  PGDM  PHARMACY  Textile Engineering

Intake  Enrollment  Passed  Placed  Average Factor
Research Areas

- Misallocation of effort and funds into research in areas which are not relevant

<table>
<thead>
<tr>
<th>Topic (Phrase)</th>
<th>All years 2003</th>
<th>preceding</th>
<th>2003-2009 (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>
<td></td>
</tr>
<tr>
<td>Sanitation</td>
<td>30</td>
<td>51</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>Groundwater Models</td>
<td>11</td>
<td>29</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>Public Transport</td>
<td>5</td>
<td>15</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Power Grid</td>
<td>12</td>
<td>56</td>
<td>288</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Topic (Phrase)</th>
<th>All years 2003</th>
<th>preceding</th>
<th>2003-2009 (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>
<td></td>
</tr>
<tr>
<td>Fuzzy Logic</td>
<td>110</td>
<td>327</td>
<td>759</td>
<td></td>
</tr>
<tr>
<td>Wavelets</td>
<td>96</td>
<td>905</td>
<td>1846</td>
<td></td>
</tr>
<tr>
<td>Genetic Algorithms</td>
<td>262</td>
<td>989</td>
<td>1373</td>
<td></td>
</tr>
</tbody>
</table>
Provision of an urban amenity such as water is a precursor to industrial growth.

The graph shows the relationship between persons employed in the formal sector (per 1000) and availability of water in the districts of Maharashtra (weighted average across all talukas).
Development and Engineering

Development of rural industry leads to industrial growth and higher HDI.

The graph depicts the relationship between HDI and agribusinesses across countries.
Clearly, there is a strong demand for basic engineering services (sadak, bijli, paani and rural enterprises).
The supply of such services should come from engineering institutions such as the IITs and other regional engineering colleges.

However, there is a demand–supply mismatch. Domestic engineering colleges are not meeting their mandate.

International social science programs offer inter-disciplinary and eclectic courses in South Asian Studies and Development Studies.
Multilateral agencies such as World Bank are involved in provision of basic amenities.
International engineering programs are focusing on inter-disciplinarity, planning, work with industry/state. One interesting example is the MIT Tata Center for Technology + Design.

New journal from Elsevier: Development Engineering!
The UBA mechanism offers a solution to the problems and demands of development.
Broadly speaking, UBA plans to achieve the following—

- Seek an alignment of curricula and research with regional development needs
- Re-emphasize field-work and case-studies as an important pedagogy
- Provide rural India and regional agencies with access to the professional resources and expertise of the institutes of higher education
- To improve development outcomes as a consequence of this research

Under UBA, IIT–B and TISS have been appointed coordinating institutions for the Subject Group titled ‘Capacity building and change of ethos in technical institutions’. 
The Basic Argument

Development Demands
(Civil amenities such as water, energy, transport, etc., livelihoods, SMEs)

Need for Knowledge, New Practices, New Research (UBA)
(New Job Profiles, Avenues for Professionals)

The Role of University and Higher Education
(Knowledge Structures, Knowledge Practices, Research in Key Areas)
Role of the University

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

serve

University

support
- advise, plan, assess

Government

Companies

employees
- new job descriptions
- knowledge products
Unnat Maharashtra Abhiyan (UMA) of GoM

- Make institutions regional resources
- Provide mechanism for citizens to approach institutions—right to knowledge
- Provides for data and fees

At institution level—Phase I
- Allows students to do projects in core areas—demand driven
- Analyze failed water supply scheme, do a taluka level water balance, support local industry
UMA/UBA: A Mechanism to Implement Development Engineering Approach

What does it need?

- **Academic freedom** for (i) institutions to offer regional projects and (ii) develop regional areas of expertise
- **Skills and training** (i) interdisciplinary skills (ii) applied social science (iii) fieldwork (iv) reporting (v) data
- **Incentives for faculty and reporting avenues**
Recommendations

- Departmental Developmental Areas (Each Department)
- Student Projects in Development (3–9 credits)
- Development Cell (Under Dean R&D)
- Development Engineering Core (3 credits)
- Regional Engineering Core (3 credits)
- Creating Space for Electives and Minors (up to 15 credits)
- Planning as a Minor (up to 15 credits)
Each core department to identify 2 or more developmental areas for action research, which will have an impact on the ultimate beneficiaries (households)

Develop 5–10 concrete case-studies every year in each area, done by students through for-credit projects

Examples of such areas are drinking water, cooking energy, rural electrification, village sanitation plans, rural public transport
## Project Areas

- For a comprehensive list of possible project topics and guidelines governing terms of payment and engagement, please visit our website – [http://ctara.iitb.ac.in/tdsc/uma/index.html](http://ctara.iitb.ac.in/tdsc/uma/index.html).

<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 analysis</td>
<td>Socio-economic and technical analysis of agricultural feeders</td>
<td></td>
<td>4-8 man months</td>
<td>EE</td>
</tr>
<tr>
<td>Agriculture pumping</td>
<td>Techno-economic feasibility of implementing energy efficiency and renewable energy /hybrid solution</td>
<td></td>
<td>4-8 man months</td>
<td>All</td>
</tr>
<tr>
<td>Rural household</td>
<td>Techno-economic feasibility of implementing energy efficiency and renewable energy /hybrid solution</td>
<td></td>
<td>4-8 man months</td>
<td>All</td>
</tr>
<tr>
<td>Assessment and analysis</td>
<td>Socio-economic and technical analysis of domestic and informal sector use</td>
<td></td>
<td>4-8 man months</td>
<td>EE, Mechanical, Chemical, etc. (depending on industry)</td>
</tr>
<tr>
<td>Feasibility study assessment and design</td>
<td>Network components and design for reliability and QoS</td>
<td></td>
<td>1-2% of project cost</td>
<td>EE, Mechanical</td>
</tr>
</tbody>
</table>
# Project Areas

<table>
<thead>
<tr>
<th>Resources</th>
<th>Logistics and planning</th>
<th>Groundwater utilization and regulation for a specific situation</th>
<th>4-8 man months</th>
<th>Civil, Mechanical, Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feasibility assessment and design</td>
<td>Assessment and design of watershed programs such as JYS or IWMP</td>
<td></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>
<td>Civil, Env. Sci. and Engg., Agriculture</td>
</tr>
<tr>
<td>Feasibility assessment and design</td>
<td>Water use efficiency of irrigation systems</td>
<td></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></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></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>
<td>All</td>
</tr>
<tr>
<td>Logistics and planning</td>
<td>Technological and business support to regional industrial clusters</td>
<td></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></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></td>
<td>4-12 man months</td>
<td>All</td>
</tr>
</tbody>
</table>
Student Projects in Development

- Student teams across departments to undertake inter-disciplinary regional field projects
- Field-work to be supervised by faculty members and coordinators
- Reports graded on quality and utility and released in the public domain
- Findings to be discussed with stakeholders
Development Cell

- Institute-wide extension cell which will respond to written requests for advice and analysis from elected representatives and state and local agencies
- Case-Studies as key mechanism– water, energy, urban and rural planning, public transport
- Identification of sources of funding for travel, stay, logistics, data and coordination
Inter-disciplinarity is the key skill requirement (engineering + social sciences such as economics, sociology, anthropology, history, political science/civics)

Course structure–
- Governance structure (at district and taluka level)
- Field work and reporting
- Data (GIS, Census Data)
- Introduction to a specific sector and state processes
- Cap–stone
Regional Engineering Core

- Focus on an engineering service of **regional importance** such as Irrigation Water for central Maharashtra, or Food Processing in coastal Maharashtra, or Hill Roads and Bridges for Himachal Pradesh
- *Planning* – resources, allocation, attributes
- CTARA, IIT–B offers a course on Water and Development (TD603)
## Creating Space for Electives

### Mechanical engineering-

<table>
<thead>
<tr>
<th></th>
<th>AICTE</th>
<th>UNIV OF ILL</th>
<th>NUS</th>
<th>IIT-D</th>
<th>COEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Engg and Sci</td>
<td>60 (34.1%)</td>
<td>29 (22.66%)</td>
<td>28 (17.5%)</td>
<td>51 (33.55%)</td>
<td>50 (27.78%)</td>
</tr>
<tr>
<td>Humanities and SS</td>
<td>14 (7.95%)</td>
<td>18 (14%)</td>
<td>20 (12.5%)</td>
<td>15 (9.87%)</td>
<td>9 (5%)</td>
</tr>
<tr>
<td>Core</td>
<td>50 (28.41%)</td>
<td>52 (40.63%)</td>
<td>54 (33.75%)</td>
<td>64 (42.1%)</td>
<td>85 (47.22%)</td>
</tr>
<tr>
<td>Core Electives</td>
<td>20 (11.36%)</td>
<td>19 (14.84%)</td>
<td>15 (9.38%)</td>
<td>12 (7.89%)</td>
<td>9 (5%)</td>
</tr>
<tr>
<td>Open Electives</td>
<td>12 (6.82%)</td>
<td>6 (4.69%)</td>
<td>20 (12.5%)</td>
<td>10 (6.58%)</td>
<td>12 (6.67%)</td>
</tr>
<tr>
<td>Others</td>
<td>Project and Internship-20 (11.36%)</td>
<td>Principles of Composition (Writing)- 4 (3.13%)</td>
<td>Project and Industry- 23 (14.38%)</td>
<td>Project and Seminar- 15 (8.33%)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>176</td>
<td>128 + 20 (minor)</td>
<td>160</td>
<td>152</td>
<td>180</td>
</tr>
</tbody>
</table>

### Electrical engineering-

<table>
<thead>
<tr>
<th></th>
<th>AICTE</th>
<th>UNIV OF ILL</th>
<th>NUS</th>
<th>IIT-D</th>
<th>COEP*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Engg and Sci</td>
<td>60 (34.1%)</td>
<td>34 (31+3) (26.56%)</td>
<td>34 (21.25%)</td>
<td>55 (36.67%)</td>
<td>50 (28.25%)</td>
</tr>
<tr>
<td>Humanities and SS</td>
<td>14 (7.95%)</td>
<td>18 (14%)</td>
<td>20 (12.5%)</td>
<td>15 (10%)</td>
<td>9 (5.1%)</td>
</tr>
<tr>
<td>Core</td>
<td>50 (28.41%)</td>
<td>28 (21.88%)</td>
<td>40 (25%)</td>
<td>60 (40%)</td>
<td>73 (41.24%)</td>
</tr>
<tr>
<td>Core Electives</td>
<td>20 (11.36%)</td>
<td>32 (25%)</td>
<td>22 (13.75%)</td>
<td>10 (6.67%)</td>
<td>15 (8.47%)</td>
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<tr>
<td>Open Electives</td>
<td>12 (6.82%)</td>
<td>12 (9.38%)</td>
<td>16 (10%)</td>
<td>10 (6.67%)</td>
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<td>150</td>
<td>177</td>
</tr>
</tbody>
</table>
Planning

- **Traditional**—Spatial, natural resources
- **Engineering services and supply chains**—drinking water, cooking energy, PDS, irrigation, water
- **The supply side**—natural + infrastructure
- **The demand side**—human and natural ecosystems, development, aspirations
- **Allocation**—who gets what and why, laws, economics, efficiency

*Synergy between engineering and planning*
What do we see

- Interesting minors—geography, planning, economics
- Broader set of skills in non-engineering areas, more professional
- Skills of life—long learning instead of a long list of courses
Departmental Developmental Areas (Each Department)

Student Projects in Development (3–9 credits)

Development Cell (Under Dean AP or Dean R&D)

Development Engineering Core (3 credits)

Regional Engineering Core (3 credits)

Creating Space for Electives and Minors (up to 15 credits)

Planning as a Minor (up to 15 credits)
Possible Outcomes

- For the IITs—connection with real problems, improvement in research, better connect with regional institutions
  - Outside chance of more core placements
- For state governments: additional applied research capacity, better evaluations, assessments, work on state programs, state issues
- For regional institutions: real problems, broader scope for innovation, improvement in regional status, better science and engineering for faculty and students
- For students: better training, professional approach, new avenues for jobs and innovation
- For society at large: access, right to knowledge, better outcomes
Consistency with International Standards

- The engineer is widely recognized as a social and cultural actor and a change-agent. This is reflected in international norms and standards such as the Washington Accord and ABET. The recommendations put forth today are consistent with Washington Accord and ABET guidelines, as are the international undergraduate engineering programs.
Washington Accord

- Washington Accord recommends a curriculum and processes suited to societal needs
- Attribute WA3 of the Washington Accord: ‘Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.’
GENERAL CRITERION 3. STUDENT OUTCOMES

The program must have documented student outcomes that prepare graduates to attain the program educational objectives.

Student outcomes are outcomes (a) through (k) plus any additional outcomes that may be articulated by the program.

(a) an ability to apply knowledge of mathematics, science, and engineering

(b) an ability to design and conduct experiments, as well as to analyze and interpret data

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

(d) an ability to function on multidisciplinary teams

(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility

(g) an ability to communicate effectively

(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

(i) a recognition of the need for, and an ability to engage in lifelong learning

(j) a knowledge of contemporary issues

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
The implementation of the above will need an additional expenditure of about Rs.13,000 per student, as indicated in the table below.

<table>
<thead>
<tr>
<th>Expenditure Description</th>
<th>Estimate per student</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development Project-TA, DA and expenses</td>
<td>Rs. 4000</td>
</tr>
<tr>
<td>2 Field Visits for Development Engg. Core</td>
<td>Rs. 3000</td>
</tr>
<tr>
<td>3 Field visits for regional Engg. Core</td>
<td>Rs. 4500</td>
</tr>
<tr>
<td>Coordination and Teaching Assistant Expenses</td>
<td>Rs. 1500</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>Rs. 13000</strong></td>
</tr>
</tbody>
</table>
Measurement and Reporting

- Preparation of departmental areas, reports and case-studies, and regular updating of the website
- Good reports to be counted as research output, creation of a separate Development Engineering journal
- Student and faculty time accounting
- Creation of a Development Cell (T&DC) modelled on the TDSC – will maintain a website containing typical project documents and output, and prepare an annual report
- Each department to maintain a webpage for Development Engineering Core
References

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