EDUCATING ENGINEERS FOR SUSTAINABLE PROGRESS: THE RELEVANCE OF ACCREDITATION

ROUND TABLE DISCUSSION

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ORGANIZATION OF THOUGHTS

- **Sustainable Development**
- **SD as Global Agenda – SD Linkages**
- **Engineering Challenges**
- **Engineering Education for Sustainable Development**
- **Competences, Pedagogy and Curriculum**
- **Quality Assurance in Engineering Education – Accreditation**
- **Recent International Accreditation Conference in India – May 18-19, 2011**

THE IMPERATIVES OF SUSTAINABLE DEVELOPMENT

- **There is no alternative to Sustainable Development**
- **It is already too late**
- **We need to stop current trends**
- **We need to do things differently;**

  and to do different things
- **Over millennia, we have moved from survival economy and lifestyles to consumption economy and lifestyles**
- **We need to move from consumption economy and lifestyles to conservation and preservation economy and lifestyles**

THE MANY DIMENSIONS OF SUSTAINABLE DEVELOPMENT

- **Energy**
- **Environment**
- **Ecology**
- **Economy**
- **Equity**
- **Earth**
- **Education**
- **Efficiency**
- **Emissions**
- **Employment**
- **Engineering**
- **Ethics**

CONCEPTS OF SUSTAINABILITY AND SUSTAINABLE DEVELOPMENT

- **Conservation of living resources ; management of the biosphere for human needs and use.**
  - **Represents an anthropocentric attitude, implying that animals and plants are all for human use.**
- **Living in harmony with Nature.**
- **Living off the income of Nature, without eroding the Capital.**
- **Must give back to the earth what we take from it. [Aga Khan]**

CONCEPTS OF SUSTAINABILITY AND SUSTAINABLE DEVELOPMENT

- **S.D. meets the needs of the present generation without compromising the ability of future generations to meet their own needs.**
  [The Brundtland Report, 1987]
- **Keeping something going for an 'indefinite' period of time.**
  - **Sustainable extraction of fossil fuels,**
  - **Sustainable farming, employing chemical fertilizers,**

  are indeed oxymorons.

CONCEPTS OF SUSTAINABILITY AND SUSTAINABLE DEVELOPMENT

- **Living within 'the carrying capacity' of the Environment.**
- **Realization that the biosphere is both for us and for our descendants:**
  "We have not inherited the Earth from our parents ; we have only borrowed it from our children".
- **S.D. is an inter-generational concept,**
  seeking equity over time, and
  minimization of disparities between generations.

CONCEPTS OF SUSTAINABILITY AND SUSTAINABLE DEVELOPMENT

- **Since the present standard of living is low in most LDCs, people aspire for a higher standard.**

  S.D. cautions that there are limits to such growth :

  Due to :

  - **Finite stock of resources (both energy & materials)**
  - **Pollution of the environment.**
  - **Exploding populations.**
  - **Escalating aspirations.**
  - **Conflicting interests.**

SUSTAINABLE DEVELOPMENT LINKAGES

- **Millennium Development Goals**
- **Grand Challenges (NAE)**
- **Human Development Indicators (UNDP)**
- **IPCC**
- **Climate Change, Global Warming**
- **Has both global as well as country-specific implications**
- **Engineering and Engineering Education are important means of tackling Sustainable Development Problems**

THE MILLENNIUM DEVELOPMENT GOALS (MDG)
8 Goals and 18 Targets

Goal 1: Eradicate extreme poverty and hunger

Target 1: Halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day.

Target 2: Halve, between 1990 and 2015, the proportion of people who suffer from hunger.

Goal 2: Achieve universal primary education

Target 3: Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling.

Goal 3: Promote gender equality and empower women

Target 4: Eliminate gender disparity in primary and secondary education preferably by 2005 and to all levels of education no later than 2015.

Goal 4: Reduce child mortality

Target 5: Reduce by two-thirds, between 1990 and 2015, the under-five mortality rate.

Goal 5: Improve maternal health

Target 6: Reduce by three quarters, between 1990 and 2015, the maternal mortality ratio.

Goal 6: Combat HIV/AIDS, malaria and other diseases

Target 7: Have halted by 2015, and begun to reverse, the spread of HIV/AIDS.

Target 8: Have halted by 2015, and begun to reverse, the incidence of malaria and other major diseases.

Goal 7: Ensure environmental sustainability

Target 9: Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources.

Goal 8: Develop a Global Partnership for Development

Target 12: Develop further an open, rule-based, predictable, non-discriminatory trading and financial system. Includes a commitment to good governance, development, and poverty reduction - both nationally and Internationally.

Target 13: Address the Special Needs of the Least Developed Countries. Includes: tariff and quota free access for LDC exports; enhanced programme of debt relief for HIPC and cancellation of official bilateral debt; and more generous ODA for countries committed to poverty reduction.

Target 14: Address the Special Needs of landlocked countries and small island developing states (through Barbados Programme and 22nd General Assembly provisions).

Target 15: Deal comprehensively with the debt problems of developing countries through national and international measures in order to make debt sustainable in the long term.

Target 16: In co-operation with developing countries, develop and implement strategies for decent and productive work for youth.

Target 17: In co-operation with pharmaceutical companies, provide access to affordable, essential drugs in developing countries.

Target 18: In co-operation with the private sector, make available the benefits of new technologies, especially information and communications.

SUSTAINABILITY – RELATED NAE GRAND CHALLENGES (6/14) -- 2008

(i) providing access to clean water,

(ii) restoring and improving urban infrastructures,

(iii) managing the nitrogen cycle,

(iv) making solar energy economical,

(v) providing energy from fusion, and

(vi) developing carbon sequestration methods

EDUCATION FOR SUSTAINABLE DEVELOPMENT

- **United Nations Decade of Education for Sustainable Development (DESD), spanning the years 2005 to 2014; UNESCO was designated as the lead agency for the Decade.**
- **The Decade's four key objectives are:**

1. **facilitating networking and collaboration among stakeholders in ESD**
2. **fostering greater quality of teaching and learning in ESD**
3. **supporting countries in achieving their millennium development goals through ESD efforts**
4. **providing countries with new opportunities and tools to incorporate ESD in education reform efforts.**

BONN DECLARATION -- 2009

- ***UNESCO World Conference on Education for Sustainable Development held in Bonn, Germany from 31 March to 2 April 2009.***

- **Unsustainable production and consumption patterns are creating ecological impacts that compromise the options of current and future generations and the sustainability of life on Earth, as climate change is showing.**

- **All countries will need to work collaboratively to ensure sustainable development now and in the future.**
- **Investment in education for sustainable development (ESD) is an investment in the future, and can be a life-saving measure, especially in post-conflict and least developed countries.**
- **ESD should be of a quality that provides the values, knowledge, skills and competencies for sustainable living and participation in society and decent work.**

• **Through education and lifelong learning we can achieve lifestyles based on economic and social justice, food security, ecological integrity, sustainable livelihoods, respect for all life forms and strong values that foster social cohesion, democracy and collective action.**

EDUCATION FOR SUSTAINABLE DEVELOPMENT (ESD) IN THE 21ST CENTURY

- **Education for sustainable development is setting a new direction for education and learning for all.**

- **ESD brings new relevance, quality, meaning and purpose to education and training systems. It involves formal, non-formal and informal education contexts, and all sectors of society in a lifelong learning process.**

•ESD highlights the interdependence of environment, economy, society, and cultural diversity from local to global levels, and takes account of past, present and future.

• Promote evidence-informed policy dialogue on ESD, drawing upon relevant research, monitoring and evaluation strategies, and the sharing and recognition of good practices.

• **Encourage and enhance scientific excellence, research and new knowledge development for ESD through the involvement of higher education institutions and research networks in ESD.**

MAJOR FEATURES OF SUSTAINABLE DEVELOPMENT TOPICS

- **Inter-disciplinary**
- **Breadth as well as Depth**
- **Hands – on Learning**
- **Project-based Learning**
- **Human Values and Professional Ethics**
- **Group and Team Work**
- **Analysis as well as Synthesis (Design)**
- **R&D, Innovation, Entrepreneurship**

KNOWLEDGE CONTENT OF SUSTAINABLE DEVELOPMENT

- **Spans Chemical, Civil, Environmental , Mechanical Engineering, Life Sciences, Biotechnology,**
- **Energy, Environment, Ecology, Economics, Education**
- **Water – Resources, Pollution, Waste water Treatment, Conservation, Harvesting,**
- **Renewable Energy Technologies**
- **Energy Conservation**

RATIONALE FOR RE-DESIGN OF THE ENGINEERING EDUCATION SYSTEM

- **There have been significant Changes in the Practice of Engineering as a Profession in the new millennium** :
  - **Constraints imposed by environmental considerations**
  - **Customization demanded by diverse customers**
  - **Opportunities offered by technology developments in several sectors**
  - **Availability of sophisticated diagnostic and computational tools**
  - **Wide choice of materials**
  - **Implications of Globalization, such as , for example, Innovation as the basis of Competitiveness**

SUSTAINABLE DEVELOPMENT IN ENGINEERING EDUCATION: COMPETENCES, PEDAGOGY AND CURRICULUM.

- **J. Segalàs, D. Ferrer-Balas, and K.F. Mulder**
- **Technical University of Catalonia,**
- **Delft University of Technology**

- **“A new kind of engineer is needed, an engineer**
- **who is fully aware of what is going on in society and who has the skills to deal with societal aspects of technologies”.**

• **EF Schumacher : "*The volume of education… continues to increase, yet so do pollution, exhaustion of resources, and the dangers of ecological catastrophe. If still more education is to save us, it would have to be education of a different kind: an education that takes us into the depth of things".***

THREE MAIN QUESTIONS

1. ***What?*** **Which SD competences must an engineer learn at university?**
2. ***How*****? How can these competences be acquired efficiently? The role of *pedagogy*.**
3. ***Where ?*** **Which education structure is more effective for the required pedagogy and also to embed SD in the curriculum?**

REQUIRED COMPETENCIES AND PEDAGOGY FOR SUSTAINABILITY LEARNING

Required Competencies:

1. **Critical thinking – *"Why and What if" reasoning***
2. **Systemic thinking,**
3. **Inter-trans-disciplinarity, and**
4. **Values and ethics**

- **Involves several Bloom's Taxonomy levels.**

Pedagogy:

1. **Passive learning: lecturing, writing exercises, problem demonstrations...**
2. **Active learning: PBL, Problem base learning, case studies, etc.**

NEXUS BETWEEN SUSTAINABLE DEVELOPMENT AND ACCREDITATION

- **In as much as Sustainable Development solutions depend on Engineering and Engineering Education, Accreditation which ensures Quality Assurance is crucial to achieving Success.**
- **Accreditation is outcomes-based , and involves both objective (quantitative) as well as subjective (qualitative or judgmental) assessment.**
- **It is interesting that *All* ABET 3a-k criteria have aspects relating to Sustainable Development.**

ABET CRITERIA – 2003/04
Criterion 3. Program Outcomes And Assessment

Engineering programs must demonstrate that their graduates have:

- **(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**
- **(d) an ability to function on multi-disciplinary teams**
- **(e) an ability to identify, formulate, and solve engineering problems**
- **(f) an understanding of professional and ethical responsibility**

ABET CRITERIA – 2003/04
Criterion 3. Program Outcomes And Assessment

- **(g) an ability to communicate effectively**
- **(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context**
- **(i) a recognition of the need for, and an ability to engage in life-long learning**
- **(j) a knowledge of contemporary issues**
- **(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.**

A RECENT INTERNATIONAL ACRREDITATION CONFERENCE IN CHENNAI

- **May 18-19 , 2011**
- **Speakers: 8 International ; 8 Indian**
- **Included: Dr. Iring Wasser**
  - **Prof. Claudio Borri**
  - **Prof Giuliano Augusti**
  - **Dr Hans Hoyer**
  - **Hasan Mandal**
  - **Prof David Holger, Former ABET President**

OBJECTIVES OF IAC

IAC was organized :

•in the backdrop of major initiatives and reforms currently being proposed in India,

• both to align our accreditation system and processes with the Washington Accord and ABET; &

• to bring in legislation to integrate the accreditation systems of different sectors of higher and professional education into a common framework, NARAHEI (National Regulatory Authority for Higher Education Institutions).

•**The National Board of Accreditation, NBA, currently responsible for accreditation of engineering programs, has initiated reforms to get closer to the outcomes-based Washington Accord and ABET frameworks.**

MAJOR OBJECTIVES OF IAC

- **To spread awareness of the Quality Assurance and Accreditation systems world-wide.**
- **To take stock of our own national initiatives and reforms.**
- **To share Best Practices from different systems ;**
- **To assist our Engineering Colleges to incorporate a Quality culture in their activities**

MAJOR CONCLUSIONS AND RECOMMENDATIONS

- **Provided "First-hand knowledge about Indian and other international practices on accreditation of engineering education".**
- **In view of the sheer size of the Indian Engineering Education system, "Institutional accreditation might be more appropriate in the Indian context".**
- **The ERASMUS Mundus programme of the EU offers some good opportunities for improving the bilateral cooperation between academics and post-graduates, especially at Ph D level.**

• **It became evident that India is facing probably the biggest challenges, given the fast and rapidly increasing number of HEIs and the tens of thousands of programs being offered. The sheer logistical aspects of this endeavor, including the need for a multitude of peers/experts is daunting".**

•"A system of national quality assurance has to be further refined, which takes into consideration the size of the country and the number of its institutions. In comparable countries, policy makers are talking about a risk-based, proportionate system of quality assurance, combining elements of institutional, system and program accreditation and taking into consideration the past history and services of HEIs".

GROWTH OF DIFFERENT PROGRAMS IN TECHNICAL INSTITUTIONS

Year	Engineering	Management	MCA	Pharmacy	Architecture	HMCT	Total	Added in Year
2005-06	1475	1888	1576	629	118	70	5756	383
2006-07	1511	2031	1619	665	116	64	6006	250
2007-08	1668	2062	1642	854	116	81	6423	417
2008-09	2388	2734	1768	1021	116	87	8114	1691
2009-10	2942	3482	1888	1054	106	93	9565	1451
2010-11	3241	3858	1937	1102	125	101	10364	799

GROWTH OF SEATS IN DIFFERENT PROGRAMS IN TECHNICAL INSTITUTIONS

Year	Engineering	Management	MCA	Pharmacy	Architecture	HMCT	Total	Added in Year
2005-06	499697	122663	61991	32708	4379	4435	725873	40691
2006-07	550986	144372	63394	39517	4543	4242	807054	81181
2007-08	653290	185780	78692	52334	4543	5275	979914	182860
2008-09	841018	227989	82578	64211	4543	5794	1226133	246219
2009-10	1071896	273732	121123	72836	4133	6387	1550107	323974
2010-11	1324246	378907	135173	103867	4933	7061	1954482	404375

NBA STATISTICS

Programme	Number of accredited Institutions	No. of eligible institutions in 2011	% (Accredited Vs Eligible)	Total no of institutions till 2010	% (Accredited Vs Total)
Engineering	**551**	**Established till 2006-07: 1511**	**36.46%**	**3241**	**17%**
Management	120	Established till 2008-09: 2734	4.38%	3858	3.11%
MCA	82	Established till 2007-08: 1642	4.99%	1937	4.23%
Pharmacy	36	Established till 2006-07: 665	5.41%	1102	3.26%
Architecture	8	Established till 2006-07: 116	6.89%	125	6.4%
HMCT	3	Established till 2006-07: 64	4.68%	101	2.97%
Total	**800**	**6732**	**11.88%**	**10364**	**7.72%**

THE WAY FORWARD

- **Invest heavily in R&D to enhance performance and bring down costs of renewable energy systems by at least an order of magnitude**
- **Energy Conservation, to reduce energy use.**
- **Reduce, Re-use, Regenerate, Recycle.**
- **Match the quantity as well as quality of energy demand and supply**
- **Take an integrated view of :**
  - **Energy**
  - **Environment**
  - **Materials**

SIGNIFICANCE OF "APPROPRIATE" STRATEGIES

- **In spite of attempts to harmonize the several national systems and processes, Accreditation has several country-specific characteristics:**

- **Size – Number of Institutions and Programs**
- **Structure of Education – Affiliated vs Autonomous Colleges**
- **National Policies – Regulation, Concurrent jurisdiction (Centre + State)**
- **Asymmetries, Diversity…**

•Traditions and Conventions

• Language

• Limitations – Sudden expansion, Demand-Supply Gap, Faculty scarcities, PhD scarcity ..

• The term “appropriate” was introduced a few decades back to recognize the diversity of different groups of countries , in terms of :

local resources, needs, lifestyles, cultures, stage of development…

• Should Accreditation be designed to be “appropriate”?