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Challenges in Accreditation of Engineering Education for Sustainable Development

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Abstract: With the advent of industrial and information revolution, engineering education has undergone changes with the objective that the programs and the graduates respond to the development issues with holistic perspective. Globalization spurred need of internationalization of engineering education and mobility of professionals across borders. Washington, Sydney and Dublin Accords came into existence. Accreditation agencies could become member of these accords for mutual recognition of their accreditation. There is disconnect in the academic and vocational programs. Skill Competency Credit Point (SC-CP) is defined. 5 SC-CP are equivalent to 1 Credit Point in higher education. This will facilitate mobility. Reasons for lower quality are identified. Accreditation of integrated practice engineering programs may also be planned. Assessment criteria for Innovation may be worked out.

Key words: integrated engineering education, sustainable development, mobility, skill competency credit point, credit transfer between vocational and academic streams

1. Towards Sustainable Development

Industrial revolution in 19th century marks as a turning point in human history. World's per capita income increased 6-fold. The dawn of 21st century witnessed phenomenal growth of ICT and its impact in every sector of economy. Computational power increased, price got reduced and the size shrank on and on.

Future prosperity of rich economies will depend both on their *ability to innovate* and on their *capacity to adjust to change*. What is required from Educational institutions in the 21st Century is a different set of concepts, competencies and skills — multidisciplinary, integration and innovation. Leadership is another key element for engineering profession to remain relevant and connected in global competition. Companies interested in maintaining a competitive edge are calling upon educators to produce engineers capable of leading multi-disciplinary teams, technical ingenuity with business acumen and produce graduates who have passion for lifelong learning. Industry is also challenging academia to broaden or restructure curricula beyond the intellectual endeavors of design of scientific inquiry to the greater domain of professional leadership and entrepreneurship. Knowledge without practice breeds a blue-sky theorist. Practice without knowledge breeds a trial–and-error lay person. Knowledge and practice breed a well-grounded, competent practitioner.

There is wide economic disparity in the world. The engineering education needs to incorporate the concept of Sustainable Development that means "the needs of the present are met without compromising the ability of future

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generation to meet their own needs". Needs of the future depend on how well we balance Social. Economic and Environmental objectives while making decisions today. Social Objectives include Equality, Access, Empowerment, Social Mobility, and Cultural Preservation. Economic Objectives include Services, Household needs, Industrial growth, Agricultural Growth, and Efficient use of labor. Environmental Objectives include Biodiversity, Natural resources, Carrying Capacity, Ecosystem integrity, and Clean air & water. The Engineering Education needs to be structured to meet these objectives.

There is paradigm shift in engineering education from traditional practices to emerging strategies. These may be categorized under philosophical theme, curricular aspects, diagnostic assessment, and innovation. Emerging strategies will focus on both commercializing knowledge and skill, innovation in application and entrepreneurship, output-centric clinically relevant curriculum, problem finding skills and knowledge management. There will be focus on *"Combining knowledge and practice", "Deriving knowledge from case-practices", "Situational problem-solving", "Learning by discovery", "Learning from failures", "Faculty training in engineering education", "Autonomy and better organizational collaboration", "Open Engineering Clinic for MSMEs", "Cross-disciplinary technology project teams", "Team innovate", "Web-based knowledge sharing and management"* (Farr J. V. & Brazil D. N., 2010; Sawhney M., Wolcott R. C. & Arroniz I., 2007; Wood R. C., 2007; Alberto Savoia & Patrick Copeland, 2011; Om Vikas, 2011).

2. Engineering Education in India

India's population is 1155 Million, workforce is 510 Million, 35% Indians are younger than 15 years, 18% between age group of 15–24. Average age is 25 years. Over 200 Million enroll in class-I each year, about 10% of these are able to finish class-XII, About Drop-out rate between KG to class-12 is about 90%. 100 Million children have no access to schooling. Literacy (Government statistics) is 67%, but functional Literacy is 33%. 60 percent (510 Million) are self employed. 25% population is below poverty line. Unemployment of 46 Million (in 2010) is likely to rise. 55% population is in villages, but their GDP contribution is declining. Rural to urban migration is increasing. 70% of labor force is still illiterate or below primary level. 300 Million of employable age are unemployed. 2.7 Million College graduates come out every year, but they lack workplace skills. Job growth is slow, whereas potential workforce is increasing. This leads to sprawling unemployment discontent (Paliwal D. K., 2002). *Both per capita income and labor productivity are low* less than 1/10 and 1/7 respectively. This is shown in Table 1.

Table 1 Country-wise Population, per Capita Income, and Labor Productivity

Country	Per capita Income	Population	% World population	Labor Productivity
China	$7,600	1,340 Mn	19.22	$9,518
India	$3,500	1,210 Mn	17.36	$7,700
USA	$47,200	313 Mn	4.48	$70,235
Japan	$34,000	126 Mn	1.80	$49,900
Thailand	$8,700	89 Mn	1.00	$13,842
France	$33,100	63 Mn	0.91	$56,563
UK	$34,800	62 Mn	0.89	$47,349
South Korea	$30,000	48 Mn	0.69	$33,552

According to *C K Prahalad Project India @ 75 by 2022*, India requires to produce 500 Million world-class skilled people, and 200 Million world-Class graduates.

There is cash flow of US $10 Billion to 12 Billion per year on Indian students studying in foreign universities (153,000 students go abroad). Demographic dividend of large young population is possible through Integrated Practice Engineering Education. I prefer to use the term “Practice Engineering” rather than “Vocational Education & Training”.

Paradox is that Indian has 300 Million unemployed people; they have no skill-sets whereas employers face huge shortage of skilled manpower. Purchasing power parity of about 16 times with respect to developed nations is window of opportunity to India (Krishna Khanna, 2010).

India has demographic dividend with 12% productive population, largest in world, in the age group of 18–24 years. But very low proportion of population has access to higher education. Current GER (Gross Enrolment Ratio) is 13.5% to compare 85% for USA with world average of 26%. Target GER is 30% by the year 2020 to become a developed country and target student enrollment is 40 Mn. 12^{th} class overall enrolment of 8 Million and science enrolment of 2.3 Million in 2007–08 is targeted to be raised to overall enrolment of 16 Million and Science enrolment of 6 Million by 2020 (Amit Khare, 2011).

3. Retrospection

3.1 Graduates: Too Few to Hire

In the Wall Street journal (April 5, 2011), article on “Graduates Million, but Too Few Fit to Hire” mentions that engineering colleges now in 2011 have 1.5 Million students, nearly 4 times the 390,000 in the year 2000. Engineering graduates in India remain unemployed for months as they lack skills necessary to join the workforce (Geeta Anand, 2011).

What are the reasons? (Om Vikas, 2011)

- *Poor infrastructure.* Most colleges don’t have well equipped labs.
- *Poor faculty*. Most private colleges resort to hire fresh graduates on contract with nominal salary. They don't have any teaching ability and also lack sound knowledge of the discipline.
- *Poor Pedagogy*. Terminology remains as bundle of jargons. Semantic aspect is not clear. Use of open technologies/standards is not encouraged. Teaching-Learning processes are not innovation-centric. There is minimal focus on R&D.
- *Poor respect to faculty*. Most of the private institutions do not provide proper office space with PC and internet connectivity. Often 4–6 faculty members are accommodated in a small room. There is no space for discussion with students and other faculty colleagues. Teachers are considered liability, revenue-drains.
- *Poor Students Performance*. What are the obstacles? Distractions, abundance of information, imbalance in curricula, stereotyped instruction delivery and evaluation methods are a few obstacles often cited. Net savvy students often bunk the classes. Copying the assignments is their collaborative venture.
  - Poor in basic sciences. Students remain poor in basic sciences — Physics, Mathematics and Chemistry.
  - Poor in core engineering science subjects. Basic concepts of core engineering science subjects are not clear.
  - Poor Interaction with society. Interaction with society in local language is absent. Multilingual computing is not introduced to carry out projects of local relevance.
  - Poor technological skills. Students lack systems thinking, critical thinking, integration skills, collaborative

problem-solving skills, techno-managerial skills.

- Poor communicative skills. Students lack professional communications skills — articulation, technical writing presentation and societal sensitivity.
- Poor achievement motivation. Interest for higher education or entrepreneurship is lacking.

3.2 Engineering Education Islands Disconnect

There are two prevalent streams in Education, namely, Vocational and Academic. These are run under the Ministry of Human Resource Development. Vocational Training is imparted by 17 different ministries and departments. However, the largest base of vocational training is by DGE&T under the Ministry of Labour. There is no scope of horizontal or vertical mobility. Engineering Education is disjoint from Vocational Education & Training (VET).

There is no direct vertical mobility in the case of vocational training. Of course there is provision for lateral entry for ITI pass-outs to get into 2nd year of Polytechnic (3-years program) and for Polytechnic pass-outs into 2nd year of BTech (4-years program). Such lateral entry is restricted to 5–10% of the intake. *But they miss requisite exposure to basic sciences and communicative skills which are offered in the first year of these programmes.* Their quality of the engineering education will remain poor.

ITI Pass-outs are expected to have hands-on experience and practice aptitude. Diploma holders (Polytechnic Pass-outs) are trained in commissioning and maintenance, testing and quality assurance. Engineering graduates (B.Tech/B.E) develop abilities in design, development and prototyping. CBSE has introduced a few vocational courses at senior secondary level (grade-XI & XII). But these are not considered for credit transfer or exemption of similar course in higher studies. There is no mechanism in vogue for credit acceptance, accumulation and transfer in the vocational courses (Om Vikas, 2012).

3.3 Curricular Imbalance

IIT Kanpur report (Paliwal D. K., 2002) on engineering curricula review discusses findings of 1st Review (1970–1972), 2nd Review (1979–1981), and 3rd Review (1990–1992). Until 1980 the duration of the BTech program was 5 years. From 1981 onwards the duration of B Tech Program was reduced to 4 years. This affected the proportion of the Humanities & Social sciences (~20%), Mathematics & Basic Sciences (~25%), Engineering sciences (~25%), Engineering Analysis & Design (~25%), and Electives (~10%) with respective reduction in Mathematics & Basic Sciences to ~40%, and HSS to ~37%. Four elective streams were identified with core and soft core electives. Most of the professional courses were retained. In 5-year BTech program, there were 8-10 HSS courses making up to 16%–19% of the curriculum, this got reduced to 4-5 HSS courses that is about 10%–11% of the 4-year BTech curriculum. It is to notice that a good HSS content is necessary for a well-rounded engineering education. Another anomaly is noticed in time and weight proportion of Lecture, Tutorial and Practical. Lecture content is on higher side. Further attraction to hard core engineering disciplines is proving difficult in the wake of emerging Information Technology. New courses are being suggested and there is emphasis on professional and communication skills, and life-long learning. It is felt that the curriculum be broad based and flexible (Prabhu, www.iitk.ac.in).

4. Accreditation towards Global Competitiveness

Higher Education in 21st century demands the following:

- *Equity and inclusion*. Access to common man needs to be drastically improved.

- *Partnership.* Public Cooperative Partnership (PCP) without commercialization.
- *Emphasis on basic scientific research and scientific aptitude.*
- *Qualitative and quantitative expansion* of secondary and post-secondary education.
- Re-inventing higher education *curricula* to meet emerging challenges.
- *Teaching Ability Certification* for faculty.
- *Assessment and accreditation* of institutions to ensure quality and relevance.
- *International mutual recognition* of educational qualifications and professionals.

At the time of placement, industry looks for certain traits in students as following:

- Cognitive Knowledge (*Know-What*): basic mastery of discipline.
- Practical proficiency (*Know-how*): ability to translate theory into practice.
- Instinctive Perception (*Know-why*): In-depth perception of cause and effect of relationships.
- Achievement Motivation (*care-why*): desire to achieve success.
- Inter-Personal interaction (*concern-who*): ability to deal with people for common goal.

Paradox. Industries, including MNCs in India, are obsessed with the mind-set of eligibility criterion of first class throughout from High school onwards rather than judging the competencies.

4.1 Accreditation Procedure

There are a number of accreditation bodies for engineering education in USA, UK, Australia, Japan, India etc. But very few countries have agreement on quality of education and passing out graduates for mutual exchange in terms of course credit transfer, transnational mobility of graduate professionals for employment. Equivalence is established on the basis of entry-level educational requirement, entry-level professionals, entry-level students and faculty in educational programs, and teaching-learning processes. Accreditation body must have autonomy, transparency and be free from regulatory bodies/government.

In **USA**, ABET is the Accreditation Board of Engineering and Technology. This accredits programs at regional/national level under four categories: Applied Science, Computing Engineering and technology respectively through ASAC, CAC, EAC, TAC (Technology Accreditation Commission). ABET is a federation of 30 Professional societies representing these fields. ABET is responsible for program-specific accreditation that assures that a college or University program meets the quality standards established by the profession. The peer-review process identifies strength, weaknesses, concerns, deficiencies and recommendation for improvement. Accreditation is granted for six years. *Graduate Attributes* include Engineering knowledge, Problem analysis, Design & Development of Solutions, Investigation, Modern tool usage, Engineer and society, Environment& sustainability, Ethics, Individual & team work, Communication, Project management & finance, Lifelong learning.

In **United Kingdom**, degree qualifications are regulated by the government. Non-degree qualifications are un-regulated. It is important to distinguish between the accreditation status of an institution, and the accreditation status of the qualification/programs it offers. National Database of Accredited Qualifications is maintained by the UK accreditation bodies subject to a regular external quality assurance reviews by the Quality Assurance Agency for Higher Education (QAA). UK Standard for professional Engineering competencies (UK-SPEC) by the Engineering Council UK adds two important competencies for Chartered Engineering-CEng or Incorporated Engineer- IEng:

- Ability to combine general and specialized engineering knowledge and to optimize application of existing and emerging technology.

- Ability to apply appropriate theoretical and practical methods to design, develop commission, operate and maintain engineering products, processes, services and system.

In **India**, program-specific accreditation is done by NBA (National Board of Accreditation) (Prabhu S. S.) under AICTE (All India Council for Technical Education), and institutional accreditation is carried out by NAAC (National Assessment and Accreditation Council) (Purao S., Vaishnavi V. K., Welke R. & Lenze L., 2009) under UGC (University Grant Commission). Grading is considered during permission to increase seats and grant-in-aid for R & D, modernization of labs, etc.

NBA periodically conducts evaluation of technical programs such as Engineering & Technology, Management, Pharmacy, Architecture, Hospitality and Mass Communication on the basis of Guidelines, Norms and Standards specified and to make recommendations regarding recognition or de-recognition of the program. NBA criteria for Assessment of UG/PG include: Organizational and Governance, Financial Resources, Allocation & Utilization, Physical Resources (central facilities), Human Resources: Faculty & Staff, Faculty, Non-teaching Staff, Human Resources: Students, Teaching-Learning Processes, Supplementary Processes, and Research & Development and Interaction Efforts. Each one has varying weight for UG & PG with a total of 1000 marks (www.nba-aicte.ernet.in).

NAAC accredits Institutions/University/Affiliated Colleges/Autonomous Colleges with the following assessment criteria for University (u), Autonomous Colleges (a), and Affiliated or Constituent Colleges (c): Curricular Aspect, Teaching-Learning Processes, Research, Consultancy & outreach, Infrastructure & Learning Resources, Student Support & Progression, Governance & Leadership, and Innovation Practices. Each one has varying weight for affiliated college, autonomous college, and university with a total sum of 1000 marks (www.naacindia.org).

Major focus is on Teaching-Learning Processes in both NBA and NAAC assessments. Essential aspect is the methodology of teaching-learning that promotes innovation and critical thinking. NAAC accreditation data reveals that fewer universities opt for accreditation; “A” grading is awarded to very few institutions that draws the inference that Innovation and research is not encouraged in most of the institutions.

There are quality assessment procedures and mechanism of awarding Accreditation thereupon. These are basically for UG & PG level engineering programs. But the Accreditation process must be in effect beginning at school level, from certificate to diploma to degree to doctorate levels. Global mobility spurred the Graduate level Accreditation. For sustainable development, quality as well as vertical mobility at all levels need to be ensured.

At school level, CBSE (Central Board of Secondary Education) has recently adopted the accreditation process of its affiliated schools through the identified accrediting agencies. CBSE would act as the appellate body. Core principles of Accreditation will include: Self-Study which engages the entire educational community in structural analysis, self-refection, and planning in response to the standards relating to students progression, faculty, teaching-learning process; Peer Review by visiting team of peers; Follow-up to ensure prescribed institutional change is accomplished; Accreditation attests to substantial compliance with established qualitative standards, integrity of statements to public describing the school’s program, its commitment to improvement and sufficiency of resources. *Accreditation will not compare or rank the schools.* Accreditation has to value to local citizen, school management, school administration, teachers and students (www.cbse.nic.in).

4.2 Mutual Recognition

There are six international agreements governing mutual recognition of engineering qualifications and professional competence. In each of these agreements countries/economies who wish to participate may apply for membership. There are three agreements covering mutual recognition in respect of tertiary-level qualifications in engineering: Washington Accord, Sydney Accord, and Dublin Accord. The other three agreements cover recognition of equivalence at the practicing engineer level, i.e., it is individual people, not qualifications that are seen to meet the benchmark standard. The concept of these agreements is that a person recognized in one country as reaching the agreed international standard of competence should only be minimally assessed (primarily for local knowledge) prior to obtaining registration in another country that is party to the agreement. These are APEC Engineer agreement, Engineers Mobility Forum agreement, Engineering Technologist Mobility Forum agreement. International Engineers Alliance (IEA) provides secretariat to these Accords (www.washingtonaccord.org). Institution of Engineers (India) is permanent member of Mobility of IEA.

NABEEA is Network of Accreditation Bodies of Engineering Education in Asia with 9 full and 6 associate members.

Mutual recognition is based on *Education Framework* — Entry level qualifications, number of years of the program; *Recognition of the program* by Competent Accreditation Authority and Reputation of the Institute; *Broad parameters of Curricula* as indicated in the mark sheet/transcript; and *Transfer of Credits.*

Competitive environment will sustain the initiatives towards integrated perspective of engineering education of quality, relevance and excellence. India has prepared ground to become Signatory/Member of the Engineers Mobility Accords.

To illustrate, **Australian Education framework** is basis for processing the request for recognition of any foreign qualification databank of foreign institutions. Engineers-Australia for Practicing Professional registers only those engineers graduated from a program accredited by the member of Washington Accord. NOOR (National Office of Overseas Skills Recognition) of Australia-Education International, Government of Australia is to recognize qualification based on Education framework. University-Australia is consortium of 39 universities to decide on recognition of foreign degrees under rules of concerned professional body.

4.3 Membership of an Accord

Main Obstacles are Differences in Education System, Accreditation system, Accreditation body, Disciplines, licensing and Registration. *Guiding Principles are* Autonomy of Signatory, Transparency to Accreditation System, Free from Government and other influences.

Washington Accord has 14 signatories from different countries.

India as a signatory of the Washington Accord will have Engineers Mobility among all its member countries. The following observations were made by the mentors from Washington Accord to claim for its membership:

- "Engineering" in degree titles for the programs in global context.
- Adequate number of secondary level student's intake with strong mathematics background, and adequate number of qualified faculty and instructors.
- Clear distinction between NBA accredited programs and AICTE licensed programs.
- Outcome based Evaluation. Output quality of graduates should be maintained irrespective of reservation.
- Fine tuned accreditation manual, Industry Advisory committee to auger industry participation in training and evaluation, and good number of trained assessment mentors.
- NBA website to provide all information about the assessment questions, list of NBA accredited programs, list of best practices, self-evaluation, institutional collaborations and their effective implementation, advantages of mobility accord, countries/accreditation boards recognizing NBA accreditation, standards & parameters for evaluation, Continuous improvement and quality assurance in affiliating universities and their engineering

colleges, etc

- Partial autonomy to institutions is desirable. Affiliation of colleges is unique system in India.

5. Challenges in Accreditation

5.1 National Vocational Educational Qualification Framework (NVEQF)

In India, there are 17 different ministries/departments that run vocational education and training programs catering to about 2.8 Million people. But there is no coordination among them, no provision of vertical mobility, and no central quality assessment and accreditation mechanism. An integrated approach is desirable to be in place. This would require inter ministerial coordination. There is need to evolve framework to link schools, vocational and university education with focus on quality and relevance. In this context NVEQF is commendable initiative by MHRD. Vocational and academic streams will be transmutable with quality and excellence. Competencies will be valued. Level 1–7 are proposed with progressive predominance of vocational content [6]. Salient characteristics of NVEQF are as following:

- AICTE (All India Council for Technical Education) will accredit the SKPs (Skill Knowledge Providers).
- Knowledge–skill proportion varies from level-1 to level-7 requiring 800:200 hours to 700:300, 600:400, 500:500, 400:600, 300:700, and 200:800 hours respectively.
- Class-IX, X, XI, XII correspond to Level-1, 2, 3, 1nd 4 respectively. After 10+2, Graduation Year-1 corresponds to Level-5, Year-2 to Level-6, Year-3 to Level-7, Post graduation may correspond to Level-8 & 9.
- At each level 6 modules are to be completed –
- *3 Skill Modules*: Trade related module, Work related module, Soft Skills related module, (these are evaluated on 3 point scale A, B, C)and *3 Competencies Modules*: Language module, Science module, Business module (these are evaluated on 5 point scale A, B, C, D, E)

These programs will have different curricular content and would require recognition based on the credited skill sets. Accreditation procedure needs to be developed.

5.2 An Integrated Program of Practice Engineering Education

A new Integrated Practice Engineering program integrating existing ITI, Diploma and Degree programs is proposed that would open up opportunity to ITI (Industrial Training Institute) pass-outs, who have hands-on aptitude, to become well-grounded practice engineer and rise up to CEO level in short span of time.

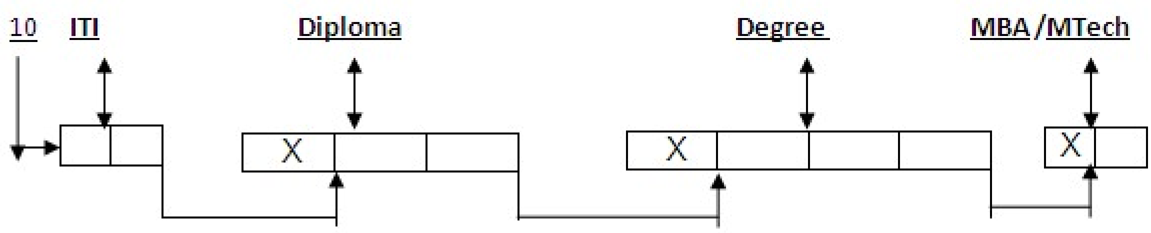

Figure 1 Career Mobility: ITI to Diploma to Degree UG and PG Program with Lateral Entry

There is provision for flexible exits at Diploma/Degree levels. There no limit on lateral entry. Finally one may exit with Diploma, Engineering Degree (UG/PG) and Management degree upon successful completion. During degree program students from this stream and from the conventional stream will mingle and study together influencing and competing with each other for knowledge and practice aspects of engineering.

This program will open up avenue to convert waste into "asset" of huge technical talent at ITI level. This will provide unrestricted and unconstrained vertical mobility for ITI Pass-outs to move to Diploma and Degree programs. The course would produce well grounded, competent and quality conscious engineers.

The curriculum will have core subjects common to all branches, and Branch specific "*Science in Vocation*" core and Elective subject(s). The program will have flexible entry and flexible exit, and Issuance of Modular certification. Entrepreneurial project based learning will be encouraged (Chesborough H., Vanhaverbeke W. & West J., 2006; Purao S., Vaishnavi V. K., Welke R. & Lenze L., 2009; Savage R. M., Chen K. C. & Vanasupa L., 2007).

5.3 Credit Allocation to Vocational Courses: Skill Competency Credit Point

European Union Credit transfer and accumulation system (ECST) considers 60 Credit Points for the entire academic year. For 1 CP for 25–30 hours of learning, these are equivalent to 1500–1800 hours of learning. ECVET European Credit System for Vocational Education & Training also recommends similarly 60 ECVET Points for one academic year. This would facilitate credit transfer from one qualification system to another; from one learning pathway to another compatible with ECST.

In India, in higher education, academic year has 180 working days; 30 weeks of actual teaching; in 6-days a week. 12 weeks are for admission and examination; 8 weeks for vacation; 2 weeks for public holidays. This is distribution of 52 weeks in a year. 1 credit point for learning corresponds to 1 hour contact time per week over 30 weeks per semester that is 30 Hours. This may be split into 80% class/contact time and 20% outside the class. Hence we may say that one Credit Point corresponds to 24 Hours of learning in class/contact time and 6 Hours outside the class.

In Unit Skill Competency Credit point (SC-CP) is defined that corresponds to 6 hours of learning. SC-CP indicates the content and level of efforts involved to successfully acquire that specific competency. Assessment for that competency may be graded as A, B, C or any other format. For mobility, Credit Points are considered. Thus 5 SC-CP may equate to 1 CP in Higher Education. 5 SC-CP = 1CP-HE will ensure mobility by way of credit equivalence. Skill Competency Credit Point will encourage larger mass to be benefitted at school level (Om Vikas, 2012).

5.4 "Engineering Education" Program

Engineering education in 21^{st} century would adopt new strategies. Focus would be on balanced mix of knowledge and practice, innovation and entrepreneurship. Curricula would be industry-driven, outcome-centric, and clinical relevant including case-practices, problem solving, and systems integration. Open engineering clinic for Micro-Small-Medium Enterprises would be desirable to be organized. A new program of "Engineering Education" is proposed to be launched to prepare right kind of faculty in both categories — disciplinary-based research faculty and Clinical faculty.

A trimester modular MPhil programme in "Engineering Education" may be designed to fill the void of quality faculty. Content of these three Modules may be as follows:

(1) Module-1

- Psychological & Philosophical Aspects of Education;
- Innovation-Centric teaching-Learning & Evaluation Methods;
- Technology-enhanced Education: e-Education;
- Basic Science Concepts: comprehension hard cases.

(2) Module-2

- Fundamentals of Systems Engineering;
- Science of Language & Professional Communication;
- Ethics in Engineering Practices: case studies;
- Quality Assessment & Accreditation Systems.

(3) Module-3

- Engineering Research Methodology;
- Educational Administration & Management;
- Entrepreneurship & Innovation Management;
- Project: Outcome-based Analysis of Engineering Education in a Domain.

“Engineering Research Methodology” (ERM) is different from conventional Research Methodology that mainly contains statistics and data analysis techniques. ERM is akin to the recent concept of Design Science Research that defines patterns of steps to carry out systematic research (Vijay K. Vaishnavi, 2011). PhD program in Engineering Education may also be initiated. It is suggested that Module-1 may be made mandatory for entry level recruitment of faculty in the engineering colleges/institutions. Module-1 may be completed during summer vacation of 2½ months. Completion of other modules may be linked with incentive of additional increments. Accreditation of teachers as professionals is also necessary (Om Vikas, 2011).

6. Assessing Innovation

We need to promote and assess quality along with relevance of the educational program to the society. Global relevance shallows the local relevance. Assessment criteria may include indicators such as annual increase in per capita income, annual progression of local technology-based entrepreneurship, annual improvement in education, health, hygiene and well being of neighboring community.

There is growing focus on research. This is normally judged in terms of research publications. Publication in refereed journals is given higher weight. Impact factor of the journal and the citation index are often enquired. There are many journals which accept and publish papers upon payment. In web era, distinction between national and international conference is meaningless. Per-review of papers in conferences is often casual. Publication in high-impact factor refereed journals is time-consuming. There is need to debate this issue. Consideration is invited to promote entrepreneurship — ideas to product, and to promote collaborative research projects. Even the teachers need to be encouraged to set up incubation units on the campus. The government should promote national research journals by the professional societies by tying up as one of the outcomes of the funded projects in terms of publication in national research journals.

Technological innovation would be in the form of new knowledge or practices that yield socio-economic benefits. This is diverse and heterogeneous technology environment by cross-functional, cross-disciplinary and cross-cultural players. Collaborative innovation with extensive use of web-based technologies will promote Group innovate, and Failure to succeed aptitude.

In order to understand Innovation processes in an organization, a new framework “Innovation Radar” is proposed (Om Vikas, 2011) that consists of 4 key dimensions:

(1) Offerings: Product/services (What),

(2) Users it serves (Who),

(3) Processes it employs (How) and

(4) Point of Presence (Where).

There are 2 sub-dimension associated with each key dimension. Multi-dimensional Innovation radar is shown below. Performance along these dimensions will indicate perceived strengths and weaknesses. This may help in assessment of innovation contribution in practice engineering.

Table 2 Multi-dimensional Innovation Radar: A 360-Degree View

Sl. No.	Dimension	Definition	Sl. No.	Dimension	Definition
1	Offerings (**What**)	Develop innovative new products or services or Human Resource in emerging areas of technology.	**7**	Processes (**How**)	Redesign core operating processes and integrate with other processes to improve efficiency and effectiveness.
2	Platform	Use common components or building blocks to create derivative offerings.	8	Organization	Change form, function or activity scope of the organization. Recognize the change imperative.
3	Solutions	Create integrated and customized offerings that provide end-to-end solutions.	9	Supply Chain	Think differently about faculty, knowledge sourcing and fulfillment. Inspire to innovate out of box and learn from initial innovations.
4	Beneficiaries (**Who**)	Discover unmet user needs or identify underserved user segments.	**10**	Presence (**Where**)	Create new distribution channels or innovative points of presence, including the places where offerings have demand.
5	Stakeholders' Feedback	Redesign user interactions across all touch points and all moments of contact.	11	Networking	Create network-centric intelligent and Integrated offerings.
6	Value Capture	Redefine how organization/ institution create innovative new revenue streams.	12	Brand	Leverage a brand into new domains.

7. Summary

Sustainable development demands engineering education with holistic perspective meeting the social, economic and environmental objectives. Globalization breaks borders for free flow of talent. Engineering Mobility accords facilitate mutual recognition of the engineering education programs and their graduates. India is poised to become signatory of Washington/Sydney/Dublin Accords. Challenges lie in accreditation of the vocational programs, integrated engineering programs, Engineering Education program, and teachers as professional with high teaching abilities. NVEQF would require new Accreditation model to develop. Skill Competency Credit Point is defined for vocational courses to facilitate mobility based on credit acceptance. An Accreditation agency should also act as mentor to facilitate the process of successive systematic improvement. Quality indicators for innovation centric practice engineering programs need to be developed. Accreditation grading should follow the $(1\text{-}e^{-x})$ pattern rather linear as much larger efforts are required to achieve higher performance.

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