

# Institutional Transformation and Development in the Engineering Education to meet the Volatility, Uncertainty, Complexity and Ambiguity (VUCA)

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## Abstract

Engineering education is facing volatility, uncertainty, complexity, and ambiguity in the last seventeen years due to fast developing global industries which established manufacturing units in India under foreign direct investment (FDI). The needs of these global industries are based on the high-quality products which were exported to the European countries and to the rest of the world. Some of the engineering institutions could modernize the curriculum, improve the resources, infrastructure, faculty's skills and competencies but the explosive growth of the institutions in the private sector could not meet the challenges. They need strategic planning, training their faculty members, improve their infrastructure and modernize the resources. They must focus on globalization and offer high-end programs. The faculty needs accelerated leadership programs. They need global thinking and mindset.

**Keywords:** Response to VUCA in the engineering education, institutional change, development, and modernization.

## Introduction

India globalized its economy in 1991. The foreign direct investments in manufacturing demanded high-quality engineers and technologists with design skills and competencies. The government of India obtained a massive loan from the World Bank to improve the capacity, quality, and efficiency of the polytechnic education in the North East, Jammu, and Kashmir, and Sikkim. Also, the Government of India started the Technical Education Quality Improvement (TEQIP) project through World Bank assistance for

improving the quality of the engineering graduates. Two projects were completed successfully and covered around 200 engineering colleges throughout the country. Further, more Indian Institutes of Technology, Indian Institutes of Information Technology, Indian Institutes of Science Education and Research, Indian Institutes of Technology, Design and Manufacturing, Indian Institute Information Technology and Management, Schools of Planning and Architecture have been established. Existing Regional Engineering Colleges have been elevated to National Institutes of Technology. All the four Technical Teachers Training Institutes in Bhopal, Chandigarh, Chennai and Kolkata were also elevated to National Institute of Technical Teachers Training and Research. Most of the states have established State Technical Universities. The Self-financing engineering colleges were established by the private societies and around 85% of the colleges come under this group. Well established self-financing engineering colleges were transformed into Deemed to be universities.

## Objectives of Research

To review the initiatives taken by various governments through All India Council for Technical Education (AICTE), World Bank assisted projects to improve the skills, competencies, leadership, consultancy works, and networking with global institutes.

To identify the gaps to meet the challenges of VUCA.

To suggest various interventions by the state and center to improve the performance of the engineering institutes to develop human and knowledge capital.

### **Literature Survey**

In the 21<sup>st</sup> century, developing countries are facing velocity, uncertainty, complexity, and ambiguity. Many Asian countries like China, Japan, Korea, and Singapore have invested more in higher education. Even though India is the third largest human resource developer in the world, it is not able to reach the top rank. Indian higher education is very much controlled by various councils, commissions, boards, and directorates. Indian leaders very lag in global thinking, leading change and retaining and developing talents. They must possess personal proficiency and become a human capital developer, strategist, talent manager and executor (Dave Ulrich's leadership model). Indian executives must be trained in action learning, international assignments, rotational programs and executive coaching and mentoring (Rebecca L. Ray et al. 2012). The leaders in India need to master people engagement, navigating and making decisions in a complex, and diverse environment. They should possess relation building and collaboration ability. In addition, they need to show agility and cultural sensitivity (Rebecca L. Ray et al. 2013). Indian higher education should be planned, structured with a formal process to develop high potentials. The authorities should have a clear articulation of the selection criteria, clear road map of developmental opportunities and a tracking mechanism to monitor the progress. The senior faculty members of higher education institutes need action learning, international assignments, rotational programs and executive coaching/mentoring (Mitchell, Ray, and van Ark, 2012). Michael Campbell and Roland Smith (2012) added the qualities of learning agility and mobility. Accelerated leadership development programs are to be carried out transparently to retain top talent. Katherine Jones, Karen O'Leonard, and Josh Bersin (2012) stated the need for the networking among the national educational management teams while leveraging their diversity to rethink approaches to the Indian market. The global context is changing fast, becoming complex and raising new risks and opportunities that senior lead new skills around dealing with context, complexity (Mathew Gitsham, 2009). Each high potential has a career development "road map". High potentials reflect on their career aspirations, the experiences and education that have

led to their current roles in the organization, and the development they need to reach their goals (Douglas A. Ready et al.2008). Competency models guide recruitment strategies as well as development and training plans (Corporate Executive Board, 2008). Shalini Shukia (2012) stated that leaders who learn to combine the East and West as they shape the future, make change happen, develop talent, nurture future human capital, and take care of themselves to become truly global leaders. Virtual and blended learning programs saved training costs and led to the deliberate use of face-to-face learning and action learning (Duke Corporate Education, 2009). Considering the need for developing competent engineers to face volatility, uncertainty, complexity and ambiguity, the development strategies adopted in the engineering education is critically reviewed and gaps have been identified. Also, suitable strategies are indicated.

Since 1947, government of India has taken the following initiatives to transform the Indian engineering education so the country would grow fast and alleviate poverty: establishing engineering institutes with the assistance of foreign governments, establishing regional engineering colleges, technical teacher training institutes, funding for faculty development, modernization and removal of obsolesce, funding for research, assessment of quality and certification, approving private deemed universities etc. After globalizing Indian economy, the government of India has obtained a loan from the World Bank for modernizing the technical education to meet the challenges of velocity, uncertainty, complexity, and ambiguity.

### **Areas of Modernization of Engineering Institutes under the World Bank Assisted Projects.**

- Curricula of various engineering and technology programs
- Consultancy, research, and development
- Infrastructure like buildings, workshops, hostels, and staff quarters
- Labs equipment, machines, electronic devices, computers and software
- Faculty development in the advances of technology and research

### **Curriculum Development**

Efforts have been undertaken in evaluating the existing curricula against the current needs of the industry, modernizing many programs and planning new programs.

- Modernizing the curricula in various engineering and technology and their implementation
- Evaluation of the existing curricula and improving the courses which are very much needed for the current industries
- Outcome-based curricula in most of the branches
- Industry relevant, credit based and flexible curricula
- Dual programs

### **Industry Relevant Programs**

Many attempts have been made by the project institutes to develop more industry relevant programs to meet the emerging needs of the companies. There are many programs which are to be fine-tuned periodically. Many traditional faculty members are not taking initiatives, since, they have not exposed to the current needs of the fast- growing industry.

Most of the Multinational Companies (MNC) have not collaborated with the technical universities in joint planning needed graduate and postgraduate programs. A few Indian companies like Bharat Heavy Electricals Limited (BHEL), Hindustan Aeronautics Limited (HAL), Engineering Construction Corporation (ECC) Limited etc. have collaborated with Indian Institute of Technology (IIT) Madras, and National Institute of Technology (NIT) Tiruchirappalli for planning and implementing industry specific programs in thermal engineering, aeronautics, and construction management. Many newer postgraduate programs could be planned with active collaboration with the National Institutes of Technology (NIT) and State Technical Universities. Association of Chambers of Commerce (ASSOCHAM), and Federation Indian Industries and Commerce (FIICI) could take more initiatives which would enable the institutes to plan the interdisciplinary and multidisciplinary programs.

More lessons can be learned from the European Union (EU), China, South Korea and Japan.

### **Outcome Based Educational Programs**

In the last five years, many efforts are being made to plan and implement outcome-based education to meet the accreditation from National Board of Accreditation. The faculty members are being developed in preparing program educational objectives and course outcomes. Under the Technical Education Quality Improvement Program (TEQIP) and Technician Education (Tech Ed) projects assisted by the World Bank, the institutes conducted tracer studies and impact studies. However, many more programs are to be planned and implemented under outcome based process of planning.

### **Cooperative Programs**

Only a few institutions offer cooperative (sandwich) programs in mechanical engineering. There are many scopes to expand the programs to other branches.

### **Faculty Development**

National Institutes of Technical Teacher Training and (NITTTR) at Bhopal, Chandigarh, Chennai, and Kolkata conduct needs analysis every year for collecting the new proposals for faculty development. The information collected would be analyzed through a program development committee. The appropriate programs would be communicated to the colleges for nominating the faculty. Approximately 20000 teachers could be trained per year. Most of the courses would be on content updating, engineering education, curriculum development, instructional materials development, multimedia program development, evaluation, institutional development, student services, and action-research and skill development.

NITTTR Chennai is conducting global faculty development since 1980 which are supported by United Nations Education Scientific Council (UNESCO), Ministry of External Affairs (MEA) and Ministry of Finance (MF) under various schemes. Also, this institute completed faculty development programs under Asian Development Bank (ADB), Swedish International Development Agency (SIDA)

United Nations Development Program (UNDP), UNESCO, and United States Association for International Development (USAID). It has a vision, understanding, commitment, and agility and considered as a leader in HRD.

Indian Society for Technical Education (ISTE) plan and conduct summer and winter schools in the content updating which are designed by the engineering colleges, state technical universities, NITs and IITs. They provide excellent training in many emerging areas of technology. However, there is a need for more programs with industrial collaboration in the industry based advanced technologies. There is a need for training in the institutional development and extension of services to the micro, small, medium enterprises (MSME) and large-scale industry in the advancement of technology. In-house faculty development programs are organized through ISTE local chapter. In more than 75% of the institutes, the training is not considered very important.

#### **Short-term Courses on Industrial Design and Manufacturing**

One-month courses were conducted by the Ministry of Human Resource Development in 1970s, but they were discontinued. There is a scope for planning industry-based programs to reduce the gap. The young faculty members would be benefitted. Most of the private institutes do not send their faculty members to undergo the needed training programs. They always run the colleges with 50% of the faculty members. The shortage of faculty members is very high even in national institutes.

#### **Postgraduate Programs under Quality Improvement Program (QIP)**

IITs, NITs, and many well performing autonomous colleges offer master and doctoral programs under Quality Improvement Program of the AICTE. These programs create more research skills and competencies. The demand has increased very much but the admission is very limited. Interdisciplinary programs need more consideration.

#### **Faculty Development through Bilateral Agreements**

Many faculty development programs are available in selected branches through bilateral programs with various countries. Australia, Canada, Germany, France, Italy, Japan, United Kingdom (UK), United States of America (USA), and many other countries offer exchange programs to undergo advanced training. Unfortunately, many chief executive officers (CEO) could not approve the participation of the selected faculty members. This is a great loss to the nation.

#### **International Conferences, Seminars, and Workshops**

ISTE conducts annual conferences in selected institutions and around 1000 faculty members attend. Many technical universities and engineering colleges also conduct international conferences, seminars on various themes. Recently Indo-Universal Collaboration for the Transformation of Indian Engineering Education was established based on the donation from nonresident Indians (NRI) and Infosys. They plan and conduct many international seminars and workshops in selected institutions with the invited global leaders.

#### **Accelerated Leadership Development**

Engineering institutes need accelerated leadership development for the middle level and senior faculty to meet the growing challenges of China, Republic of Korea, Japan, Singapore, and Malaysia. Developing internal talent makes institutions capable of managing the demands of MNCs. Accelerated development enables the faculty to train the graduates to become industry ready. The graduates would acquire the critical knowledge needed for the jobs. Also, the senior faculty members need advanced skills and competencies in the following areas:

- Ability to innovate
- Client focus
- Critical problem-solving
- Decision making
- Diversity
- Executive development capability
- Internal Revenue Generation and utilization
- Innovation
- Relationship building

- Strategic planning and management
- High performing team building

These skills would help them to train the graduates. Even though many steps are taken, the outcome is not commensurate with the expectation.

#### **Institutional**

Under various World Bank assisted projects in Technical Quality Improvement (TEQIP) have focused on the following three areas: Capacity Development, Quality Improvement, and Efficiency Improvement. The subcomponents focused on the research, consultancy and income generation. Specialized short-term courses were planned in management development. The faculty members were encouraged to develop continuing education programs for the working professionals and executive development programs for the corporate sector. The needed areas are globalization, experiential learning, acceleration through job enrichment, job rotation, and talent-management to face risks. Further, the executives need to focus on metacognitive skills, achievement motivation, leadership skills and performance management.

#### **Initiatives under Sub-Component 1.2 of TEQIP**

- Scaling-up Postgraduate Education
- Research & Development and Innovation
- Development of R&D, and Institutional Consultancy Activities

#### **Performance of Selected Project Institutes**

1. Rungta Research and Development Foundation of Rungta College of Engineering, Bhilai
  - Nano Technology
  - Bio-diesel performance
  - Energy auditing and performance test in internal combustion engine
  - Product design and development
  - CAD/CAM & Rapid Prototyping
2. Sardar Patel College of Engineering, Gujarat
  - Scaling-up Postgraduate Education
  - Developing Demand Driven R&D and Innovation

Establishing Centers of Excellence for Focused Applicable Research

BMS College of Engineering, Bangaluru

- New Postgraduate Programs (Bio=Chemical Engineering, Bio-Medical Signal Processing, Manufacturing Science and Engineering, VLSI & Embedded System)

#### **The future developments to meet the Volatility, Unpredictability, Complexity and Ambiguity using the Resources Created under TEQIP and the developed faculty:**

- i) Develop interdisciplinary and talented graduates*
- ii) Set Direction for Industry Specific Research*
- iii) Improve the Strategic Planning*
- iv) Align the Resources towards Outcome-based Research*
- v) Bid for Sponsored Research under MNCs, and IDAs*
- vi) Motivate and Inspire the graduate students and faculty members*
- vii) Focus on Emerging Technology*
- viii) Execute and Follow through Patents*
- ix) Lead through multidisciplinary postgraduate programs, MOOCs, and Executive Development Programs*

#### **Needed Training Programs for the Engineering Graduates**

Most of the alumni have provided information to the institutes through feedback for the tracer study questionnaires. Some of the selected programs are as follows:

- Global thinking and mindset
- Leading changes and transformation of the workplace
- Acquiring job specific talent in planning, design and prototype development
- Employee training in quality and productivity
- Decisions in a complex, diverse, and ambiguous environment

- Relationship building with clients, suppliers, and distributors
- Collaboration with the executives and technology specialists
- Agility
- Cultural sensitivity to work in international sites and centers
- Integrity
- Sustainability of productivity, quality and cost
- Entrepreneurial talents so that they can plan and manufacture ancillary components

It appears that their feedbacks are based on the difficulties faced by them in their jobs. Most of the Indian companies plan production and service centers in various countries and these employees would be transferred to these centers in due course. Most of the graduates did not get opportunities to acquire the needed professional skills during their educational programs.

#### **Factors of Successful Programs**

From the analysis of the literature, it is found that the following factors ensure successful training programs which could be planned by the employers (Rebecca et al.).

- Holistic in design, planning and implementation in real life situations
- Global focused on the international market
- Transparent at every stage of planning and implementation
- Leader-led
- Customized program for the given participants
- Based on the 70-20-10 rule [ 70% challenging experiences, 20% relationships, and 10% formal programs] programs are to be designed
- Activities should lead to experiences in the work environment and culture
- Broad based
- Challenging to plan and develop products and services using the modern resources
- Future focused

#### **Filling the Gaps in Job Related Skills**

The IT companies provide skills to the new recruits through in-house training programs. The manufacturing companies also plan six months programs to fill the gaps between theory and practice. Many finishing school programs were developed and offered by the companies. Soft skill training programs are added to the graduate students.

#### **Consultancy Centers**

Almost all national institutes have established consultancy centers utilizing their excellent senior faculty members, and the modern resources. They can provide excellent solutions to the government sector, private sector, and MNCs. They should establish consultancy centers in EU and USA.

#### **Innovation Centers**

Only well- developed institutes of national importance have established innovation centers where any global company can come with the problems in design and manufacturing. The faculty would collaborate and work on the problems. This has helped many MNCs seek solutions for their design, manufacturing and maintenance problems. The institutes can generate sufficient revenue. The State Technical Universities should follow this model.

#### **Incubation Centers**

Many NITs and IITs started incubation centers based on the successful product development by the graduates. This activity would bring a greater success to the entrepreneurship development in India. These centers aid the young graduates.

#### **Startup Companies**

For the successful product development through incubation centers, next is getting funds for starting large scale production. The venture capitalists select promising proposals and fund the production. This is promising to support the young entrepreneurs. The engineering students can plan product innovation and incubation.

#### **Research and Development**

Most of higher education institutes focus on interdisciplinary research and get funds from CSIR, DRDO, DST, TIFAC, and UGC. The outcomes would ensure the needed knowledge capital. Many institutes concentrate on the industry relevant product development. They need close collaboration with the R&D Centers.

### **Creation of Centers of Excellence**

Most of the institutes fail to capitalize the outstanding faculty members' expertise and the available opportunities to create Centers of Excellence. There is a need for the developing appropriate initiatives by the Directorates of Technical Education (DTE), AICTE, and MHRD. The colleges who got assistance through TEQIP can initiate strategic planning to formulate Centers of Excellence.

### **Globalization of Engineering Education**

The European Union has initiated developments through Bologna Process and networking with the universities. Many American universities have started a collaboration with leading Chinese Universities, Korean Universities, and Japanese Universities. Indian universities could get more assistance through this globalization so that the faculty could be enriched.

### **Gaps in Skills and Competency Development**

The senior faculty members are to be developed to meet the challenges of VUCA. They need focused training on Accelerated Leadership Development Programs which could be planned and offered as in-house programs.

### **Desired initiatives from the industry**

Most of the industries except a few public-sector organizations do not take any in-depth interest to cooperate and collaborate in planning industry-relevant programs and train the faculty and students. For their own benefit, they are expected to take lead in the following areas:

- Identification of Skills and competencies needed from the fresh graduates
- Providing case studies
- Cooperative programs

- Providing industrial training
- Research themes based on the industry needs
- Topics for employees' development programs
- Themes for executives' development programs
- Sponsored postgraduate programs
- Skill development programs
- Creating a chair
- Donating equipment

### **Conclusions**

The Indian engineers face volatility, uncertainty, complexity, and ambiguity. The engineering institutes must create a global vision and bring transformation in all programs. Faculty members of engineering colleges need accelerated leadership development programs. The engineering graduates need global thinking, developing talents and taking decisions in a complex, diverse, and ambiguous environment. Indian engineering institutes need to relook at their vision, understanding, clarity and agility to meet the challenges of technological velocity, uncertainty on the needed human capital, complexity in planning and developing knowledge capital, and ambiguity. Using the resources created under TEQIP, the outstanding faculty could be empowered to bring needed improvements to meet VUCA. The project institutions have to grow further.

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