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Dynamic Process for Enhancing Engineering Faculty Competence in India

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Abstract : Indian engineering colleges need more qualified faculty, since, thousands of engineering colleges have been approved by AICTE with teachers who possess only bachelor's degrees without any experience in curriculum design, instructional design, evaluation, and industrial training. Many of them were not exposed to advanced industrial design and advanced manufacturing practices. This has resulted in the unemployment of about 70% of the graduates. This paper focuses on the systematic planning, and implementing appropriate faculty development programs not only for the fresh graduate teachers but also the senior faculty members through various long-term programs, short-term courses, industrial training, research works, Massive Open Online Courses (MOOCs) under SWAYAM, and training through specialized overseas courses that are implemented by Ministry of Education. National Institutes of Technical Teachers Training are offering MOOCs in various areas of engineering education. Continuous process development has been suggested. The engineering colleges could reimburse faculty members on the cost of training under MOOCs which are offered by edX, COURSERA, etc. Further, the colleges should organize faculty development programs in collaboration with the well-known global universities and Research & Development Centers of Multinational Companies (MNCs) which are functioning here. Such a dynamic initiative will bring excellence in the knowledge capital. The government can assist professional associations to plan industry-relevant workshops. Considering the difficulties in getting admission for thousands of faculty members in Quality Improvement Programs (QIP), alternate, hybrid and flexible programs are suggested. The significant outcomes of these initiatives are: i) It increased the skills and competencies of the faculty members and students; ii) The graduates have become be industry-ready; iii) Many regions have come industrially competitive, iv) The new initiatives like Pandit Madan Mohan Malavia National Mission on Teachers and Teaching (PMMMNMTT) and MOOCs have improved the faculty competencies in hundreds of colleges; v) Global Initiative for Academic Networks (GIAN) have increased interdisciplinary research capability of the faculty members; vi) The overall outcomes of these initiatives have improved the engineering curriculum, attributes of the graduates and interdisciplinary research. It is suggested to undertake further research on the finetuning of the curricula to meet the challenges of Industry-4.0

Keywords: Faculty Competence, Dynamic Process, QIP, Summer Schools, Webinars, MOOCs.

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1. Introduction

According to Asian Development Bank, the Asian countries need to improve the tertiary institutions of world standards, research centers, and model campuses for the knowledge-based economy (KBE).

India's education system, as one of the world's largest, has been studied and reflected on through academic papers, used as a case study, and been the subject of many renowned books (Richard Everitt, Director Education & Society, British Council of India). By 2025, India will have the second-largest graduate talent pipeline globally, following China ahead of the USA.

The government of India has planned to transform this sector since 1992. Every aspect of higher education is being considered and remodelled: funding, leadership and management, quality assurance, accountability, relationships with industry, international collaboration, and the way research and teaching are conducted. If these reforms succeed, the breadth and depth of change will be transformational.

According to Professor Pankaj Chandra, Director of Indian Institute of Management (IIM), Bangalore "Change at the scale, we will see in the next ten years in education in India is unprecedented in human history".

Considering the need for competent engineers for the fast development of Indian industry after the independence, engineering faculty development has been well planned by the Ministry of Education to improve the inexperienced faculty members of the engineering colleges and polytechnics.

1960s United States Agency for International Development (USAID) offered training programs and advanced courses to engineering professors in India. Many state governments sponsored the faculty members to M.S. and Ph.D. programs in well-known foreign universities in UK and USA and provided a salary to them and met the travel expenditures. Also, the government of India got assistance from Germany, the United Kingdom (UK), the United Nations Development Program (UNDP), the United States of America (USA), and the Union of Soviet Socialist Republics (USSR) for establishing five Indian Institutes of Technology (IIT) in the 1960s. In the 1970s, Summer Schools were organized for training the engineering faculty members through PL480 funds of USA. Now the IITs are offering Master and Ph.D. degree programs to engineering college faculty members under Quality Improvement Programs (QIP) of the All-India Council for Technical Education (AICTE).

1.1 Learning Needs Assessment and Analysis of the Engineering Students

Most of the Boards of Studies rely on the expertise of the members in analyzing the performance needs of the graduates. To meet the fast-changing industrial growth, new technologies, and near-future needs, it is essential to get information from various employers and alumni. The engineering graduates have to be trained in product analysis, design, prototype development, testing the prototype, improving it, estimate the cost, value analysis, manufacturing, marketing, and maintenance. Questionnaires can be prepared and distributed. Analysis of the feedback will provide authentic information of the needed skills, competencies, and attitudes to develop a curriculum.

1.2 Need-based Faculty Development Programs

Since 1992, all the four National Institute of Technical Teachers Training and Research (NITTTR)s at Bhopal, Chandigarh, Chennai, and Kolkata are offering need-based quality improvement programs in engineering education for college teachers. This is based on the recommendation of the Bhattacharya Committee in 1991. The following significant programs are planned based on the expressed needs of the colleges: 1. Instructional Design, 2. Development of Industry-Specific Curricula under TEQIP I and II, 3. Measurement and Evaluation of Students' Achievement, 4. Institutional Development, 5. Bidding for Development Projects, 6. Establishment of Instructional Media Development Centers, 7. Leadership Development, 8. Planning Continuing Education Programs, 9. Curriculum Innovation, 10. Educational Ethics, 11. Globalization of Engineering Education, 12. Planning Tracer Studies under TEQIP I & II, 13. Impact Studies under TEIP I and II, 14. Developing Detailed Project Proposal for Capacity Development and Quality Improvement, and 15. Internal Revenue Generation.

1.3. Other Faculty Development Courses

Indian Society for Technical Education (ISTE) is also offering Summer and Winter Schools for faculty

development. Now various State Technical Universities (STUs), National Institutes of Technology (NITs), and well-grown Autonomous Engineering Colleges also offer Master and Ph.D. programs under Quality Improvement Program (QIP). World Bank assisted projects Technical Education Quality Improvement Program (TEQIP) I and II offered many faculty-development programs from 2004-2016. TEQIP III is being implemented to improve the weaker states.

In the 21st century, the economy of a nation is partly dependent on the available human capital. The Government of India is taking many initiatives to train and develop the faculty members of engineering institutes. However, there is a great gap in faculty development. The concept of pretraining of the university faculty is not there. It is suggested to train the recruits through a four weeks program in curriculum planning, instructional design, developing educational aids, leadership, interdisciplinary research, and consultancy projects. Due to the recruitment of lakhs of untrained faculty who join the engineering colleges, there is a need for bringing the dynamic process of faculty development. However, most of the CEOs of engineering colleges express that faculty development is the biggest challenge. These challenges made us explore appropriate models for faculty development through a research program.

2. Objectives of Research

- To review the training needs of engineering faculty at various levels.
- To plan various modes of offering engineering faculty development programs.
- To plan flexible and hybrid part-time faculty development programs to solve the problems faced by the engineering faculty members.

3. Literature Survey

Centra (1978) described various types of faculty development programs. Wilkerson (1998) developed strategies for improving teaching practices through faculty development.

Ole Vinther and Anette Kolmos (2002) stated that Danish Engineering Institutions have created a national partnership to facilitate staff and faculty development. The National Pedagogical Network for Engineering Education based in Ballerup, Denmark targets quality pedagogical and curriculum development for all Danish Engineering institutions.

Gillespie, Hilsen, and Wadsworth (2002) developed a guide to faculty development. They added practical advice, examples, and resources. Davis et al. (2003) created a comprehensive faculty development program. Mills and Treagust (2003) analyzed the effectiveness of problem- based learning against project-based learning in engineering education. Cole et al. (2004) developed an intensive longitudinal model for faculty development in teaching skills. Eric Aikens et al. (2005) concluded that faculty development is a continuous improvement plan for inclusive excellence. Froyd et al., (2005) recommend a framework for faculty development as follows: 1. Goal-oriented learning, 2, Active learning, 3. Meaningful learning, 4, Explaining while learning, and 5, Self-monitored Active learning.

Erklenz-Watts, Westbay, and Lynd-Balta (2006) brought out an alternate professional development program. Glowacki- Dudka and Brown (2007) brought out professional development through faculty learning communities.

Johan Malmqvist et al. (2008) described the faculty professional competence include project management, communication, teamwork, and organizational management.

Kavita, Kalpana, and Amarjit Singh (2010) evaluated the criticality of faculty development to enhance teaching effectiveness. According to them careful needs assessment, concepts, and skills are needed in the transformation process. Cook and Kaplan (2011) considered the problem of advancing the culture on teaching campus and suggested the use of a teaching center. Ronald (2011) described a new model of project-based learning (PBL) where the students develop their learning objectives. The projects are offered by the collaborative industries. Patil and Codner (2007) reviewed the accreditation process of engineering education programs and suggested a proposal for global accreditation. Kirk Ingold's (2008) faculty development centers around goal-oriented teachers, social systems, and the learning-centered model. James Jacob, Welyan, and Huiyuan Ye (2015) have stated that higher education professional development trends increasingly focus on areas of quality improvement, quality assurance,

and optimal technology delivery models to achieve academic excellence. World-class universities rely on their faculty professional development centers for an array of professional development programs to support teaching research and student learning.

MOOCs of NITTTRs

All the four NITTTRs at Bhopal, Chandigarh, Chennai, and Kolkata have been approved to offer many faculty development programs in the following areas: Educational Psychology, Curriculum Design, Instructional Materials Development, Instructional Design and Delivery, Educational Evaluation, Higher Education Administration, Leadership, Strategic Planning, Human Resource Development and Management, Creation of Centers of Excellence, Accreditation through NBA, Educational Research, Internal Revenue Generation, Student Personnel Administration, Globalization of Engineering Education, Content Updating, etc. They also offer many postgraduate programs and interdisciplinary doctoral programs. They need a sufficient number of high-performing and motivated faculty with the needed competencies. Since 2018 they offer MOOCs in various areas exclusively for engineering college faculty members. According to Asian Development Bank (2011), professional development programs were established in many higher education institutes to support various initiatives that promote effective teaching and research. In many Asian countries (UNESCO, 2014) faculty qualifications prevent them from being able to keep pace with the rising demands of higher education students. According to European University Association (EUA) (2008), professional development centers in European Universities can move effectively and efficiently reach out, communicate, respond and provide a solution, guidance, and technical assistance. Robert Matross Helms and Alegneta Asfaw stated that many American Universities are developing formalized student learning outcomes that focus on internationalization and global knowledge. According to them, it is primarily the faculty, as the drivers of teaching and learning, who are responsible for helping students achieve these outcomes. They suggested promoting faculty participation in short-term programs abroad. Some of the models are faculty seminars abroad (University of Richmond), and International Faculty Development Seminars. They stated that The Fulbright Specialist Program sends faculty abroad for two to six weeks on curriculum development. As per Dee Fink (2013), faculty development focuses on organizational change and development. England and five Nordic countries have mandated 175-200 hours of a faculty development program for all newly recruited faculty members. The Ministry of Higher Education in Japan issued a mandate in 2008 that all universities must establish a faculty development program. The College of Engineering of Lund University in Sweden made proficiency in teaching compulsory for all professors.

3.1 Stanford Center for Professional Development (SCPD) Program in China:

At the beginning of each course a faculty member from the Management Science and Engineering Department on the home campus goes to China to teach for a week, then remains involved with students through email and videoconferencing throughout the rest of the course.

Purchase College and State University of New York (SUNY) have established a Center for Collaborative Online International Learning (COIL). This center develops more online courses and conducts workshops and conferences.

3.2 Partnership Delegation Grants of Grand Valley State University (GVSU) of USA: The faculty members receive funds to travel to foreign universities and conduct classes. On return to the home department, they survey the long-term impact of their experiences.

3.3 Faculty Development Program Abroad of Maricopa Community College District of USA:

The faculty receive international travel grants for 30 days and they have to submit the status of the outcome report.

3.4 Purdue University's Center for International Excellence administers the Global Learning Faculty Development Program.

This is designed to assist Purdue instructors to be stewards in optimizing and transforming classroom teaching and learning by integrating global issues, activities and experiences into learning objectives and course content which will facilitate a global experience.

3.5 The Center for Student Engagement and Learning Innovation at Canada's Thomson Rivers University:

This offers a two-part workshop that walks faculty through the process of internationalizing their courses.

3.6 Global Programs and Strategy Alliance of the University of Minnesota:

Organizes a series of lectures and workshops for faculty that focused on internationalizing the curriculum.

Rebecca Brent and Richard Felder (2003) described the NSF-sponsored Southern University and College Coalition for Engineering Education (SUCCEED) and its successful induction of large members of Engineering faculty members to participate in instructional development programs. Their suggestions are as follows:

- Emphasize disciplinary relevance in faculty development programs.
- Keep them practical.
- Include both disciplinary and pedagogical expertise on workshop facilitation teams.
- Cite the research work
- Avoid appearing prescriptive, dogmatic, or evangelical
- Practice what you preach,

3.7 Educating Engineers for the 21st Century

Julia E King, the Chair of the Educating Engineers for the 21st Century Working Party. According to this group, BRIC nations are producing a record number of engineers. According to King, the focus of the industry on the skills and competencies are as follows:

Table-1 (Average of 480 experts views)

Skills	Percentage
Practical Application	29.01
Theoretical Understanding	20.4
Creativity and understanding	18.95
Team Working	15.32
Technical Breadth	13.67
Business Skills	2.65

3.8 The Future of Indian Higher Education and Opportunities for International Cooperation

Leonie Siok Yoong Lee (2011) questioned that whether quality expansion is possible through affiliated colleges in South Asia. According to him, the affiliated colleges are the weakest link in South Asia's Higher Education. India has responded to the demand explosion by fostering the growth of an affiliating college system. Most of the affiliated colleges do not meet the basic requirements of adequate infrastructure and minimum teacher qualification, and they do not have academic autonomy.

The following are quality concerns:

- The loose regulatory system governing the licensing and registration of new colleges.
- Lack of both External and Internal Quality Assurance and Accreditation (QAA) frameworks for existing colleges.
- High graduate unemployment rates corroborate feedback on the college curriculum.
- Lack of qualified teachers; Insufficient permanent teachers.
- Poor and inadequate infrastructure and facilities.
- Complex governance structure: multiple controls with unclear stakeholder relationships.
- Unsustainable organization structures: a large number of colleges affiliated to one university and high average enrollment per college.
- Market forces distorted by lack of information and government policies; weak capacity to monitor and enforce rules
- Role of political economy (The chairmen are from the political parties.).

The faculty development initiatives would improve the quality of the faculty members.

3.8 South Asia Institute (SAI) at Harvard University, USA

The Lakshmi Mittal South Asia Institute, Harvard

University (2012) conducted a "Multidisciplinary Approach to University Leadership Development for university leaders from Maharashtra. Thirty leaders and policymakers, vice-chancellors, directors, principals, and deans attended the program. Harvard faculty challenged the participants to rethink their understanding of university culture, learning approaches, research, liberal arts education, library science, technology, and funding.

3.8.1 Outcomes

The visiting leaders collected the following ideas:

- Increasing communication among university leaders,
- Actively engaging all stakeholders in their institutions in decision- making,
- Incorporating new technologies for learning in the classroom and in the library system, and
- Institutionalizing a fund-raising network.

3.9 Excellence Model of European Foundation for Quality Management

Manuela Brusoni et al. (2014) have presented an Excellence Model developed by the European Foundation for Quality Management (EFQM). The enablers as per this model are:

- Leadership
- Policy and Strategy
- People Management
- Partnership and Resources
- Process Management

Excellent leaders develop and facilitate the achievement of the vision and mission. They develop organizational values and systems required for sustainable success and implement these via their actions and behaviors.

Through appropriate policy and strategy, organizations implement their vision and mission by developing a stakeholder focused strategy.

In this model, people management focuses on the management, development, and release of the full potential of their people at an individual, team-based, and organizational level. They care for, communicate, reward, and recognize in a way that motivates staff and builds commitment to using their skills and knowledge for the benefit of the organization.

Through partnerships and resources, organizations plan and manage external partnerships, suppliers, and internal resources to support policy and strategy and the effective operation of processes.

Process management focuses on the organization's design and improves the processes to fully satisfy and generate increasing value for customers and other stakeholders.

This model will be of great use in planning faculty development in engineering institutes to bring excellence.

3.10 Challenges for Indian Higher Education

Lynne Heslop (2014) identified the following four broad challenges for Indian Higher Education:

- The supply-demand gap is increasing
- Shortages of high-quality faculty members
- The curriculum is not tuned to incorporate modernized industrial practices.
- Absence of interdisciplinary research and innovation
- Absence of industrial linkages

3.11 Harvard Institute for Superintendents and District Leaders

Andres Alonso, Faculty Chair is conducting a four-day program for the superintendents to achieve excellence for all students since 2017. The course is centered around clear expectations for students; rigorous curricula aligned to standards; professional development that improves instructional quality, and assessment as a tool for feedback and accountability. The participants will have an opportunity on their leadership strengths for developing a team with a full range of capacities needed to lead systematic reform.

3.12 1000 Chinese University Leaders to Receive 'Upgrade' Training Abroad

China has stepped up its overseas training program for presidents and vice-presidents of public universities to compete with world-class systems and top international universities. 1000 university presidents and vice presidents have been sent to Australia, Britain, Germany, and the USA for leadership training programs. An amount of US $12.8 million has been committed. The leadership scheme was funded by Lee Shau Kee Foundation and Pei Hua Foundation. A group of 23 university leaders and administrators have been trained at Oxford's Leadership and Public Policy program. The University of Michigan at Ann Arbor in the USA conducted the training program for 24 university leaders and administrators through the 2012 Michigan China-University Forum. The training has focused on curriculum development and student evaluation.

3.13 Engineering Education in the Rapidly Changing World

Kamp Albert (2016) developed a vision for engineering education in 2030 that encompasses the following eight key aspects:

- The rigor of Engineering Knowledge
- Critical Thinking and Unstructured Problem-Solving
- Imagination, Creativity, Initiative
- Communication and Collaboration
- Interdisciplinary and System Thinking
- Global Mind-Set: Diversity and Mobility
- Ambitious Learning Culture: Student Engagement and Professional Learning Community
- Employability and Lifelong Learning

These largely concur with the categories of the Technical, Professional, Personal, Interpersonal, and Cross-cultural Engineering Criteria of the Accreditation Board for Engineering and Technology (ABET) and the Revised Attributes of a Global Engineer by the American Society for Engineering Education (ASEE).

3.14 Harvard Seminar for New Presidents

Harvard University program focuses on critical issues in the first months and years of the presidency, with intensive sessions that address a range of topics, including board governance, fundraising, academic leadership, strategic planning, and lifestyle decisions. The seminar provides a practical orientation to the presidency, familiarizing new presidents with the opportunities and hazards they will likely face and preparing them to respond to multiple responsibilities.

3.15 New initiatives of Ministry of Education, Government of India

The Mistry of Education developed a scheme of Pandit Madan Mohan Malaviya National Mission on Teachers and Teaching (PMMMNMTTNM) in 2015. This scheme offers teacher development programs for all university faculty members. The following are the components of this mission:

- 30 Schools of Education
- 50 Centers of Excellence for Curriculum and Pedagogy
- 5 Centers of Excellence in Science and Mathematics Education
- 25 Teaching Learning Centers
- 20 Faculty Development Centers
- 2 Inter-University Center for Teachers Education
- Subject Networks for Curriculum Renewal and Reforms
- National Resource Center for Education/Higher Education Academy
- 5 Institutes of Academic Leadership and Education Management
- Teaching-learning Centers have started conducting faculty development programs for various branches of arts, science, and engineering. Many engineering colleges are offering engineering faculty development programs under this scheme.

3.16 Global Initiative for Academic Networks (GIAN)

The government of India started Global Initiative for Academic Networks (GIAN) program in November 2015. In 2018, it is proposed to fund joint research projects between the Indian Higher Educational Institutes and the best of Global Universities. Accordingly, the government of India has sanctioned the Scheme for Promotion of Academic and Research Collaboration (SPARC). This promotes global research collaborations. IIT Kharagpur is coordinating this scheme. The outcome of this scheme is quality research papers, suggestions for industry improvement, enhancing the competencies of the faculty members, and creating active cooperation with world-class researchers.

3.17 Indo-US 21st Century Knowledge Initiatives

This has been established by the US Government for cooperation between the Indian faculty members and US universities for joint research, faculty visits, and faculty training.

The Indus Foundation Inc (2011) convened Indo-Global Education Summit, 2009, 2010, and 2011 in Hyderabad.

The Indus Foundation focused on the following collaborations between Indian and Foreign Universities:

- Research Collaborations
- Organizing Certificate, Joint/Dual Degrees
- Twinning and Transfer Programs
- Distance Education Programs
- Faculty Exchange Programs
- Vocational Education Programs
- Partnership Programs
- Study Abroad India Programs
- Collaboration Methodology

400 foreign universities have been identified for collaboration. A large number of CEOs of the universities attended the summit and exchanged their planning and collaborations.

3.18.1Synthesis

Most of the global institutes have studied the problem of faculty development and are looking for alternate methods using various advances in electronic delivery. The advances in ICT would help to cover a large number of faculty and they can be trained at a minimum cost.

A hybrid model is envisaged by combing face-to-face discussion as a follow-up to MOOCs. The programs have been planned to train the faculty without any disturbance to them.

Most of the international institutes focus on the globalization of faculty development, curriculum development, and research studies on the return on investment.

The new initiatives like PMMMNMTT, GIAN, and Indo US 21st Century Knowledge initiative would bring innovative faculty development focused on quality and research through global collaboration.

4. Faculty Development Programs of NITTTRs

The following programs and development activities are offered by NITTTRs:

1. Established Extension Centers in all southern states to work closely with the State Directorates of Technical Education and undertaking the following activities:

2. Short-term Faculty Development Courses are based on the professional needs of the teachers to meet the advances in engineering and technology.

3. Long-term programs in M.Tech. and Ph.D.

4. Research projects, assisting the states in planning many Detailed Project Proposals (DPP) for Capacity Development, Quality Improvement through World Bank Assisted Projects, and Direct Central Assistance.

5. Continuously evaluating the curricula against the needs of the fast-growing industries and improving them.

6. Preparing appropriate instructional packages (textbooks, item banks, learning aids, and teacher support materials).

7. Conducting national and international conferences to exchange innovations.

8. Assisting industries and other higher education institutes to develop the executives.

9. Undertaking diverse global executive faculty development programs under various schemes of Government of India and International Development Agencies like Asian Development Bank, GIZ, SIDA, UNDP, UNESCO, USAID, and World Bank (Thanikachalam. V, 2018, 2019).

10. Incorporating MOOCs with face-to-face programs of NITTTR Chennai.

11. Getting Deemed University Status so that many innovative multidisciplinary postgraduate and doctoral programs could be undertaken easily.

12. Provide solutions to engineering institutes through Design Thinking, IoT, and Artificial Intelligence.

4.1 Training Needs Assessment

The Curriculum Development Center of NITTTR Chennai conducts a training needs assessment every year by sending a questionnaire to all the Polytechnic Colleges in the southern region. The professional training needs of the faculty members are assessed every year and presented to the Program Development Committee which consisted of representatives of the Directorates of Technical Education and the Heads of the Departments. Around 200 courses are usually selected for further detailed planning and implementation. A set of selected courses for entry-level faculty members, middle-level faculty members, senior faculty members, and CEOs level are presented in Tables- 1, 2, 3, and 4.

Table 1 : Training Needs of Entry-Level Faculty Members

Area	Skills and Competencies
Formative and Summative Evaluation of Engineering Curricula	Exposure to Systems Approach (Input, Process, Output, Feedback) , Context - Input-transformation Process - Product (Skilled graduates (CIPP) Outcome-based Curriculum, Formative Evaluation, Summative Evaluation, Improving the Learning Resources, etc.
Instructional Design	Programs Educational Objective (PEO), Course Outcomes (COs), Project - based Learning (PjBL), courses based on the needs analysis, Pedagogy, Cognitive Competencies, Motor Skills, Attitude, etc.
Measurement and Evaluation	Preparation of Multiple-Choice Items, Matching Items, Fixed Response Items, Short-Answer Items, Final Question Papers based on the Table of Specification, Open Ended Question, etc.
Content Updating	Advances in various courses, Emerging Technologies, Industrial Methods, Analysis, Product Design, Prototype Development, Testing, Improving, etc.
Interdisciplinary Research and Development	Identification of Research Problems, Educational Research Methods, Research Questions, Research Design, Population, Sample Size, Questionnaire Preparation, Getting Feedback Data Collection, Analysis, Inferences, Conclusions, etc.
Consultancy Works in Testing	Planning Consultancy Projects, Testing, Inference, Report Writing, Costing, etc.

The above needs assessment has been used to train and develop faculty members.

4.2 Implementation of In-house Faculty Development Programs

The above courses have been offered through in-house faculty development. The faculty members

have been given all the course materials, power points, and assignments. They can take up the assignments and complete them and post the output to the course faculty for their review and suggestions for improvements. Online courses were offered and contact classes duration was reduced to two days. This mode has saved time and cost. Also, the course material, power points, and the completed assignments could be made as open access material so that the faculty can take them as and when they need. A set of senior faculty members could also be trained in each institute and they can undertake the courses without travel to outstation faculty development institutes. Further, the power points could be presented through webinars. Such arrangements saved time and cost. For each area, train master trainers were trained in each institute. Later, they can plan faculty development programs as in-house courses. A senior professor could be elevated to "Dean-Faculty Development" and he/she can plan many short-term courses based on the needs of the faculty members.

Table 2 : Middle-Level Faculty Members (Associate Professors)

Curriculum Development and Improvement	Training Needs Analysis, Outcome Based Program, Flexible Curriculum, Reverse System Approach, Industry Relevant Courses, etc.
Instructional Materials Development	Production of Various Instructional Materials, Publication, Monographs, MMLP, etc.
Development of Measuring Instruments and Evaluation of Achievement	Case Studies, Item Banks, Research Works, Term Papers, Capstone Projects, Field Investigations, Take Home Examinations, Open book tests, etc.
Continuing Education Program Development	Research-based training materials, Games, Case Studies, Open problems, Analysis, Prototype Development, Maintenance Manuals, etc.
Advancement in the Technology	Emerging Technology, ICT, Sustainable Development, Advances in IT-based design methods, Clean Development Mechanism.
Educational Research and Development	Interdisciplinary Research, Multidisciplinary Research,
Modernization of Labs and Workshops	Modernization Projects, Maintenance, Testing , Periodical Calibration, etc.
Accreditation of Programs	Self- Evaluation Reports, Academic Auditing under NBA, ABET, Effecting Improvements.

4.3 Planning Weekend Faculty Development Courses

An external faculty development institute could commission to offer a series of courses. A set of colleges can form a consortium and the courses can be planned on Saturdays so that the faculty can attend them.

Table 3 : Senior Level Faculty Members (Professors)

Interdisciplinary and multidisciplinary Curriculum	Global Trends, Networked Curriculum, Dual Programs, etc.
Instructional Resources, Production and Publication	Publication, Marketing, Copyright, Translation, Overseas Publication, Royalty,
Examination Reforms, Evaluation of Program Achievement	Internal evaluation, final evaluation, grading, adjudication of theses,
Development New Labs, Production Units,	Modern Equipment, Digital measuring instruments, online data recorders, etc.
Establishment of Consultancy Centers	Dedicated Consultancy Centers, Innovation Units
Leadership Development	Leadership development, Performance evaluation, Appreciative inquires, etc.
Educational Administration	Strategic Planning, Tactical Planning, Perspective Planning Financial Management, Academic Audit, PPBS, HRM, HRD, etc.

Table 4 : CEO Level (Dean/Director/ Principal)

Institutional Development	Development of Educational Ecosystem, Strategic Planning, Industry-Institute- National Labs-Government- Partnership, Networking with the National and International R&D labs, Corporate Universities, AICTE, Alumni Centers, Continuous Improvement in the Curricula,etc.
Creation of Centers of Excellence	Innovation Center, Sponsored Consultancy Projects under IDAs, Incubation units, Startup units, etc.
Higher Education Administration	Faculty Recruitment, Capacity Building, Quality Improvement, Efficiency Improvement, Development of High Performing Teams, Decentralization, Delegation, Faculty Empowerment, Consortium of Engineering Colleges, Financial Management, etc.
Globalization of Engineering Education and Global Networking	Comparative Education, Faculty Exchange, Student Exchange, Joint Research Projects, Joint Consultancy Projects, Peripatetic Seminars, Diverse Global Faculty Development under IDAs, etc.
Faculty Development	In-house Faculty Development, Industry-based Development Workshops and Programs, Training Manuals, Monographs, Newsletters, MMLPs, Videos, etc.
Patents, IP	Licensing to Transnational Companies, SMEs, etc.
Knowledge Transfer	Licensing to SMEs, Companies, International Development Agencies (IDAs),
Internal Revenue Generation	Through Consultancy, Fees, Royalty, Service Charges, Sales of Books, Rent, University Foundation, Donations from Corporates, Alumni, etc.
Planning National and International Conferences	Collaboration with International Universities, IDAs, Planning International Seminars, Conferences and Workshops, etc.
Bidding for Consultancy Projects under IDAs	Directions to prepare Technical Proposal, Financial Proposal, Negotiation, Contracts, Agreements, etc.
Educational Research, Tracer Studies, and Impact Studies	Research Proposals, Longitudinal Studies, Short-term Impact Studies, Long-term Impact Studies, etc.
Establishment of Campus Placement Cell	Linking with the companies, campus placement, follow-up, etc.

4.4 Other Modes of Implementation

The course coordinators are selected based on their expertise. Then venues and dates are selected to suit the participants of all southern states. The Extension Centers in Bangalore, Hyderabad, Kalamassery, and Vijayawada implemented state-specific courses. Additional faculty members are included from the state technical universities and industries wherever needed. The program duration varies from 3 days to 12 days. Also, new courses are planned based on the emerging needs of the State Directorates of Technical Education.

4.4.1 In-House Programs

The Institute also offers many in-house programs based on the requests to meet the faculty development under the ongoing national or state projects. These in-house programs are very economical.

4.4.2 Outcome Assessment

The participants are given questionnaires using Kirkpatrick's four-scale model to evaluate the course content, method of presentation, case studies, demonstrations, educational media used, guest faculty, transfer exercises, guidance for implementation, etc. The outcome is evaluated and courses are updated for replication. Best programs are retained.

4.4.3 Impact of Faculty Development

Colleen Flaherty (2016) stated that faculty development impacted student learning. The Tracer Study (1998) conducted by the institute after completion of World Bank assisted projects in the

southern region proved the high performance of the engineering students. This is due to intensive training of the faculty of the project institutes, curriculum revision, and improving the learning resources.

4.4.4 Continuous Improvement in Planning and Conducting the Faculty Development Programs

Every year the planning process is updated and needed changes are incorporated. Many All -India Programs are introduced based the emerging needs. The following are additional courses offered on preparing Detailed Project Proposals, Capacity Building, Quality Improvements through Overseas Programs under World Bank/UNDP, research studies on alumni, establishing continuing education centers, and establishing consultancy programs.

4.4.5 The Existing Faculty Development Programs are as follows:

- Quality Improvement Programs to offer Master and Doctoral Degree Programs through IITs, NITs, State Technical Universities, and well-performing Autonomous Engineering Colleges and funded by AICTE.
- Summer Schools and Winter Schools are offered by well- established engineering colleges, IITs, NITs, NITTTRs and funded by AICTE either through the Indian Society for Technical Education.
- National Institutes of Technical Teachers Training and Research since 2001.
- World Bank Project assisted projects like Technical Education Quality Improvement Programs (TEQIP I and II).
- Academic Staff Training Colleges (Human Resource Development Units) are attached to universities and funded through University Grants Commission.
- In-house faculty development programs based on the initiatives of the colleges
- Medium-term and long-term training and development programs through bilateral agreements with various developed countries.

4.4.6 Faculty Members Self-Planned Training and Development Programs

Many faculty members plan their training and development programs based on career plans. The colleges can formalize the planning through an annual plan. Some of them are:

- Joining part-time postgraduate (master and doctoral) programs in the nearby institutions which are recognized
- Resigning and joining full-time postgraduate programs in various State Technical Universities, NITs, IISC, IIITs, and IITs
- Resigning and joining foreign universities in the USA, UK, Canada, Australia, and other developed countries.
- Registering on-line MOOCs offered by Coursera, edX, World Bank Institute, IGNOU, SWAYAM, and DEP of various Indian and Foreign universities
- Undergoing short-term workshops under IUCEE, and other conference organizers

4.4.7 Problems in Getting Full-time Faculty Development Programs to Undergo Postgraduate Programs in the existing QIP Institutes

Most of the faculty members could not get admission to enrol in the quality improvement programs offered by various IITs, NITs, State Technical Universities, and Autonomous institutions. The reasons are as follows:

- The number of seats is limited in the QIP institutes.
- The number of faculty members is more in engineering who have joined the teaching profession with a bachelors' degree.
- Most of the administrators of engineering colleges do not forward the applications for QIP due to a shortage of teachers.
- Most of the self-financing institutes terminate the faculty after forwarding their applications under QIP so that they are not liable to pay the salary.
- The stipends are limited to support the family.

- Sometimes the faculty get admission far off institutions which is very difficult for them to move with the family to those cities.
- Hostel accommodations are limited in some institutions.
- Family quarters are rarely available.
- The house rent is very exuberant in many cities.

4.4.8 Outcomes of the Faculty Development

· The engineering curricula are continuously evaluated and improved to meet the emerging needs of the industries.

- State Directorates can establish many new diploma programs to meet the demands of industries.
- The faculty members can undertake challenging programs.
- The State Universities can establish more graduate and postgraduate programs based on the availability of trained faculty members.
- More skilled and competent engineers are readily available for establishing new industrial corridors and hubs.
- More entrepreneurs can emerge in many specializations.
- Many states can attract new industrial initiatives in higher occupations like design and research.
- Many engineering institutes have been turnaround through well-trained and motivated faculty members (Thanikachalam. V., 2018).
- Many polytechnics and engineering colleges can undertake consultancy projects from the industries,
- They can generate internal revenue.

4.4.9 Development Programs for Industries and Government Engineering Departments

The senior faculty members undertook many executive development programs under various projects of World Bank, UDAID, GIZ, CIDA, etc. These departments fully utilized the expertise of the Institute. The outcomes of training and development resulted in efficiency and effectiveness (Thanikachalam. V, 2017, 2018).

4.4.10 Problems in Undergoing Part-time Programs in Postgraduate Programs

The significant problems faced by the teachers are as follows:

- Workload increases on the faculty members since there is no provision to get additional faculty who can handle the classes during the faculty training period.
- Many institutes do not provide funds for reimbursing the expenditure incurred by the faculty for undergoing the outstation faculty development programs.
- They find it very difficult to undergo many new courses due to limited time available for assignments, tests and laboratory works.
- Sometimes the participants have to travel about 40 kilometers to reach the institutions.
- The desired specialization may not be available in the desired QIP institute.

4.4.11 Planning Hybrid Faculty Development Programs

- To overcome these difficulties, it is proposed to plan- flexible faculty development programs using various modern facilities as follows:
- Planning sequential summer and winter schools to cover the planned courses.
- Developing needed instructional materials, case studies, assignments, test items, and references, and upload them to the institute web for easy downloading by the faculty members.
- Offer needed MOOCs as a part of the program.
- Offer many lectures through webinars.
- Recorded lectures can be included on YouTube for easy access.

- Conduct additional face-to-face presentations during weekends in various cities and towns to clarify doubts.
- Establishment of study centers so that the teacher trainees can get guidance, counselling, coaching, and mentoring.
- Uploading lectures on YouTube and make them available to the teacher trainees.
- Offering the dissertation work through recognized and qualified local faculty guides in various engineering colleges.
- Recognizing industry-based practicums and evaluating the outcome and calculating the credits and marks in consultation with the industrial engineers and managers.
- Recognizing the work done in the workshops, and other faculty training courses offered by the organizers of the national or state seminars and conferences.
- Allotting guides or supervisors to monitor and evaluate the progress and achievement of the teachers who wished to undertake self-planned courses.
- Improving the library resources for the faculty self-planned courses.

4.4.12 Faculty Performance Requirement as per AICTE Regulations of 2019

1. Participating in International Conferences and Workshops
2. Undertaking Consultancy Works
3. Start-up activities
4. Creation of Entrepreneurship
5. Community Services
6. Working in an Industry for six Months
7. Professional Development
8. Teaching Research Fellowship in a Foreign University
9. Quality Improvement Program in a Foreign University

4.4.13 Impact of the Faculty Development Programs on the National Economy

- Multinational companies (MNCs) have expressed the availability of engineering graduates to undertake design, production, and maintenance.
- Many states have established special economic export zones for manufacturing modern products.
- GDP is increasing due to the availability of trained human resources.

4.4.14 Major Short Comings on the Existing Faculty Development Programs:

- Only the top 100 universities/ colleges can alone participate in the GIAN/ SPARC projects.
- The GIAN programs need an in-depth focus on the globalization of engineering education.
- Most of the PMMNMTT institutes need more trained faculty to plan needed high-end programs
- Only well-performing universities can alone plan global research programs or send their faculty members for undertaking joint research projects.
- The faculty training through MOOCs has to be encouraged for undertaking research works and recruitments for high posts.
- The Interdisciplinary and multidisciplinary programs are not focused on the faculty development programs.
- Till now there is no mandate for undergoing the faculty development for the engineering faculty members.
- There is an urgent need for well- planned programs for training the trainers to plan and implement courses under PMMNMTT.

4.4.15 Needed Focus on the Faculty Development for the next five years

- Establishing separate departments in all state technical universities for the development of

faculty members from various types of engineering colleges.

- Focus on the globalization of the engineering curriculum.
- Planning impact studies on the new initiatives.
- Improving the curricula to absorb the digital technology-based design and manufacturing.
- Creating a center for undertaking interdisciplinary research projects.
- Networking with the R&D Departments of industry and national laboratories.

4.4.16 Transition to Meeting the Needs of Industry-4 through Dynamic Curriculum

Josh Bersin, et al. (2017) suggested that successful organizations must be designed for speed, agility, and adaptability to enable them and win in today's global business environment. The following actions are needed:

- Share values and culture
- Create transparent goals and projects
- Ensure free flow of information
- Reward faculty members for their accomplishments and creation of knowledge capital
- Build accountability
- Facilitate faculty learning, innovation, and student impact
- View the institute as an agile network,
- Empower the faculty by team leaders
- Fuel by collaboration and knowledge-sharing
- Base the departments on work and projects,
- Focus teams on research and developments, publications, consultancy to MSMEs, and services to the society
- Facilitate the advancements through global projects, diverse global faculty development, and multifunctional leadership assignments
- Faculty "create followers" to grow in influence and leadership
- Lead by orchestration
- Create a culture of safety, abundance, and importance of risk- taking and innovation
- Eliminate restriction for innovation but focus on the complex problem solving
- Define clear responsibilities for teams, but roles and job titles would change regularly
- Facilitate self-managing teams (Vanessa and Jane, 2004).

5. Conclusion

Engineering curricula have to be based on the in-depth learning needs analysis and NITTTRs are offering assistance to plan industry-relevant courses since 1992.

The faculty development programs are also to be based on the training needs analysis and NITTTRs are offering around 200 courses exclusively of engineering colleges.

Institutes have to plan for preservice training programs, in-house faculty development programs, permitting them to undergo MOOCs, industrial exposure, curriculum development, formative and summative evaluation, instructional packages development, interdisciplinary research programs. NITTTRs are offering one week to four weeks preservice courses based on the requests of the Directorates of Technical Education. The Ministry of Education is funding for implementing research projects with global universities under GIAN/SPARK Scheme. The colleges could plan developing consultancy projects for industries and internal revenue generation as envisaged by TEQIP I and II.

The faculty development programs under MMMNMTT may accommodate a large number of engineering faculty members.

Hence, innovative hybrid faculty development

programs are suggested with MOOCs which are developed through the SWAYAM scheme of the Ministry Education. It is composed of various successful components and integrated into a new model. This model can be implemented as a pilot program and later refined to suit the faculty members. NITTTRs have become the Associated Center of UNESCO's Asia and Pacific Educational Innovation for Development (APEID). They also conduct around 10 to 15 international faculty development programs which are sponsored by the Ministry of External Affairs and Ministry of Finance since 1982. The faculty members could be included in these programs to get an experience of working with a diverse global faculty member.

Such a radical method would meet the high demands from the engineering faculty members to plan global programs and network with foreign universities. Further research is required to modernize the engineering programs to meet the challenges of Industry-4.0

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