CHAPTER 2 – REVIEW OF LITERATURE

This chapter consists of the following sections:

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CHAPTER 2 - REVIEW OF LITERATURE

As a precursor to field research an exhaustive literature survey was conducted to understand the current state of affairs pertaining to talent shortage; with special reference to India. The secondary literature survey traces the evolution of technical education in India, and the usage of conventional teaching practices in our higher education institutes. The results are juxtaposed with innovative learning aids and/or learning theories championed by a few leading institutes. But polarized use of such methods result in corporates facing increasing difficulty in staffing creative talent/employable human resources to suit business needs. The corporates experiment with different TSCM initiatives to make their resources billable/employable. Industry best practices, in the area of talent management are also discussed in detail. International best practices are also looked into in detail. Finally, "employability models" propounded by prominent educational researchers are analyzed.

In summary, the literature survey is categorized into:

- Engineering education scenario in India
- Campus recruitment process
- Employability of engineering graduates
- Governmental initiatives in India
- Industry-academia partnerships
- International benchmarking
- Conventional teaching practices
- Learning aids
Learning theories

Employability models

2.1 Engineering Education Scenario in India

In India, the origin of formal technical education dates back to the formation of the Indian Universities Commission in 1902. Post-independence the formation of the All India Council for Technical Education (AICTE) was set-up in November 1945 as a national level Apex Advisory Body for technical education. The AICTE was vested with statutory authority for planning, formulation and maintenance of norms and standards, quality assurance through accreditation, funding in priority areas, monitoring and evaluation, maintaining parity of certification and awards and ensuring coordinated and integrated development and management of technical education in the country.

Based on the recommendations of the National Working Group set up by the Government of India (Ministry of Human Resource Development) the AICTE Act No. 52 was promulgated on March 28, 1988. Accordingly the statutory AICTE was established on May 12, 1988 with a view to proper planning and coordinated development of technical education system throughout the country, the promotion of qualitative improvement of such education in relation to planned quantitative growth and the regulation and proper maintenance of norms and standards in the technical education system.

The purview of AICTE (the Council) covers programs of technical education including training and research in Engineering, Technology, Architecture, Town Planning, Management, Pharmacy, Applied Arts and Crafts, Hotel Management and Catering Technology etc., at different levels (Banerjee & Muley, 2007).
India awarded about 2.37 lakh engineering degrees, 20,000 engineering masters degrees and 1000 engineering PhD’s in 2006 (a total of 2.58 lakh engineering degrees of all types). India has about 1500 engineering institutions with about 67,000 faculties. India’s growth rate for engineering degrees is higher than the other countries. China has high growth rates for the PhD degrees. India’s doctorate degrees are less than 1% of its graduate degrees. This is significantly higher for all the other countries. India produces more computer science and IT engineers than other disciplines.

*Engineering education* in general and *quality of engineering education offerings* in specific has emerged as an important area of concern in the Indian engineering education scenario in the new millennium.

A World Bank study lists the generic weaknesses existing in Indian education system in producing skilled manpower ready to face the challenges of today’s competitive economy (World Bank study on science and technology manpower in India (2001). Industry/Academia interactions as cited in KPMG Advisory Services & Nasscom, 2004). Some of the observations were:

- Shortage of skilled faculty with industry exposure
- Rigidities in the curriculum and evaluation system

Now that we have looked at the national scenario on Engineering Education, it is relevant to look at how the output of this system is evaluated and absorbed by the Industry which leads to the crucial problem of “EMPLOYABILITY”.
2.2 Campus Recruitment Process

Revamping the learning environments in academics to instill “global competitiveness” in graduate pool demands a long time line and consensus across various stakeholders (public, private and student community). Hence, in the light of rising “talent shortage” and increasing manpower requirement, organizations compete with each other to pick up the cream of talent directly from campuses. The term “Campus recruitment” refers to the system where various organizations visit the campuses of educational institutions to recruit youngsters. Many youngsters use the platform of campus recruitment to start their professional careers right after their studies. Those who make it through the tough selection process are then trained in “company-specific” skills for a specific period before getting deployed as full-time employees.

Organizations use a variety of criteria to identify and select the Institutes that they would want to visit for campus recruitment. One of the studies done in this area provides some insights on these criteria (Cunnigham as cited in NAS, 2006):

- **Curriculum/ranking** – Is the school accredited: Is the curriculum relevant to the needs of your organization?
- **Location** – Will the distance to campus justify the time and money it takes to recruit there? Will the distance create relocation and retention issues?
- **Demographics** – Does the overall enrollment and percentages of woman and minority candidates meet the company’s recruiting needs?
- **Graduation dates** – When will candidates be available for work?
Career services/faculty/student organizations – Are the services the company needs available through the career center? Is the faculty accessible and interested in career opportunities for their students? Can the company collaborate with the student organizations?

Competitive environment – Are the student’s expectations in line with what the organization can offer?

Potential recruiters/team leaders – Does the company have enough alumni to create a recruiting team?

Internal opinion of the institution – What is the general opinion of the campus within the company? Would the institution be accepted as part of the campus recruiting program?

Another study in a similar area provides the below guidelines for organizations that are keen on pursuing a strong campus hiring strategy (WetFeet Inc. as cited in NAS, 2006):

1. Focus on schools that most closely fit company needs, not just prestigious schools.
2. Arrive early.
3. Network with student clubs and organizations.
4. Nail the campus info session.
5. Define what you offer, including downsides, for good job fit.
6. Send enthusiastic and informed recruiters.
7. Take time for personal touches such as e-mail, calls, and thank you messages.
8. Follow up on promises.
9. Make people feel wanted.
10. Provide a great work experience, especially in internships. People will hear about it.

In India, about 15-18% of manpower requirement in services companies is met through campus recruitment, followed by 6-10% in product development companies. In the IT Services companies in India, of late, the campus intake has shot up to as high as 70%.

The selection process consists of a combination of any of the below 5 steps:

1. Many organizations prescribe a minimum academic level of performance from the students. Typical criteria would be an average aggregate percentage across the first 6 semesters. While some organizations prescribe it as 60%, others have it as 65 or 70%. Academic performance normally stands out as the first elimination criteria during recruitment.

2. Aptitude test evaluates prospective candidates in areas such as Quantitative Methods, Verbal Ability, Logical Reasoning and Basic Domain Knowledge. The companies administer this test in the first stage to filter in candidates who are good with their quantitative skills, reasoning ability and have acceptable comprehension ability.

3. Group Discussion tests the candidates for the following skills:
   a. Inter personal – listening, speaking, receptiveness, team spirit, etc.
   b. Clarity of thought – knowledge and ability to connect know facts
   c. Communication skills – coherence in thought and speech

A topic is given to a group of candidates for discussion and each member is evaluated on their responses and innate leadership skills.
4. Interfacing interviews helps the companies to evaluate the candidate on various aspects such as goals, attitude, motivational levels, ability to integrate to company culture, etc. It may consist of:

   a. Technical interview where the technical expertise of the candidate is tested;

   d. HR interview wherein the soft skills of the candidate are analyzed and salaries are decided; and

5. Psychometric tests which measures the ability of the candidates in organizing ideas, production of ideas, reasoning, emotional stability, dominance and key personality traits for various job roles.

This interesting crisscross between the Indian engineering education system churning out the graduates and the plethora of firms trying to fulfill their talent supply by adopting selection criteria that they have internally evolved, leads to the huge socio-economic problem of “EMPLOYABILITY” of graduating engineers which provides us a rich platform for pursuing our research.

2.3 Employability of Engineering Graduates

The engineering graduates from India exhibits several inadequacies in the employability parameter. Some of them in the words of overseas clients are given below (Krishna, n.d.):

- Spoken English sounds like Greek and Latin...
- Pedestrian writing skills, no e-mail etiquettes
- Insensitive towards cross-cultural issues....
- Lack of grooming makes you guys lesser mortals
• Utter disregard to the dress code....

• Lack of personal and community hygiene....

• Under-developed table manners, lack of dining discipline....

• Lack of soft skills, less idea about art of living

• No sense of humour....

• Dearth of well rounded professionals, incomplete guys

• Lack of multi-disciplinary competency and holistic approach

• Inability to relate to real-world problems, inability to see the larger picture

• Little abstraction capabilities

• Lack of business domain appreciation

• IT fundamentals not too strong, lack of in-depth knowledge....

• Problem of treating job as an extension of the campus

• Technicians rather than consultants

• Too many boys, very few men

• Moved up the value chain is a distant cry on the horizon

The inadequacies observed by employers in engineering graduates is attributed to the nascent stage of software engineering education, heterogeneous input from engineering colleges and the inherent fallacies in formal education.

To make engineering graduates in India employable, NASSCOM has mooted several initiatives like recasting IT curriculum with focus on fundamentals and introducing business skills and consulting methodology teaching. A few other initiatives include:

• Introducing extensive teaching of behavioral skills by experts

• Training on cultural sensitivity

• Grooming for holistic personality development
Training on communications & presentation skills
Conducting attitudinal change workshops
Including systems engineering as a discipline
Giving incentives for reading
Creating intellectual assets and knowledge repositories
Encouraging researchers
Deploying reputed IT companies as Campus Mentors
Working closely with industry associations like NASSCOM, Institute of Electrical and Electronics Engineers (IEEE), Computer Society of India (CSI), etc. for an on-going industry-academia interface.

Specific interventions recommended in the education sector towards making graduates employable include (Narayanan, 2005):

- Learning pedagogy – by substituting the traditional classroom-examination centric model with a problem-based learning model to teach students how to apply knowledge in practical situations.
- Instructional resources and faculty – by creating a knowledge portal through the collaborative efforts of subject matter experts/mentors, industry, faculty and students which can be accessed by the entire learning community.
- Multi-disciplinary mindset – by nurturing an ideal software professional with the following mental abilities:
  - Abstraction capability (Mathematics)
  - Instrumentation, measurement, and empirical formulation (Physics)
  - Modeling and behavior extrapolation (Aeronautics)
- Inspection and quality control (Mechanical Engineering)
- Elegance of design (Electrical Engineering)
- User-friendly interfaces (Electronics Engineering)
- Safety considerations (Chemical Engineering)
- Aesthetics and patterns (Architecture)
- Brevity and clarity of communication (Literature)

- Art and science of living – by supplementing formal education with formal mechanisms such as self appraisal, peer feedback, presentation skills, coping with team members of heterogeneous characteristics, resolution of inter-personal conflicts, values, attitudes, ethics and assimilating multi-lingual, multi-cultural environments.

- Holistic mindset – by acquiring analytical skills to synthesis seemingly disjoint influences.

- Abstraction – by gaining required skills on reuse at higher levels of deliverables.

- Project management – by addressing soft factors such as effects of schedule pressure, harnessing experience, coping with geo-political environment and human aspects.

- Role of professional societies – by serving as watchdogs of technology evolution and market needs.

- Workshops/summits/programs/focused research – by inducing more interactions between the industry and academia.

- Mentorship or knowledge enhancement programs – for institutes and colleges under the aegis of NASSCOM IT Workforce initiative.
Faculty Development Programs and Entrepreneurship Development Cells – by exploring industry-academia alliances.

Case studies - on industry-academia partnerships

Pool of professionals with diverse skill sets – to perform both at entry level and project management level

IT employers believe that education, training, and retooling will play a vital role in developing skilled and competitive IT workforce. They feel that “Employability” skills cannot be taught in traditional learning environments and are willing to enter into stronger partnerships with colleges and universities to produce employable graduates.

Employability skills reflect the abilities and interests coming under the purview of PEOPLE, where.

- P = Problem Solving Abilities (organization, judgment, logic, creativity, conflict resolution)
- E = Ethics (diplomacy, courtesy, honesty, professionalism)
- O = Open Mindedness (flexibility, open to new ideas, positive outlook)
- P = Persuasiveness (excellent communication and listening skills)
- L = Leadership (accountability, management and motivational skills)
- E = Educational Interests (continual thirst for knowledge and skills development)

A market Study by Robert Half Technology, a global provider of technology professionals, U.S.A revealed that 53% of 1420 CIOs surveyed offered IT employee trainings in Non-IT areas. The industry is in fact looking for a holistic education covering business skills, behavioral skills, and technical skills.
The key enablers in this process are the support that government and quasi government agencies provide to educational institutes and the extent of Industry Academia partnerships that prevail. Let us now try and understand both these aspects.

2.4 Government Initiatives

The Government of India anchors some of its key initiatives through the Ministry of Human Resource Development (MHRD). Some of the notable ones are:

- Universities are not required to seek the approval of Central or State governments for signing Memorandum of Understanding (MoU) with foreign institutions for collaborations in research.
- Financial contributions from alumni to their respective institutions needn’t be routed through Bharat Shiksha Kosh.
- All decisions pertaining to quality of education made by University Grants Commission (UGC), AICTE, National Council for Teacher Education (NCTE) and other statutory bodies must be made available in the public domain.
- The scheme of providing block grants hitherto only to IITs has been extended to other universities through the UGC.
- Participation in All India Engineering Entrance Examination (AIEEE) by educational institutions has been made optional.
- Indira Gandhi National Open University (IGNOU) and the Distance Education Council under the Statutes of the IGNOU have been given the mandate to expand the reach of education through the Open and Distance Learning (ODL) for higher education.
2.4.1. **Quality Improvement Program (QIP)**

The Government of India launched QIP in the year 1970. One of the main objectives of the Program is to upgrade the expertise and capabilities of the faculty members of the degree-level engineering institutions in the country. The Program is now being implemented and monitored by the AICTE.

The main activities under QIP include:

- Providing opportunities for faculty members of AICTE-recognized degree-level engineering institutions to improve their qualifications, by offering admissions to Masters and Ph.D. degree programs.
- Organizing Short Term Courses at the QIP Centers for serving teachers.
- Curriculum Development Cell activities which help to improve classroom teaching.

Since the inception of the QIP Scheme, curriculum development cells have been set up for improving the effectiveness of technical education in the country by undertaking activities which include curriculum development and revision or preparation of monographs, text books, teacher’s manuals, teaching aids and other resource materials, examination reforms, organizing inter-institutional programs, seminars, workshops and panel discussions, development of educational technology, creation of methodologies for formal and informal training, technical education of the handicapped and other activities.
2.4.2. State Level Initiatives

Each state runs some pioneering initiatives that aim for the betterment of graduating engineers. One such initiative that is championed by the Andhra Pradesh government called the Jawahar Knowledge Center (JKC) and it is detailed below.

Concept and Design of JKC:

- Bring the best students to good places where the right learning environment is provided in a residential set up.
- Work with the industry to understand the needs and impart the appropriate ‘industry-grade’ skills.
- Produce 100% employable graduates.

JKC Specifics:

- 32 centers in 17 districts, each with a computer lab of 50 state-of-the-art connected computers, Internet connectivity, a modern classroom, a media room, and facilities for residential accommodation to the 40 best students from various colleges and 8 mentors [total stakeholder coverage included 1066 students of Computer Science Engineering (CSE), Computer Science & Information Technology (CSIT), Electronics and Communication Engineering (ECE) from 102 engineering colleges, 150 mentors and 42 industrial partners].
- LMS with extensive content from experts and support for collaborative tools.
• Dedicated set up for each student on an extended basis (goal: 24 x 7 x 365) access to the designated student.

Despite several bottlenecks which included delay in transferring mentors, infrastructural shortcomings and restless youth, JKC project won the National e-Governance Award 2005 for Exemplary Initiative (Bronze Medal).

Beneficiary perspectives of JKC achievements include mastering the following skills to manage oneself in the modern corporate culture:

• Soft-Skills
• Inter-personal and communication skills
• Self-development and interview skills
• Spoken English and English

Over and above the governmental agencies that have been trying their best to bridge the gap between the Industry and Academia through all these initiatives, the Industry itself has stretched out to the Academia and launched several initiatives where partnership has yielded significant successes. A study of the same is detailed below.

2.5 Industry-Academia Partnerships

Success stories of institute-industry collaboration are many in India. Some of the landmark developments in this area have been pioneered by the following Institutes:

• Birla Institute of Technology and Science (BITS), Pilani 1973 Practice School
• Indian Institute of Technology (IITs) and Indian Institute of Management (IIMs) 1980s
Institutes can offer laboratory facility and conduct:

- Material and product testing
- Software verification
- Continuing education programs

Industries can sponsor R&D projects and train students. Provisions can be made for faculty to work in industries availing sabbatical leave and also permit industry personnel to teach in academic institutions.

Several IT firms have been actively engaged in partnering with the Academia to support them. Some of these partnerships are detailed below.

### 2.5.1 Academic Partnerships by IT Firms as part of TSC Strategy

Some of the leading firms in the IT sector have evolved customized internal talent management practices to suit their distinct needs from the campuses. For example, Infosys architects a high performance Infoscion through selective recruitment of qualified candidates, streamlining the career path to organizational growth, and devising training programs to address four key areas, namely, people, work, technology and business. Thus by hiring the best and by lending a competency based edge to people practices Infoscions are competitively positioned for championing sustained growth (Ravichandar, & Hema, 2003).
Learning and Development at TCS is designed to develop total professionals with right skills by emphasizing on “life long learning” (Neethi, 2004). At Convergys a mandatory program; titled “Operating in a Global Environment” focuses on diversity awareness & appreciation, communication skills, and team work, assertiveness, and self awareness. Satyam runs Campulse for entry level IT professionals which includes Campulse Mentors, Faculty Development, News Letter, and e-learning, and Annual Placement Officers Meet. Wipro offers a 10 week integrated Project Readiness Program which covers Corporate readiness, Technical readiness and a Real Life Lab.

While these are internally run for the fresh campus recruits, firms normally adopt a backward integration strategy into the Academia through strategic partnerships, some of which are explained below.

**Infosys**

_Campus Connect_ - The focus of the Rs 10-crore nation-wide program is on preparing “industry-ready” entry-level professionals with the required technical and software skills. The Faculty Enablement Program, is part of Campus Connect shares Infosys’ educational experiences and best practices with faculty from various engineering colleges. Approximately 40 faculty members from 19 institutes participated in the initial fortnight long session held in Mysore and Pune, covering areas like computer hardware and system software, programming fundamentals and management systems, among others. A roll-out of this has been done across all other Infosys Development Centres. As a part of the Campus Connect initiative, Infosys has also launched a Campus Connect portal engaging 30 institutions across India in the first phase to enable students and faculty to access
technology related information and courseware that is relevant to the IT industry. There are online tests and dummy project material to help students assess their current capability levels. In the Financial Release dated September 30, 2006 (Indian GAAP Press Release) Infosys has announced more investments for the Campus Connect program (Gupta, 2004).

Zensar

The trends in software services have resulted in the emergence of new focus areas, namely:

- New application development
- Solution patterns for vertical markets
- Application migrations (legacy as well as current)
- Application maintenance (migration during maintenance)
- Product development
- Product enhancement and maintenance
- Application documentation
- Legacy code optimization

The academia needs to accommodate the latest changes in software services by:

- Launching formal courses for design of new products, services and solutions
- Nurturing Software Engineers through more of systems training
- Launching new curricula in areas ranging from technical skills in Embedded Systems, Object Oriented design and Knowledge Management to domain skills in Manufacturing, Retail, Distribution, Banking, Insurance, Telecom, and Utilities
Using new pedagogy involving optimal combination of classroom courses with synchronous and asynchronous e-learning tools

Industry-academia partnerships can be fostered by:

- Jointly designing new courses to be taught partially by industry professional and Chief Technology Officers.
- Ensuring the participation of Institutes in initiatives of NASSCOM to bring industry experience to faculty and students.
- Starting industry sponsored special interest groups in academic institutions to research on new technologies and develop cutting edge ideas.
- Engaging youth at a very early stage of the learning cycle to build the 2 million brains that the industry needs by Year 2008.

Texas Instruments (TI)

TI, the global leader in semiconductor technology has launched UniTI (Universities and TI) initiative. It consists of direct engagements with universities or via its university distributor (Cranes Software) and third parties (Epsilon Control, Gill Instruments, I Micro Systems, Mistral Software, Sands India) in India. TI extends its reach to potentially all engineering institutes in the country, and offers all the elements that are required to successfully set up Digital Signal Processing (DSP) education programs in any engineering institution. TI’s university program in India, in terms of its 500+ operational TI DSP labs (Mar 2006) at over 450 Indian engineering institutions, is TI’s largest university program worldwide.
Hewlett-Packard (HP)

HP has entered into an alliance with Jadavpur University to facilitate mutual exchange of knowledge in mobile computing on WiFi systems, mobility solutions, distance education, cellular networks and satellite communications. Both students and faculty of the university will be encouraged to conduct research at the HP labs facility located in Bangalore.

Cisco

Cisco, the networking major has set up more than 130 Networking Academies across 20 States and union territories in India, which have more than 6,000 active students. The flagship course - CCNA (Cisco Certified Networking Associate) trains students, government employees and in-transition workers to design, build and maintain complex computer networks. It incorporates an E-Learning system that includes multimedia curricula, online testing, performance-based skills assessment and classroom management through a Web interface.

TIBCO Software Inc and IIIT, Pune

In this tie-up TIBCO will provide the International Institute of Information Technology with its business integration software at no charge, to ensure the necessary skills, training and knowledge transfer. This will help infuse software integration and real-time business into education to ensure that students’ skills match the market demand to create innovative solutions. The faculty will receive hands-on training from Tibco and full-time students will receive research opportunities and research guidance.
Drishti Soft and IITs (Guwahati and Delhi)

Drishti Soft, Gurgaon-based telecom firm has made arrangements with IITs Guwahati and Delhi to help the students in securing projects and develop entrepreneurship. In one such project a thin client (a remote basic computer with no peripherals, is connected to a server) was built by the students using a 900 Mhz ARM processor, the kind that is used in washing machines, under the guidance from Drishti. The thin client will offer basic functions such as video, Web browsing and voice over IP, he said.

Magma Design Automation India

Magma Design Automation India, a wholly owned subsidiary of Magma Design Automation Inc., USA, provider of semiconductor design software, has entered into a partnership with IIT, Madras, to increase talent trained and exposed to next-generation Electronic Design Automation tools.

Satyam Computer Services Limited

Satyam Computer Services Limited has signed a MoU with the IIT, Madras to jointly undertake research and development projects in IT. ADHYAYAN is a 2-day faculty development workshop convened by Satyam. It has been rolled out across 10 locations covering 1052 selected candidates. 88 faculty members and 4 Associates. The topics covered include Operating Systems, Data Structures, Algorithms, Relational Data Base Management Systems, Quality and Software Engineering, Teamwork, Work culture, Time management, Ownership for learning and corporate expectations. The approaches adopted in ADHYAYAN gives the participants better insight into the differences...
between teaching and learning and convey the meaning of What, Why and How to learn through sample lectures, sample exercises and references.

Samtel Group

Samtel Group, Department of Science and Technology, Government of India and IIT, Kanpur set up a Prototype Development Unit for cutting-edge Organic Display Technology.

24x7 Learning

24x7 Learning, the Bangalore-based e-learning implementation company has launched ‘SkillBridge’, an employability enhancement program aimed at upgrading the behavioral and IT skills of fresh engineering and management graduates and make them employable. It is an 8-month program targeting the fresh engineering graduates in tier II and tier III cities with a low job-placement record and will impart various skills like communication, personality development, team work, spoken English, interview preparation in a blended and interactive manner (multi-modal simulations, quizzes and on-site workshops) to fresh graduates. The company plans to train around 20,000 students under this program in the current fiscal. 24x7 learning has so far entered into agreements with SJM Institute of Technology, SKS VMA College of Engineering, Gandhi Institute of Technology, Kaustav Institute of Technology, Cambridge Institute of Technology, and National College of Engineering among others.
NIIT

NIIT has launched “Integrated ANIIT for Engineers” (IAE), a dual-qualification program to be pursued alongside engineering studies. IAE is initially targeting the southern cities of Chennai, Hyderabad, and Bangalore, as South India produces 54% of engineers in the country. Later it will be rolled out on a country-wide scale in phases. The curriculum begins with the fundamentals of computing and IT, and spans a comprehensive learning cycle across programming and database management, with specialization options in the most popular application development frameworks such as Java and .NET. In addition, the IAE program also trains students on communication, time-management, and behavioral skills, to make them industry-ready.

Wipro

“Fast Forward” is a two day personality development workshop targeting the recruits chosen by Wipro. This fun filled workshop conducted at the campuses aims to make the “campus to corporate” transition smooth. Awareness is built amongst future Wiproites on the “requirements of the Wipro World”. The program hones self confidence, self awareness, and clarity of thought, attitude towards learning, adapting and excellence thus enhancing their knowledge on corporate culture.

NASSCOM

Industry bodies like NASSCOM and Confederation of Indian Industry have also taken a lead in bridging the gap with Academia. For example, below are some of the initiatives of Nasscom.
Nasscom has signed a MoU with UGC and AICTE to strengthen professional education through curricula, faculty, infrastructure, pedagogy improvements in line with the IT industry’s requirements of demand for skilled professionals. Its IT Workforce Development (ITWD) initiative (started in 2004) involves working with the academia across the country to encourage and facilitate greater industry interaction, thus helping them share relevant feedback, stay updated on developments in the industry and giving them an opportunity to incorporate positive changes to their curriculum. As of 2006 Nasscom has run 15 such programs across India, primarily in Tier II colleges, and has trained close to 500 faculty members. E.g. Bannari Amman Institute of Technology (BAIT), Coimbatore, invited faculty members of 40-50 engineering colleges to its campus, to undergo faculty training programs conducted by Sun Microsystems on Java and Microsoft on .Net technologies. Close to 150 faculty members were trained in this program.

HR initiatives championed by NASSCOM:

1. **MoUs with UGC and AICTE:** NASSCOM signed a MoU with UGC and AICTE in 2007 to strengthen professional education (through curricula, faculty, infrastructure, pedagogy improvements) in line with the IT industry’s requirements of demand for skilled professionals.

2. **Industry-Academia partnership:** NASSCOM in its ITWD initiative is also working with the academia across the country to encourage and facilitate greater industry interaction, thus helping them share relevant feedback, stay updated on developments in the industry and giving them an opportunity to incorporate positive changes to their curriculum and pedagogy.
3. **National Assessment of Competence:** NASSCOM has launched NASSCOM Assessment of Competence (NAC) program for the potential employees in the Business Process Outsourcing (BPO) industry. NAC is an industry standard assessment and certification program that aims to ensure the transformation of a “trainable” workforce into an “employable workforce.” In the first phase, the pilot which was launched recently, ran for 3 months in 3 cities, namely, NCR, Mumbai and Bangalore. Around 36 key ITeS-BPO companies and nearly 15,000 graduates participated in the pilot.

4. **National Skills Registry:** NASSCOM is working with industry, present and prospective BPO employees and HR consultants to determine the best method to improve retention rates in the industry. NASSCOM in collaboration with the National Securities Depository Limited (NSDL) has launched National Skills Registry (NSR), in an attempt to further strengthen security in the Indian IT industry. NSR, a global first, is a centralized database of information about the employee’s professional and educational background. The NSR has been specifically designed to ensure authenticity of data through independent verification and biometric identification of the individual.

5. **Certification Program for Frontline Management:** Under the aegis of NASSCOM’s Executive Development Program (NEDP), NASSCOM and Quality Assurance International (QAI) India Ltd, the leading quality consultancy in India, last year unveiled the first-of-its-kind Certification Program for Frontline Management for ITeS-BPO sector. The program has been launched nationally and was organized in the five major metros, Delhi, Mumbai, Bangalore, Chennai, and
Hyderabad, in FY 2005. The program will soon be extended to other cities like Pune, Kolkata, Chandigarh, and Jaipur.

Institute-Industry-Partnership is championed as a grand alliance for Joint Technology Development Missions and innovative product developments much in line with the grand Vision of our Honorable President, Dr. A. P. J. Abdul Kalam: From the tag of a developing country to a developed country by 2020.

2.5.2 Maturity model in Industry-Academia Interactions

Interactions between academic institutions and industry evolve over time into five distinct stages of "maturity".

- **Supplier-Buyer relationship** – companies visit academic campuses primarily to recruit students with salary assuming undue significance.

- **Donor-Receiver relationship** - Once the companies realize the potential of the rookies from a particular campus, they tend to start long term relationships may be by setting up scholarships. E.g. Infosys, General Electric, HP and Lucent have endowed a number of scholarships to B Tech and M Tech students at selected IITs / IIITs for the past decade.

- **User-Consultant relationship** - companies use faculty-student groups to deal with challenges they face with their products and services often at a huge cost.

- **Sponsor-Institution relationship** – marked by large-scale investment by companies in the establishment of Research Centers at selected institution often resulting in significant IP generation. E.g., the "Display Technology Research" Centre
established by Samtel Corporation - founded by IIT Kanpur alumnus Satish Kaura - at IIT Kanpur.

- Long-term Partnership - firms interact with academic institutions at multiple levels – recruitment, donations, funded projects, research centers and move beyond; companies give quality time of the senior management to shape the very contours of growth of the institution concerned. E.g. (Infosys & Tata Consultancy Services) and Multi-National Companies (Intel, Microsoft, HP, and IBM) have reached this level in India with at least a handful of institutions (IIITs, IITs and IISc).

While most of the efforts in the Indian context have been to develop the technical capability of faculty through Faculty Development Programs (FDP) or setting up labs and infrastructure, let us have a look at how the scenario is in the International context.

2.6 International Benchmarking

The best practices in grooming employable graduates are collated below.

2.6.1 Engineer 2020

Engineer 2020 is a futuristic initiative, launched under the aegis of The National Academy of Engineering (NAE) Committee on Engineering Education in the US for nurturing industry-ready engineers to meet the needs of the new era. The phase 1 of the project: The Engineer of 2020: Visions of Engineering in the New Century engaged a diverse group of stakeholders to the engineering enterprise in a series of activities to
gather facts, forecast future conditions, and develop future scenarios of the possible world conditions for the 2020 engineer.

During Phase – 1 attempt was made to answer the following:

What will or should engineering be like in 2020?

Scenario-based planning technique which allowed for the usage of multiple possibilities was used. The specific scenarios used were:

- The next scientific revolution
- The biotechnology revolution in a societal context
- The natural world interrupts the technology cycle
- Global conflict or globalization?

Summary of findings of Phase-1 published in 2004:

If the engineering profession is to chalk out its own future it must:

- Agree on an exciting vision for its future;
- Transform engineering education to help achieve the vision;
- Build a clear image of the new roles for engineers in a techno-savvy world;
- Accommodate innovative developments from non-engineering fields; and
- Find ways to focus the energies of the different disciplines of engineering toward common goals.

The second phase of the project will build on the phase 1 visions of engineering to develop strategies and concrete plans for engineering education. A national summit of
current and emerging leaders in engineering education will be convened to outline a strategy for ensuring the currency and vitality of 21st century engineering education. The agenda will include a renewal of curricular and delivery models, and a reassessment of institutional policies that will affect the growth and development of engineering professionals.

2.6.2 ASTD (American Society of Training & Development)

A competency study done by ASTD has identified four unique roles within the workplace learning and performance (WLP) profession (Bemthal et al, 2004):

- Learning Strategist – gives a strategic direction to WLP improvement initiatives to achieve long term business success.
- Business Partner – works with the client to identify WLP improvement opportunities.
- Project Manager – monitors the effective delivery of WLP solutions.

Areas of expertise in WLP:

- **Career Planning and Talent Management** - Ensuring that employees have the right skills to meet the strategic challenges of the organization; assuring the
alignment of individual career planning and organization talent management processes to achieve an optimal match between individual and organizational needs; promoting individual growth and organizational renewal.

- **Coaching** - Using an interactive process to help individuals and organizations develop more rapidly and produce more satisfying results; improving others' ability to set goals, take action, make better decisions, and make full use of their natural strengths.

- **Delivering Training** - Delivering learning solutions (for example, courses, guided experience) in a manner that both engages the learner and produces desired outcomes; managing and responding to learner needs; ensuring that the learning solution is made available or delivered in a timely and effective manner.

- **Designing Learning** - Designing, creating, and developing learning interventions to meet needs; analyzing and selecting the most appropriate strategy, methodologies, and technologies to maximize the learning experience and impact.

- **Facilitating Organizational Change** - Leading, managing, and facilitating change within organizations.

- **Improving Human Performance** - Applying a systematic process of discovering and analyzing human performance gaps; planning for future improvements in human performance; designing and developing cost-effective and ethically justifiable solutions to close performance gaps; partnering with the customer when identifying the opportunity and the solution; implementing the solution; monitoring the change; evaluating the results.
• **Managing Organizational Knowledge** - Serving as a catalyst and visionary for knowledge sharing; developing and championing a plan for transforming the organization into a knowledge-creating and knowledge-sharing entity; initiating, driving, and integrating the organization’s knowledge management efforts.

• **Managing The Learning Function** - Providing leadership in developing human capital to execute the organization’s strategy; planning, organizing, monitoring, and adjusting activities associated with the administration of workplace learning and performance.

• **Measuring and Evaluating** - Gathering data to answer specific questions regarding the value or impact of learning and performance solutions; focusing on the impact of individual programs and creating overall measures of system effectiveness; leveraging findings to increase effectiveness and provide recommendations for change.

The International Academia is having several initiatives in Top Tier Institutes like Massachusetts Institute of Technology (MIT), Stanford and Carnegie Mellon wherein the focus of their research seems to be on Innovative Learning methods that will bring about a different breed of Engineers.

2.6.3 **The Stanford Center for Innovations in Learning (SCIL)**

Founded in 2002, SCIL conducts scholarly research to advance the science, technology and practice of learning and teaching. The Center brings together teachers, scholars and students from around the world to study how to improve formal and informal learning across cultural boundaries.
These are the areas in which SCIL research efforts are currently focused:

*Strengthening the Learner*

Projects in this area focus on giving students the tools to better access or understand information. Current studies include exploring the use of mobile devices in the classroom and evaluation of the creation of electronic portfolios as a means of reflecting on learning experiences.

- Collaborative Research: Exploring the Value of Learning by Teaching: This work explores how to capitalize on the adage that people learn quite well by teaching others with a twist. Students teach computer software programs called Teachable Agents (TA). The goal of TA is to develop and understand motivating and effective instruction where students teach the computer to explore the intuitively compelling notion that people learn best when they teach.

- Think Quest and Oracle Academy: An evaluation of three programs underway at the Boys and Girls Club of the Peninsula, this study will measure the effectiveness of the Oracle Academy and Think Quest, two technology programs that teach research, design and technical skills to low-income youth.

- ePortfolios, Idealogs, and Folio Thinking: Since 1998, this ongoing research effort has focused on the use of ePortfolio pedagogy and practices to support reflective thinking and student learning in higher education. Current projects focus on the use of wikis, idealogs, and other social software to support portfolio-related activities in engineering education.
MobileMedia: A community-based data collection service for "invisible" populations in developing countries. MobileMedia collects data from people in order to connect them to currently inaccessible services while generating local employment.

Structuring Learning Environments

By developing and studying physical and virtual environments, researchers are working to understand the impact of where learning takes place. From utilizing new, flexible classroom furniture to the development of better ways to collaborate and share information, researchers are testing and analyzing learning spaces.

LIFE Center: A collaboration among Stanford University, SRI International and the University of Washington, the LIFE Center seeks to understand and advance formal and informal learning through the exploration of interdisciplinary theories and collaborative research.

Effects of Action and Knowledge on Spatial Inference: There are many competing claims about the use of hands-on activities in education. Researchers on this project seek to develop relevant evidence while addressing fundamental questions about the role of the physical body in problem solving and learning.

How External Representations Propel Development and Future Learning: Written symbols and representations have a profound influence on scientific discoveries. This study is exploring the question of whether symbols and representations also have a profound influence on children's abilities to acquire higher-order thinking skills.
Biological Bases of Alphanumeric Learning Interventions: This work explores how the brain learns (and how to help the brain learn) to associate written symbols with their meaning in foundational educational domains.

_Making learning visible:_

Students and their professors can show what they are thinking while they work using new tools that allow annotation and sharing of high-resolution video, and digital simulation to suit a wide range of disciplines. When thinking and teaching become transparent, both student and teacher benefit.

- Video Tools for e-Learning: DIVER (Digital Interactive Video Exploration and Reflection) is SCIL-developed software that allows users to "make movies within movies" by creating virtual pathways through existing video content. In using DIVER as a new form of information technology researchers on this project are helping to increase access to high-quality academic content.

- English Language Acquisition; National Professional Development: By developing online multimedia curriculum for teachers of English Language Learners this project aims to broaden the availability of such training, and to improve the quality of it by offering video classroom case studies.

2.6.4 _Technology-Enabled Active Learning (TEAL) at MIT_

The objective of the TEAL project is to transform the way physics is taught to large physics classes at MIT in order to decrease failure rates and increase students' conceptual understanding. Visualization technology was used to impart meaningful learning by
enabling the presentation of spatial and dynamic images, which portray relationships between complex concepts. The TEAL project is centered on an “active learning” approach, aimed at helping students visualize, develop better intuition about, and conceptual models of electromagnetic phenomena. Instead of having the lecturer poised before an inert mass of students, followed at some later date by a separate "hands-on" lab, the TEAL class is based on tables of nine students--three groups of three--with the professor and teaching assistants alternately lecturing and mingling at the tables as students work with test apparatus linked to laptops. The walls are lined with projection screens as well as traditional chalkboards, enabling everyone to view sophisticated visualizations and simulations that bring the material to life. The groups were mixed up halfway through the semester, to break up unhealthy work relationships and give everyone a fresh start.

TEAL has been used in Physics 8.02 (Electricity and Magnetism) since 2005, and special trainings were given to equip the faculty. Peter Dourmashkin, senior lecturer in physics at MIT and associate director of the Experimental Study Group and his colleague John Belcher have demonstrated a 20 to 30 percent improvement in students' conceptual understanding of the course material, relative to their peers (Dori, Belcher, Bessette, Danziger, Mckinney, & Hult, 2003).

2.6.5 Carnegie Foundation for Advancement of Teaching

Founded by Andrew Carnegie in 1905 and chartered in 1906 by an act of Congress. The Carnegie Foundation for the Advancement of Teaching is an independent policy and research center with a primary mission "to do and perform all things necessary to
encourage, uphold, and dignify the profession of the teacher and the cause of higher education."

The Knowledge Media Laboratory (KML) uses new media and emerging technologies to exchange information, share knowledge and produce innovations that can transform teaching and learning. KML works to create a future in which communities of teachers, faculty, programs, and institutions collectively advance teaching and learning by exchanging their educational knowledge, experiences, ideas, and reflections by taking advantage of various technologies and resources.

The KML is currently working with its partners, including Carnegie Foundation programs, to achieve the following goals:

- To develop digital (or electronic) tools and resources that help to make knowledge of effective teaching practices and educational transformation efforts visible, shareable and reusable.

- To explore synergy among various technologies to better support the scholarship of teaching and learning.

- To build the capacity for faculty and teachers independently to take advantage of information and communications technologies that enable them to re-examine, rethink and represent teaching and student learning, and to share the outcomes in an effective and efficient way.

- To sustain communities of practice engaged in collaboratively improving teaching and student learning by building common areas to exchange knowledge and by building repositories for the representation of effective practice.
KML projects include:

- The Gallery of Teaching and Learning – an interactive online gallery that presents knowledge of and experience in transforming and improving teaching and learning at many levels, documented by taking advantage of multimedia and network technology. It includes:
  - Collections – works created by the Foundation’s programs and their participants and partners.
  - Exhibitions – showcase and discuss opportunities and challenges of representing and understanding teaching and learning as scholarly work.
  - Case studies – provide inspiring exemplars of how technology-enabled educational knowledge representation and sharing helps advance teaching and learning in various contexts.

- KEEP Toolkit - The KEEP Toolkit is a set of web-based tools that help teachers, students and institutions quickly create compact and engaging knowledge representations on the Web. With the KEEP Toolkit you can:
  - Select and organize teaching and learning materials;
  - Prompt analysis and reflection by using templates;
  - Transform materials and reflections into visually appealing and intellectually engaging representations;
  - Share ideas for peer-review, assessment, and collective knowledge building; and
  - Simplify the technical tasks and facilitate knowledge exchange and dissemination.
Collaborative Innovation Center (CIC) is a partnership between Carnegie Mellon, the Carnegie Museums, and local economic development organizations, funded with $8 million in Commonwealth of Pennsylvania tax support to create the optimal environment to serve the next generation of university–industry collaboration. The CIC provides office and lab space for technology companies wishing to collaborate with Carnegie Mellon to create innovative new concepts and products for the marketplace.

Carnegie Mellon University is launching an $18 million initiative with $3 million in seed funding from the Kauffman Foundation to infuse entrepreneurship and innovation-management courses throughout the university’s undergraduate curriculum. Under the new plan, the university seeks to create a minor in entrepreneurship and innovation that spans the entire undergraduate program at Carnegie Mellon and to leverage relationships with new global partnerships to broaden and deepen the educational potential of those efforts. The new initiative will begin in close collaboration with Carnegie Mellon’s College of Engineering, where the plan is to begin reforming undergraduate engineering education and then disseminate it across campus.

A new graduate degree program created by the university’s College of Engineering will be launched in 2007. The Engineering and Technology Innovation master’s program is a one-year, interdisciplinary degree that teaches engineers and technical professionals skills to foster and manage technical innovation. The effort will be managed through the establishment of a new Institute for the Study of Entrepreneurship, Innovation and Technological Change that will be the hub for education and research in innovation and entrepreneurship.
Carnegie Mellon students learn by actually doing and making. To challenge the students to undertake creative and interdisciplinary projects (in arts, humanities, and science and technical fields), undergraduate participation is ensured in research under the guidance of a faculty with an annual year-end celebration of their work at the Meeting of the Minds Symposium every May.

Service learning is part of the Carnegie Mellon life and part of several courses. The first-year students are immersed in learning through guided practice in the introductory engineering courses and College of Fine Arts studios and productions.

The Eberly Center for Teaching Excellence - supports faculty seeking to improve their teaching, based on the latest understanding of student learning. One-on-one private consultations are held on course design, implementation and evaluation. Discussions are conducted across departments and colleges to address common concerns, to facilitate interdisciplinary collaborations, and to help transfer and adapt successful strategies. Seminars are conducted on teaching effectiveness to provide an opportunity for graduate students and post-doctoral fellows to discuss teaching and learning issues.

The stark contrast between what is happening in the International Academia and the Indian Academia brings back the focus to some of the key issues that confront teaching and learning paradigms in the Indian context – where the focus for students and faculty is more on examination as the measure of success rather than the readiness to the next stage in life.
2.7 Conventional Teaching Practices

Engineering colleges in the country can be broadly classified into Tier A, B and C colleges. Tier A colleges are the Indian Institutes of Technology and the National Institutes of Technology which are premium engineering colleges that promote higher levels of research, experimentation and industry relevance. Students of these institutes have a wide choice of employment and higher education opportunities. The problem really boils down to the Tier B and Tier C colleges where variations are found across curriculum, faculty capability and teaching methods. It is important for us to delve further into this topic and understand it better.

Most of Indian engineering institutes have conventional learning environments wherein the creative energy of the talented students remains untapped. The students lack enough opportunity and the learning approach of many students for many subjects remains stagnated at *reproduction directed level* as per Vermunt’s framework for classifying learning styles (Coffield, Moseley, Hall, & Ecclestone, 2004, as cited in Goel, 2006).

As part of teaching, learning, and assessment processes, students are repeatedly engaged in such activities that promote rote learning and conformity. The system does not make a focused effort to transform student’s learning approach to *application* or *meaning directed levels*. A very large number of students are awarded 60% to 80% marks without giving them sufficient experience of design. The teaching and assessment methods usually focus on course coverage and knowledge *acquisition* with little scope for meaningful usage of knowledge for invention, decision making, experimental inquiry, investigation or problem solving. A World Bank Study on Science and Technology...
Manpower in India published in 2001 commends on the lacunae observed in conventional learning environments:

- Faculty lacks industry rigor, R&D background and exposure to tools.
- Students lack opportunity and encouragement for creative thinking.
- Inflexible and rigid curriculum is not exposed to innovation/industry.
- Teaching is exam oriented without focus on communication and problem solving skills.
- Continuous evaluation is often not systematized.
- Examinations are often memory based and encourage partial studying.

2.8 Learning Aids

The quality of an education system depends on its effectiveness in creating a positive and active learning environment for the students. To achieve high order of intellectual behavior within such a learning environment student activities, instructor activities and student assessment parameters need to be customized, e.g., Student activities are centered around solving problems, recognizing problems and developing tools to solve them to effect application (Bloom, Enghart, Furst, Hill, & Krathwohl, 1956).

For effecting active learning the students must be trained to actively engage in the subject matter by doing things rather than perform passive listening and watching. The retention rate is a mere 5% in traditional lecture method whereas it rises to 90% if the learner is teaching others (Faculty Innovation Center. “Active Learning,” n.d.).
2.8.1 Software of Pedagogy

Personal enquiry notes indicate the following ways in which the students learn:

- By learning 10%
- By seeing 20%
- By discussing 40%
- By doing 90%

Thus, students imbibe nearly 90% of learning “by doing”. Accordingly the traditional method of lecturing is paving way for all-inclusive teaching methodologies tapping the audio-visual sensory perceptions of the students. Case studies, drilled down exercises, internet exercises with compelling discussions, role plays and simulation discussions have become an integral part of teaching methodologies. In the Dalton Plan, instructors outline the work of each semester, divide them into units (monthly) and assign them to students individually. In the problem solving method, instructors tap the reflective thinking among students concerning awareness, analysis, illumination, incubation and verification. Heuristic methods make use of illustrated problems for active learning. Role playing helps the students to develop supervisory skills and see others’ point of view and contribute towards the development of attitude. Simulations provide a realistic picture of both knowledge and skill. Instructors decide on the right pedagogical tool on the basis of:

- Methods of instruction
- Methods of learning
- Methods of assessment
Many of these have been successfully used in the Engineering Colleges across the world and a few of them are listed below.

2.8.2 **Innovative Teaching Methodologies**

A range of teaching methodologies and tools are used to impart active learning to a diverse learning community. A few such innovative teaching practices across engineering institutions are listed below:

**Monash University**

Software Engineering Practice course, a compulsory 2nd year course in the Bachelor of Computing at Monash University, encompassing about 250 students each year, is aimed at providing students with practical experience of software engineering practice as well as familiarizing them with a theoretical background of software engineering, and object-oriented design and programming. To provide a positive learning environment the following teaching tools were developed at the end of extensive anonymous student surveys conducted over a period of 3 years (Dick, Postema, & Miller, 2000):

*Practical assignment.* Students consider practical assignments as a challenging task contributing to their knowledge of software engineering practice.

*Tutorials.* The comprehensive tutorial notes provide a practical reference for the students as well as direct assistance on their assignments allowing them to actively participate in the work and experiment with principles.
**Web page.** The course web page provide students with another avenue for communicating information to students, and act as a repository and distribution point for course materials and enable them to post anonymous feedback to lectures or tutors.

**Help desk.** The course specific help sessions provide students with a formal consulting mechanism at a prescheduled time.

**Personal Assistant for Software Engineers (PASE).** Students use the automated tool to record time and defect metrics in the Personal Software Process (PSP), which was manually recorded in the past.

Students rate the various sources of assistance available to them at the end of each semester and they consistently rated the tutor, other students and the tutorial notes as the greatest source of assistance.

**Cockrell School of Engineering, University of Texas at Austin**

A voluntary survey of 411 students spread across different departments throws interesting insights into their faculty’s approaches to instruction, use of teaching tools, and their own perspectives on learning. Most of the engineering faculty use technology for lecture delivery (Faculty Innovation Center, n.d.).

**PowerPoint.** Nearly 39% of the students reported the use of PowerPoint by their Professors. But the Professors were less spontaneous and moved too quickly when they used PowerPoint. A quarter of the faculty provided complete notes from their PowerPoint presentations while 14% offered incomplete PowerPoint notes.

**Word.** A very small% of the faculty (3%) gave students completed notes in Word while 3.5% of the faculty gave incomplete notes in Word.
**Chalkboard or Dry Erase board.** Nearly 40.5% of the students reported the use of a chalkboard or dry erase board by their faculty.

**Document camera.** Nearly 20% of the students reported the use of document camera by their faculty.

**Visual models (picturesgraphics).** Nearly 53% of students reported the use of visual models in their classrooms and pictures/graphics were used 75% of the time by their faculty.

One student opined that “the Professor, who uses a variety of methods for teaching, keeps things interesting, talks and writes down everything, uses visual aids and avoids PowerPoint.”

The survey results indicate that the use of other media in the class helps students because students are often visual learners. PowerPoint, the popular teaching aid helps in presenting textual data.

The different forms of instructional media and technology-based support tools developed by the Faculty Innovation Center (FIC) include:

**3D visualizations.** The FIC created an animation of the drilling process of an oil well for the Department of Petroleum and Geosystems Engineering for the benefit of students.

**Podcasts.** Content (audio, video or enhanced media) is stored as an instructional asset in a portable and archive-ready format. Students can subscribe to the content they need and automatically receive regular updates.

**Distance learning facilities.** Remote students can view the faculty lectures, which are posted for on-demand viewing at any time, live via a streaming webcast.
**Interactive simulations.** Students can manipulate the parameters in a simulated environment and observe the consequences of their actions.

**Online instructional tools.** Polaris Portfolio tool helps students to post projects, work in groups, do reflective exercises on their engineering education and create a media-rich resume.

**Video production.** Short documentaries highlighting research projects on emerging technologies help students to comprehend the future practical significance of classroom concepts.

**Video conferencing.** A user-friendly self-service video conferencing system termed as Tandberg 6000, provides seamless two-way interaction between faculty and students spread across multiple locations. The system easily transmits audio and video along with data from other sources, such as a laptop or document camera.

**Web sites.** Instructional and informational web sites with animation and interactive elements help to illustrate key concepts to students.

**Cape Cod Community College, West Barnstable, Massachusetts, USA**

Cooperative learning techniques utilizing teams in class are employed in teaching engineering and math courses. The procedure as listed by a practicing faculty of cooperative learning (Panitz, n.d.):

1. Faculty sends a welcome letter and course syllabus describing the teaching methods to each student before the commencement of the semester.

2. Faculty calls for an un-announced quiz on chapter 1 in the first class to check whether the students are keen to learn the subject.
3. After 20 minutes the faculty leaves the room asking the students to pair up and work together.

4. In the last 20 minutes the faculty asks the class to arrive at a consensus and put the answers on the board.

5. The class is given the full freedom to reach a consensus without letting an authority monitor their actions.

6. In the end the quiz is not graded and the sole purpose of the entire exercise was to trigger the attention of the class on the particular subject.

7. In the 2nd class, the faculty conducts a warm up exercise to help students get to know each other better.

8. Faculty uses Pair-Share-Report technique to learn why the students chose engineering and what concerns they have about the course.

9. Most students express concern about group learning techniques.

10. Faculty explains the concept of cooperative learning and what the class procedures and grading methodology will be (individual tests, group projects, team homework presentations, and a factor for class participation).

11. Faculty forms teams of 2-4 students depending on class size and entrust each team with the responsibility of solving and presenting in class at least one homework problem per assignment.

12. Faculty assigns homework projects to teams several times during the semester.

13. Faculty encourages the teams to come out with effective explanations and resort to lecturing as a last resort.

14. Faculty dons the role of a facilitator during the entire learning process.
University of Oklahoma

Team-based learning adopted in "Applications Programming":

**Rapid Assessment Process.** Weekly reading assignments were given from a custom textbook developed for the course and this was followed with one Rapid Assessment Test (RAT) each week. Lecture-mode of delivery was taken up after the RAT.

**In-class Activities.** The students were stimulated to work together in teams while still coding on their own by following these steps whenever they had a problem:

- Ask one team member for help, if it remains unanswered then
- Ask the team for help and if it still remains unanswered then
- As a team, ask the instructor for help

**Project.** Group projects were assigned where they were made to work on various aspects of the project, namely, generating program requirements, project design, and usability testing, as a team.

**External evaluation.** The final evaluation of the poster session wherein each team defended their project was done by the department’s industrial advisory board member. This gave the students an insight into how assessments are done in the “real world.”

The above examples highlight the fact that many Engineering campuses across the globe use a variety of multi-modal teaching aids and techniques quite successfully. While several aids are available for imparting education, there has been hardly any development that has happened on the student front to support them in their learning process. One such work has been the study of how students take notes in a classroom. The work done at Cornell in this area is explained below.
2.8.3 Cornell Note-taking System

Taking lecture notes is another important activity of the student community. The traditional way of taking down whatever the teacher dictates in a class room has got a modern face-lift with the advent of the Cornell note-taking system (Figure 2-1 to Figure 2-5), a widely-used note-taking system devised in the 1950s by Walter Pauk, an education professor at Cornell University. Pauk advocated its use in his best-selling book How to Study in College. It’s immensely popular among the student community to create condensed notes (Paul, 1997, as cited in Learning Tool box, n.d.).

1. Divide the paper into three sections.
   a. Draw a dark horizontal line about 5 or 6 lines from the bottom using a marker.
   b. Draw a dark vertical line about 2 inches from the left side of the paper from the top to the horizontal line.

[Diagram of Cornell note-taking system]

Figure 2-1 Cornell note pages – step 1

2. Document course name, date and topic at the top of each page.
3. Write Notes
   
a. The large box to the right is for writing notes.
   
b. Leave a line between ideas and topics.
   
c. Use abbreviations, whenever possible.

4. Review and clarify
   
a. Review the notes as soon as possible after class.
   
b. Pull out main ideas, key points, dates, and people, and write them in the left column.
c. Summarize the main ideas in the bottom section.

Figure 2-4 Cornell note pages – step 4

5. Study your notes
   a. Reread your notes in the right column.
   b. Spend most of your time studying the ideas in the left column and the summary at the bottom.

Figure 2-5 Cornell note pages – step 5

It is to be noted though that while the Cornell Note Page brings in an amount of standardization, it does not strictly follow any learning theory that is aligned to the Engineering education.
The combination of innovative teaching methods and aids for student learning when applied with the knowledge of the various theories of learning brings about the maximum impact on the transformation that is expected among the engineering academia. Since it is important to understand the various researches done in the area of learning, let us review some of the popular learning theories.

2.9 Learning Theories

In psychology and education, learning theories are attempts to describe how people and animals learn thereby helping us understand the inherently complex process of learning. There are basically four broad categories of research in this area. They are:

- Behavioral Learning
- Cognitive Learning
- Humanist Learning
- Social Learning

Some elaboration on each of the above is provided below.

Behaviorism is a theory of animal and human learning that only focuses on objectively observable behaviors and discounts mental activities. Behavior theorists define learning as acquisition of new behavior which is unconcealed. Instructors use punishments and rewards as reinforcement techniques.

Piaget’s development theory is based on the idea that the developing child builds cognitive structures—in other words, mental "maps," schemes, or networked concepts for understanding and responding to physical experiences within his or her environment. A
child's cognitive structure increases in sophistication with development, moving from a few innate reflexes such as crying and sucking to highly complex mental activities. The curriculum is customized to enhance the learner’s logical and conceptual growth. Instructors emphasize on experiences to impart effective learning.

**Brain-based learning** is based on the structure and function of the brain. As long as the brain is not prohibited from fulfilling its normal processes, learning will occur. The curriculum is designed around learner’s interests. The instructors promote peripheral learning among learners and guide them in self-assessments.

**Right brain/left brain thinking** theory of the structure and functions of the mind suggests that the two different sides of the brain control two different “modes” of thinking. It also suggests that each of us prefers one mode over the other.

<table>
<thead>
<tr>
<th>Left Brain</th>
<th>Right Brain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logical</td>
<td>Random</td>
</tr>
<tr>
<td>Sequential</td>
<td>Intuitive</td>
</tr>
<tr>
<td>Rational</td>
<td>Holistic</td>
</tr>
<tr>
<td>Analytical</td>
<td>Synthesizing</td>
</tr>
<tr>
<td>Objective</td>
<td>Subjective</td>
</tr>
<tr>
<td>Looks at parts</td>
<td>Looks at wholes</td>
</tr>
</tbody>
</table>

The curriculum is designed giving equal weight to the arts, creativity, and the skills of imagination and synthesis. The instructors incorporate more patterning, metaphors, analogies, role playing, visuals, and movement into their reading, calculation, and analytical activities for wholesome learning.
Constructivism is defined as a philosophy of learning founded on the premise that, by reflecting on our experiences, we construct our own understanding of the world we live in. The learner generates his/her own "rules" and "mental models," which are used to comprehend new experiences. The curriculum is customized to use the learner's prior knowledge and emphasizes on hands-on problem solving. Learners are encouraged to actively participate in the learning process and judge their own progress.

Observational learning also called social learning theory, occurs when an observer's behavior changes after viewing the behavior of a model. An observer's behavior can be affected by the positive or negative consequences: called vicarious reinforcement or vicarious punishment, of a model's behavior. Collaborative learning is emphasized to impart positive reinforcement.

Vygotsky and Social Cognition learning model asserts that culture is the prime determinant of individual development. Humans are the only species to have created culture, and every human child develops in the context of a culture. Therefore, a child's learning development is affected in ways large and small by the culture--including the culture of family environment--in which he or she is enmeshed. The curriculum is customized favoring more interactions between learners and learning tasks. The teaching methods are fine tuned to inculcate independent problem solving in future in the learners.

Learning styles theory implies that how much individuals learn has more to do with whether the educational experience is geared toward their particular style of learning than whether or not they are "smart." In fact, educators should not ask, "Is this student smart?" but rather "How is this student smart?" The curriculum is customized by emphasizing on
learner’s intuition, feeling, sensing, and imagination, in addition to the traditional skills of analysis, reason, and sequential problem solving. The instructors design their teaching methods to tap various combinations of experience, reflection, conceptualization, and experimentation.

**Multiple intelligences theory** suggests there are at least eight ways (verbal-linguistic, logical-mathematical, visual-spatial, body-kinesthetic, musical-rhythmic, interpersonal, intrapersonal and naturalist) that people have of perceiving and understanding the world, labeled as a distinct “intelligence” or set of skills allowing individuals to find and resolve problems they face. The curriculum incorporates arts, self-awareness, communication, and physical education in addition to the verbal and logical themes. The instructors use different methods like role playing, musical performance, cooperative learning, reflection, visualization, story telling, etc.

While the above learning theories cut across the gamut of an individual’s life span across differing contexts, in the Engineering education space where the learning typically happens within the confines of a classroom, cognitive learning model is most relevant. So, let us delve deeper and try to understand the various facets of cognitive learning:

- Cognitive Learning – Fundamentals
- ACT – R theory (Adaptive Component of Thought - Rational theory)
- Meta cognitive learning
- Constructivism
- Bloom’s Taxonomy
- Gardner’s Multiple Intelligence
2.9.1 Cognitive Learning - Fundamentals

Cognitive learning emphasizes on cognitivism: a term used to denote unobservable change in mental knowledge. Cognitive learning theory contradicts the basic tenet of behavioral learning theory which focuses on observable change in behavior at the end of the learning process.

The origin of cognitivism can be traced back to 1879, when Wilhelm Wundt established the first psychology laboratory in Leipzig, Germany where he used introspection as method of self-observation to examine the working of the mind. Soon some major theories evolved in the field of cognitive learning:

- Piaget's Cognitive Development where learning process is described as an iterative process wherein new information is shaped to fit with the learner's existing knowledge, and existing knowledge is itself modified to accommodate the new information.
- John Anderson's ACT-R theory explains how mind determines what knowledge is available based on its contextual appropriateness by performing a Bayesian inference.
- Schema Theory describes that the knowledge we have stored in memory is organized as a set of schemata or mental representations, each of which incorporates all the knowledge of a given type of object or event that we have acquired from past experience.
Learners usually organize the things they learn, forming mental associations over the years. When they learn new things they are thus able to associate it to things learnt in the past (Gerald, 1996). The various steps in this process are:

- **Steps 1-3. Comprehension**: Prior to reading a new text, readers generally predict what it will contain or what a statement will mean. In the process they predict what prior knowledge is relevant for the concerned topic and try to associate the new text with already existing knowledge. They also forecast what strategies will help in better understanding of the text. For example, a sports fan may decide to read a detailed review of a sports event but the same strategy may appear meaningless for a reader with no prior knowledge.

- **Steps 4 and 5. Learning**: Though the reader may comprehend the new text, very rarely he/she may register the entire information. A reader generally comprehends only information which can be connected to the prior knowledge. But a cognitive reader converts “comprehended information” into “learned information,” through such activities as taking notes, summarizing, outlining, making analogies, relating the information to oneself personally, creating mental imagery, and similar activities known as elaboration. The reader goes through the following cognitive processes during this phase:
  
  - **Elaboration** refers to any method of “thinking about new ideas and prior knowledge together” so the two become more deeply connected.
  
  - **Learning** takes place when the new information becomes a part of the existing knowledge network.
When elaborated and richly integrated, the new knowledge becomes meaningful and useful. The new knowledge can fit into the existing knowledge network or it can modify that network.

❖ Steps 6 and 7. Recall and Reconstruction: In the last step of cognitive learning process, the reader will recall a gist of the new information he/she has added to the knowledge network and when needed reconstruct what he/she know. The learning becomes fruitful if the reader is able to infer new things from the reinforced knowledge network.

"Cognition is an active, recursive, integrated process by which we continuously model the world and continuously modify the model."

op.cit, "Serving the strategic reader: cognitive theory and its implications for the teaching of writing."

Bloom’s taxonomy and Kolb’s learning cycle are two well established cognitive models used in academics. Oregon State University (OSU) has successfully modified these well known cognitive models and applied it to engineering education.

The curriculum is designed to make the learner operate in the higher cognitive domain and to transition smoothly between the levels of analysis, synthesis, and evaluation (Oregon State University, 2007).
Kolb’s learning model is composed of four elements:

1. Concrete Experience
2. Observation and Reflection
3. Abstract Conceptualization
4. Active Experimentation

The model is modified to suit the needs of engineering education in OSU.

Both models are integrated successfully in the entire learning process in OSU to mould quality engineers.

1. Create concise and measurable course learning objectives.
2. Match learning objectives
3. Categorize learning objectives into either lower (knowledge, comprehension, application) or higher (analysis, synthesis, evaluation) cognitive domains, according to the modified Bloom's taxonomy. Conduct a pre-assessment of student's pre-existing knowledge.
4. Create an assessment plan consisting of three methods to assess each learning objective.
5. For each learning objective, plan activities that correlate to each quadrant in the Kolb learning cycle.
6. Conduct post-assessment of student learning according to the assessment plan and report results.
7. Create instructor improvement plan for the following year and provide reflection on previous year's improvement plan progress.
2.9.2 ACT-R on Cognitive Learning

ACT-R is a cognitive architecture mainly developed by John Robert Anderson at Carnegie Mellon University. Researchers create domain-specific ACT-R models based on assumptions about human cognition, which in turn are based on numerous facts derived from psychology experiments. We can compare the quantitative measures derived from ACT-R models and those collected from human participants and thus validate the efficacy of cognitive modeling (Budiu, n.d.).

ACT-R's main components are:

- Modules
- Buffers
- Pattern matcher

**Modules.** There are two types of modules:

- Perceptual-motor modules, which simulate the real world, e.g., visual and the manual modules.
- Memory modules. There are two kinds of memory modules in ACT-R:

  **Declarative memory** consisting of facts, e.g., \(2+3=5\): How fast a fact can be retrieved from declarative memory depends on sub-symbolic retrieval equations, which take into account the context and the history of usage of that fact.

  **Procedural memory:** made of productions representing knowledge about how we do things, e.g., Knowledge about how to type the letter "A" on a keyboard.
Buffers. ACT-R accesses its modules (except for the procedural-memory module) through buffers. For each module, a dedicated buffer serves as the interface with that module. The contents of the buffers at a given moment in time represent the state of ACT-R at that moment.

Pattern Matcher. The pattern matcher searches for a production that matches the current state of the buffers. Only one such production can be executed at a given moment, which upon execution can modify the buffers and thus change the state of the system. In case several productions match the state of the buffers, a sub-symbolic utility equation estimates the relative cost and benefit associated with each production and executes the one with the highest utility.

ACT-R framework is widely used in technical domain. Context Aware Cognitive Model system is one such model used to develop Contextual Car Driver Interface enhancing safety and driver-car interactions. It helps to analyze driver’s intention and monitor the driver’s physical and cognitive state, namely, current intentions, approach used to fulfill their intention, temporary memory, and long term memory for any impairments or information overload (Kam, 2002).

2.9.3. Meta cognitive Learning

Metacognition is an important concept used in educational psychology, which refers to the ability of the learners to have active control during cognitive learning process. Expert learners are more skilled at using metacognitive strategies than novice learners. The former group is more adept in monitoring their progress during the learning process and
making changes and adapting their strategies accordingly (Winn & Snyder 1998, as cited in Halter, n.d).

"Metacognitive skills include taking conscious control of learning, planning and selecting strategies, monitoring the progress of learning, correcting errors, analyzing the effectiveness of learning strategies, and changing learning behaviors and strategies when necessary."

- Ridley, Schutz, Glanz, & Weinstein, 1992, as cited in Halter, n.d.

John Flavell, an American developmental psychologist is regarded as the founder researcher in metacognition. It was first defined in 1977 by Flavell and Wellman in the context of describing four levels of mental activity.

1. Actual implementation using hard-wired processes in the brain
2. Retrieval from semantic storage
3. Methods and strategies and
4. Metacognition, i.e. the knowledge, awareness, and (conscious or implicit) control/monitoring of the lower levels of cognition.

In 1979 Flavell proposed that metacognition includes knowledge and regulation of cognition. The knowledge about metacognition consists of:

- Person variables or knowledge of self (e.g., knowing that one learns better when studying in a quiet room than in front of the television);
- Task variables or knowledge of task (e.g., knowing that it's easier to prepare for a multiple-choice test than an essay test); and
Strategy variables or knowledge of strategies (e.g., when and how to use cognitive and metacognitive strategies).

Metacognitive regulation refers to the use of metacognitive strategies in a sequential way to control the cognitive learning process and to ensure that the cognitive goal is met (Livingston, 2003). Suppose the cognitive goal of a learner is to understand a 5 page text. After reading through the first page the learner can test the level of comprehension by trying to answer some self-coined questions. Failure to answer the questions will convey that learning has not been effective and the learner can re-read the same page.

In academics, metacognitive instruction helps learners to identify metacognitive knowledge and to develop metacognitive regulation. Examples of metacognitive skills that can be induced in learners by metacognitive instruction include creating awareness of:

- Difference between understanding and memorizing a body of knowledge
- Which strategies to apply to master the topic?
- How to assess one's own level of comprehension?
- When is a particular explanation relevant to one's way of thinking?
- How to monitor one's own progress during the learning process?
- How to arrive at own solutions for a problem?
- How to check the effectiveness of own solutions?

Reflective group discussions are useful in mastering metacognitive skills. Concept maps and Vee heuristic are commonly used metacognitive tools to help learners/researchers gain a big picture by way of intra-group communications (Iuli, n.d).
2.9.4 Constructivism

"Constructivism is a psychological theory that construes learning as an interpretive, recursive, building process by active learners interacting with the physical and social world."


The psychological basis of Constructivism has been connected with Jean Piaget, an eminent psychologist who believed that the fundamental basis of learning was discovery. According to Piaget during the process of logical reasoning an individual’s thinking will pass through various reconstructions; akin to psychological development of children. To reach an understanding of basic phenomena, children bank on their ability to produce and create and accept ideas they may later find as untruthful.

Adult learners also experience successive development stages during the learning process involving interplay of cognitive functions. Lev Vygotsky, expanded Piaget’s perspective by introducing the concept of social constructivism whereby each person can achieve more than the level he/she is presumed to be through proper guidance from his/her immediate environment. Later on even in the absence of guidance the learner moves on to the next level (Anastasiadis & Metaxas, 2006).

Constructivism is a learning theory and not a mere description of teaching. There are nine general principles of learning that are derived from constructivism.
These nine principles are (Epstein, 2002):

1. Learning is an active process in which the learner uses sensory input and constructs meaning out of it.

2. Learning consists both of constructing meaning and constructing systems of meaning habituating learners how to learn.

3. Learning process must involve physical actions and mental exercises to actively engage both the mind as well as hand; termed as “reflective activity” by John Dewey, one of the first major contemporaries to develop constructivism.

4. Learning involves language that we use. Lev Vygotsky opined that language and learning are inextricably intertwined.

5. Learning is a social activity intimately associated with our network of our associates like our teacher, our peers, our family, as well as casual acquaintances.

6. Learning is contextual; we learn in relationship to what else we know, what we believe, our prejudices and our fears.

7. Learning of new knowledge happens only when the learners can link it to some previous knowledge.

8. Learning is not instantaneous; we need to practice new knowledge and gain more insights into it before we can absorb it and use it.

9. Learning is driven by motivation of the learner.

Different Types of Constructivism

The psychological theory of constructivism talks about two focus areas, namely, individual cognitive structuring process and social effects on learning. The corresponding
theories are named as "cognitive constructivism" and "social constructivism", respectively.

**Cognitive Constructivism.** The first type of constructivism is Cognitive constructivism which focuses on both what learners learn and the process by which they do so. Piaget’s theory of cognitive development suggests that humans cannot be “given” information which they automatically understand and use, they must “construct” their own knowledge. They build their own knowledge through experience, which allows them to create mental images in their head. The teachers must equip the classroom encouraging students to explore and construct their own knowledge. Rather than remaining as passive suppliers of knowledge, the teachers ensure that the classroom give the students the opportunity to construct knowledge through their own experiences.

**Social Constructivism.** The second type of constructivism is Social constructivism. Vygotsky’s theory places more emphasis on the social context of learning. The theory gives more emphasis on social group surrounding the student and argues that students can, with help from adults or children who are more advanced, grasp concepts and ideas that they cannot understand on their own. Unlike in cognitive constructivism where teachers let students explore and understand new knowledge on their own, in social constructivism they step in as guides whenever the students encounter problems and encourage them to work in groups.

The constructivist approach is most suited in technology learning, because technological knowledge is more often created rather than discovered. Technical learning process involves learning by manipulation (e.g. trial and error), comparison and problem solving
in a non-prescriptive real-world-like context that leaves room for creative thinking and innovation (Järvinen, 2001, pg. 40-41, as cited in Tetard et al, 2005).

2.9.5 Bloom’s Taxonomy and its Elaborations

Bloom’s taxonomy refers to the hierarchy of learning domains developed by a group of cognitive psychologists headed by Benjamin Bloom, an American educational psychologist at the University of Chicago in 1956. The team worked on the premise that abilities can be measured along a continuum from plain and simple to rather complex. Bloom also found that over 95% of the test questions required students to think at the lowest possible level wherein they had to only recall the information learned. The taxonomy developed by the team included the three domains; cognitive, psychomotor, and affective. The instructors can present information and frame questions within particular levels.

The three domains reflect the “goals of the training process” i.e. at the end of the training session the learner should have acquired KSA:

- Mental skills (Knowledge) in the Cognitive domain
- Manual or physical skills (Skills) in the Psychomotor domain
- Growth in feelings or emotional areas (Attitude) in the Affective domain

Following the 1948 Convention of the American Psychological Association, B S Bloom took a lead in formulating a classification of "the goals of the educational process". Three "domains" of educational activities were identified. The first of these is Cognitive Domain. It involves knowledge and the development of intellectual attitudes and skills.
Eventually, Bloom and his co-workers established a hierarchy of educational objectives, which is generally referred to as *Bloom's Taxonomy*. It attempts to divide cognitive objectives into subdivisions. These subdivisions range from the simplest behavior to the most complex. These divisions outlined are not absolutes and other systems also have been devised. However, Bloom's taxonomy is easily understood and widely applied. We will call these divisions as levels henceforth. There are six levels which are discussed below.

**Level 1: Knowledge**

Knowledge is defined as the remembering of previously learned material. This can be specific facts or even complete theories. Essential is bringing in mind the appropriate information. This is the lowest level of learning outcomes in the cognitive domain. A few examples of learning objectives at this level include knowing:

- Common terms
- Specific facts
- Methods and procedures
- Basic concepts
- Principles

**Level 2: Comprehension**

Comprehension is defined as the ability to grasp the meaning of information (as provided by knowledge level above). This may be exhibited by the ability to:

- Translate material from one form to another (words to numbers)
Interpret material (explaining or summarizing)

Estimate future trends (predicting consequences or effects)

These learning outcomes go one step beyond the simple remembering of material. This is the lowest level of understanding. A few examples at this level include ability to:

- Understand facts, principles
- Interpret verbal material, charts and graphs
- Translate verbal material to mathematical formulae
- Estimate the future consequences implied in data
- Justify methods and procedures

**Level 3: Application**

Application is the ability to use learned material in new and concrete situations. It can be ability to use:

- Rules
- Methods
- Concepts
- Principles
- Laws
- Theories

A few examples at this level include ability to:

- Apply concepts/principles to new situations
• Apply laws and theories to practical situations
• Solve mathematical problems
• Construct graphs and charts
• Demonstrate the correct usage of a method, procedure or an algorithm

**Level 4: Analysis**

Analysis is the ability to break down material into its component parts so that its organizational structure may be understood. It can be ability to:

- Identify parts
- Analyze relationships between the parts
- Recognize the organizational principles involved

Here understanding of both the content and the structural form of the material is expected which is of course above knowledge and application. A few examples at this level include ability to:

- Recognize unstated assumptions
- Recognize logical fallacies in reasoning
- Distinguish between facts and inferences
- Evaluate the relevancy of data
- Analyze the organizational structure of a work (art, music, writing)

**Level 5: Synthesis**

Synthesis is the ability to put parts together *to form a new whole*. It can be:
• Production of a unique communication (theme or speech)
• A plan of operations (research proposal)
• A set of abstract relations (scheme for classifying information)

Here we have more focus on creative ability and the formulation of new patterns or structure. A few examples at this level are: ability to:

• Write a well organized theme
• Give a well organized speech
• Write a creative short story (or poem or music)
• Propose a plan for an experiment
• Integrate learning from different areas into a plan for solving a problem
• Formulate a new scheme for classifying objects (or events, or ideas).

**Level 6: Evaluation**

Evaluation is ability to judge the value of material (statement, novel, poem, research report) *for a given purpose*. The judgments are to be based on definite criteria. The student may determine the criteria or it can be given to them.

Learning outcomes in this area are highest in the cognitive hierarchy because they contain elements of all the other categories, plus conscious value judgments based on clearly defined criteria.

A few examples at this level are: ability to find out –

• How useful the *maps of India* will be – *for planning a 15 days trip* from Pune to Bangalore, Mysore & Kodaikanal.
How useful the garden layout plan will be – for creating a half acre garden around a company

The learning approach that best suits the lower levels of knowledge gain would be the Objectivist approach and for the higher levels of knowledge it would be the Constructivist approach.

Objectivism is defined as below by Gagne in his research work of 1992.

- Gain attention
- Inform learner of learning objectives
- Stimulate recall of prerequisites
- Present stimulus material
- Provide learning guidance
- Elicit performance
- Provide feedback
- Assess performance
- Enhance retention and transfer

Constructivism is defined as below by Jonassen in his research work of 1998.

- Great emphasis on learning environment
- Knowledge is constructed
- New information is interpreted in the context of the learner’s own experiences
- Stress conceptual interrelations and multiple perspectives
- Meaning can be different for every learner
- The emphasis is on the learner’s role in knowledge construction
2.9.6 Gardner's Multiple Intelligence Theory and its Elaborations

The theory of multiple intelligences, which revolutionized the traditional notion of intelligence rooted on Intelligence Quotient (IQ), was developed in 1983 by Dr. Howard Gardner, professor of education and research in neuropsychology at Harvard University. He propounded eight different intelligences to cover all aspects of human potential, namely:

- Linguistic intelligence ("word smart")
- Logical – mathematical intelligence ("number/reasoning smart")
- Spatial intelligence ("picture smart")
- Bodily – kinesthetic intelligence ("body smart")
- Musical intelligence ("music smart")
- Interpersonal intelligence ("people smart")
- Intrapersonal intelligence ("self smart")
- Naturalist intelligence ("nature smart")

Institutionalized education generally focuses on linguistic and logical-mathematical intelligence. Students gifted in the remaining areas of intelligence end up being labeled as underachievers. The theory proposes a major revamp in curriculum and teaching methods helping the students to identify their multiple intelligences and develop them and use them to succeed in both personal and professional sphere. It calls for teachers to be trained in using music, cooperative learning, art activities, role plays, multimedia, field trips, etc in line with the multiple intelligences of their diverse learning community.
In practice teachers/instructors are advised to do brainstorming for eliciting eight different pathways to teach a particular topic. In a spatial approach they can draw eight lines signifying eight different types of intelligence radiating from the topic written down in the center of a paper. The different ideas/pathways to convey the selected topic are then written down next to each of the eight spokes. For example, the law of supply and demand in economics can be taught in eight different ways:

- Read out the law (linguistic)
- Teach mathematical expressions of the law (logical-mathematical)
- Examine a graphic chart that illustrates the principle (spatial)
- Examine the law in terms of supply of food and your stomach’s need for food (bodily-kinesthetic and intrapersonal)
- Demonstrate the law through a song like Dylan's "Too Much of Nothing?" (musical)
- Substantiate the law in the human world of commerce (interpersonal)
- Observe the law in the natural world (naturalist)

The theory is equally relevant in adult learning and development, where it helps adults to exploit their inherent potential and make optimal use of it in their life. A highly bodily-kinesthetic person will be a big failure in a desktop job which demands from him/her more use of logical intelligence. According to Gardner, *individuals develop natural proclivities to learn via particular “bio-psychological potentials” as a result of heredity and early training* (Presentation on Learning Styles/Multiple Intelligences, 1999). The practitioners of adult learning must customize their teaching pathways to be in line with the natural competence of their learners. The natural competence in turn depends on the
individual's natural proclivities and cultural nurturing developed over time. The individual learner's natural competence reflects his/her intelligence, which must be taken as the "entry point" for initiating the learning. Subsequently they can be led to other "entry points" for optimal learning. The effectiveness of learning will have a permanent impact on the attitude of the learner and help in the identification of suitable life and or work options in the long run.

While there are several theories related to learning, there are only a few models that have been propounded around employability and some of the path breaking efforts in this direction is detailed below.

**2.10 Employability Models**

The concept of employability must be better understood in a broader perspective to fully appreciate the practical use of "employability models," currently doing the rounds in our higher education sector. McQuaid and Lindsay, 2005 gives a "holistic" framework of employability. It has three main interrelated components, or sets of factors that influence a person's employability: individual factors (includes a person's 'employability skills and attributes); personal circumstances (includes a range of socioeconomic contextual factors related to individuals' social and household circumstances); and external factors (includes those influencing a person's employability, such as labor demand conditions and enabling support of employment-related public services.

Models, propounded by educationists in the area of employability necessarily advocates structured interventions by academia and industry to churn out creative talents. Pool and Sewell, 2007, has proposed the "Key to Employability" model (**Figure 2-6**): a practical
model for achieving graduate employability. The students must be given all support to develop items in the mnemonic “CareerEDGE”. Upon reflecting and evaluating these experiences, the crucial links to employability can be developed. The model can be used to demonstrate to employers how the roles of Higher Education Institutions and business can both contribute to graduate employability with the resultant benefits for both parties.

Romaniuk and Snart, 2000, examine the role of Prior Learning Assessment (PLA) in general and the portfolio method in particular to enable the contemporary workforce to embrace the shift from employment to employability through encouraging enhancement of both personal and professional growth. PLA is an approach to evaluate and recognize learning based on the identification and substantiation of learning from a broad range of sources, namely, family, school, work, community, volunteer, hobby and travel. The learner can choose any method like documentation via portfolios, transcripts, certificates, and licenses, oral interviews, product samples, and performance tests, to substantiate the learning to the assessor; be it an academic institute or an employer.
Finn, 2000, talks about various New Deal and area-based employment programs introduced by UK government to improve employability; replacing the age-old benefit regime existing for unemployed. The New Deals for the unemployed consist of a complex mix of mandatory advice, employment and training programs. They normally commence with an advisory process aimed at helping an individual find work, followed by a more or less resource intensive range of employment and training options which aim to improve individual employability. There is a “follow through” process of advice and support for those who fail to get a job. Individuals who fail to take up a place or leave early without good cause will have their benefit reduced. A Government commissioned report from the National Institute of Social and Economic Research estimated that in its first year the New Deal for Young People had reduced youth unemployment, relative to
what it would otherwise have been, by 30,000: equivalent to a reduction in long-term youth unemployment of nearly 40%.

Phillips, 2007, discusses about the benefits of skills scheme; a 3-way partnership between employers, schools and students to promote employability. Employers can improve the quality of work placements and help students develop employability skills by embedding learning in the areas of business awareness, team working and self management.

2.11 Summary

From the above Literature survey and secondary research, the following key factors emerge:

1. The demand supply gap is for real at a National level – however for the Top companies in the IT space the gap is more of getting the right skilled people from the campuses.

2. The Government and Industry bodies have taken several initiatives to enhance the quality of output through Industry Academia partnerships and Faculty Development Programs

3. Several of these Industry Academia partnerships focus on specific areas and there is no single consolidated program that has shown a significant result.

4. The Industry is looking for not purely technical skills but a combination of behavioral and managerial skills from young aspirants.

5. This is mainly because the IT professionals are expected to be in positions of solution providing and customer facing roles in a very short career span compared to other Industries.
6. There are not enough initiatives in the academia that nurture these skills as an integral part of the curriculum.

7. Teaching them as additional subjects would make the Engineering Colleges lose sight of their main objective of developing fundamental Engineering knowledge which is their prime purpose.

8. As a comparison, the US as a country has woken up to the fact that they are losing out the edge that they had in Engineering Academia and have initiated a National project called Engineer 2020 which has Industry and Academia working closely with the National Academy of Engineering and the National Science Foundation.

9. There is an urgent need for evolving a model that builds on the various learning theories and at the same time enhances employability.

10. The model has to be relevant, practical and easy to adopt in the exiting context of Engineering education in the country.