CHAPTER II
REVIEW OF LITERATURE

2.0 Introduction

An ideal situation for both academy and industry is to go in perfect harmony which may not be the reality always. There is a perceived conflict between the requirements of the industry for graduates with competencies and the actual competencies the graduates have acquired during their academic career. Many studies have been reported in this area from various countries including India. This chapter provides a review of works relevant and related to this study.

The present investigation is designed to identify and analyze these skill requirements as they exist among the graduate engineering students, it does explore several issues of direct relevance to this study -- industry needs and graduate engineers’ employability and skills.

The review of literature in a subject field is a critical look at the existing research that has relevance and significance to the work that is being carried out by a scholar. Literature review is a classification and evaluation of what researchers have reported on a topic. Literature reviews can be organized according to a guiding concept, such as a research objective or a core problem.

Cormack defines the concept of review of literature as “the process of systematically identifying published materials which meet a set of predetermined set of criteria.”¹ A literature review sets the track for addressing a particular research question and identifies what is current in the field. It also allows a researcher to refine the research question based on the experiences of others.
The reviews provided in this chapter are drawn from previous studies reported by scholars on the industry needs and graduate engineer skills. The reviews comprise of Indian and foreign studies on the topic of present investigation. Reviews cover existing and current literature that includes a variety of forms like the

1. Journal publications;
2. Conference publications;
3. Other library sources
4. The Internet and
5. Reports literature from tertiary institutions.

Today’s college students, in a technology enhanced environment, are expected to learn content at a faster rate than ever before. In doing so, they are expected to develop the “hard” technical skills as well as the “soft” people skills necessary to be successful in the workplace as found expressed in various separate contributions by Hofstrand\(^2\); Shivpuri and Kim\(^3\); Candy and Crebert\(^4\); Martin et al.,\(^5\); and Tanyel, Mitchell, and McAlum\(^6\). As a general theme, the contributors recognized the difficulties, the post-secondary educators had in preparing graduates with skills needed in the industry.

Literature search brought in evidences of surveys of industry perceptions of engineering graduates for both technical and non-technical skills and attributes. Most of these studies have consistently identified communication, interpersonal and teamwork attributes as competency gaps. The Key Competencies framework defined by the Mayer Committee in 1992 in Australia was a landmark development in this regard. The Mayer set of Key Competencies shared a number of features with national frameworks developed in other countries around the same time. The major exception was that Mayer precluded values, attitudes and other personal qualities.
There is a growing body of evidence which supports the contention that, Emotional Intelligence (EI) is crucial to the performance and success of individuals and hence, organizations as expressed in the contributions of Bachman et al., 7 2000; Fox and Spector 8; Jordan et al., 9; Lopes et al., 10. Much of this research focused on how it related to workplace success and performance. There are studies which have shown the positive impact of emotional intelligence on individuals’ leadership ability in the publications of Scheusner, 11; Boyatzis, 12; Cherniss,; Butler and Chinowsky 13, on work performance in Wong and Law 14, on management ability in Slaski and Cartwright 15; Carmeli 16; Zhou and George 17, on academic performance in Petrides et al., 18; Parker et al. 19, and in their ability to perform cognitive tasks in Schutte et al. 20

Goleman 21 also claimed that, because Emotional Intelligence (EI) affects almost every aspect of work life, employees who are high in EI tend to be ‘star performers.’ There is also some evidence that it is important in determining group performance. Elfenbein 22 (2006) demonstrated that a high average level of individual EI of team members predicts stronger team performance. Hence, given the strong relationship between EI and performance, EI tests have been advocated for personnel selection and development.

2.1 Engineering Graduate Attributes: Global Perspectives

Practically, engineering graduates, need to be prepared with nontechnical skills besides the increasing use of advanced and appropriate technology befitting their future workplace environments. However, it is an accepted fact as found in the literature that there is a mismatch between engineering graduate students’ skills and those needed in the workplace as opined by Radcliffe 23; Patil, 24 in their papers.
The data collected in a report of the University of Manchester Institute of Science and Technology showed that careers of most engineers included managerial tasks although many remained in predominantly technological jobs. Furthermore the report summary stated that most engineers’ careers warranted for a variety of managerial skills and expertise, particularly in leadership and the management projects as reported by Dudman and Wearne\textsuperscript{25} in one of their publications. A report on graduate skills and employability (including engineering graduates) published by the Business Council of Australia (BCA), warned universities of the graduates falling behind in their ability to meet industrial needs thereby leaving a competency gap, batch after batch.

2.1.1 Identifying Competency Gap: Multi-national Perceptions

Curriculum’s focus on content was found disconnected from engineering practices as felt by Goel and Sharda\textsuperscript{26}. Dodridge\textsuperscript{27} as well as Mason\textsuperscript{28} in separate works that are to be found in a 1998 survey report of consolidated works published by EMTA (Engineering and Marine Training Authority). They identified practical skills, multiskilling computer literacy, communication skills, management skills, personal skills, and problem solving skills as the most important skill deficiencies amongst engineers.

Many countries in the world irrespective of their economic and political strength have been analyzing the problem of competency gap between the industry needs and the graduate engineers. Right from USA to Cyprus, many countries have been generating research reports periodically on this concept.
2.1.2 United States on Employability Skills of Graduate Engineers

Secretary’s Commission on Achieving Necessary Skills (SCANS) report found out that, to a degree [extent], colleges and universities are failing in their role to properly prepare graduates for the expectations of the workforce. The need to improve the employability skills of the workforce has been an issue across all phases of education. Steps have been taken to define and address key skill areas needed for improvement, specifically at the secondary level. In 1990, SCANS report was initiated to define the skills needed by high school graduates in the workforce. The focus of the report was to determine how high schools could best mirror industry in an effort to make the transition from school-to-work less difficult for secondary graduates. In addition to aiding in an easier transition for graduates, unemployment was also a concern.29

The know-how identified by SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. These are categorized under two headings namely, workplace competencies and foundation skills. The latter was proposed in June 1991 under the Secretary’s Commission on Achieving Necessary Skills (SCANS), US Department of Labour. In that report, the introductory letter states that ‘we understand that schools do more than simply prepare people for a living... this report concerns only one part of that education, the part that involves how schools prepare young people for work.’ However, it can be seen that SCANS adopts a broad approach that integrates workplace skills with personal attributes, values and basic skills within a flexible approach to voluntary national skills standards.

Accreditation Board for Engineering and Technology (ABET), United States has three accreditation commissions namely Engineering Accreditation Commission (EAC); Technology Accreditation Commission
(TAC) and Computing Accreditation Commission (CAC). All these three commissions have given their recommendations separately in their reports which form part of the ABET's publication in 2004. The set of criteria is almost similar in concept with recommendations on attributes that an engineering graduate must attain:

a) an ability to apply knowledge of math, science, and engineering;
b) an ability to design and conduct experiments, as well as analyze and interpret data;
c) an ability to design a system, component or process to meet desired needs;
d) an ability to function in multidisciplinary team;
e) an ability to identify, formulate and solve engineering problems;
f) an understanding of professional and ethical responsibilities;
g) an ability to communicate effectively;
h) an understanding of the impact of engineering solutions in a global and societal context;
i) a recognition of need and ability to engage in life-long learning;
j) a knowledge of contemporary issues; and
k) an ability to use the techniques, skills and modern engineering tools necessary for engineering practice.

A consensus is found among the three commissions as expressed in their recommendations. Work in the US is being taken forward in particular by the National Skills Standards Board (NSSB). In USA, Washington Accord is an International Body of Engineering Alliance, created for accrediting courses and qualifications which are accepted as equivalents in global standards. India is having a provisional status – a status passing through standardization and their engineering qualifications. Other than India, countries like Germany, Russia, and Sri Lanka are in the list of provisional status.
2.1.3 United Kingdom

According to Engineering Professor’s Council (EPC), United Kingdom, the key skills for engineering are communication skills, general IT user abilities, application of numbers, working with others, problem solving, and improving own learning and performance. EPC\textsuperscript{32} also identified the following primary competencies for engineers:

a. Transform existing systems into conceptual models.
b. Transform conceptual models into determinable models.
c. Use determinable models to obtain system specifications.
d. Select optimum specifications and create physical models.
e. Apply the results from physical models to create real target systems.
f. Critically review real target systems and personal performance.

Curriculum content is no longer the key. The accreditation agencies in many countries had transformed their accreditation criteria and standards in terms of core competencies. National Academy of Engineers (NAE)\textsuperscript{33}, in their vision report for 2020 recommends that engineering schools should vigorously exploit the flexibility inherent in the outcome-based accreditation approach to experiment with novel models for education.

United Kingdom Standards for Professional Engineering Competence (UK-SPEC) from Engineering Council, UK \textsuperscript{34} has prescribed that an Incorporated Engineer must be able to:

a) use a combination of general and specialist engineering knowledge and understanding to apply existing and emerging technology;
b) apply appropriate theoretical and practical methods to design, develop, manufacture, construct, commission, operate and maintain engineering products, processes, systems, and services;
c) provide technical and commercial management;
d) demonstrate effective interpersonal skills; and
e) demonstrate a personal commitment to professional standards, recognizing obligations to society, the profession and the environment.

### 2.1.4 Portugal and Belgium

The number of competencies varies among the norms and definitions of different countries in the world. Portugal for example identified a set of ten skills required at the end of basic education. The common denominator regarding general key competencies comprises Communication, Working with others and Problem solving. Numeracy is considered a general key skill in the UK alone as compared with mathematical competence which is viewed as a subject specific competence with its ‘transversal’ nature seen as important for problem solving, reasoning and communication. ICT is seen as a Key Skill in the UK but is a transversal tool in Portugal.

Portugal and Belgium are alone considering the ability to take charge of one’s own physical well being as a general key competence. ‘Learning to learn’ is again treated differently, while the same is being implicit in problem solving in Scotland.

### 2.1.5 France and Finland

In France, development of the mother tongue, communication skills, mathematical concepts, social and personal skills and the ability to learn are seen as distinctly important. Finland is at the forefront of research into ‘Learning to Learn’ which is often seen as the key competence. For example — ‘this metacompetence underpins all other generic skills that might be brought into a revised set of key generic skills’ — Key Skills are generally developed through specific subjects or subject areas. Whether implicit or
explicit, countries appear to have almost identical sets of compulsory subjects. All systems encourage an active and creative attitude to learning, the development of critical thinking skills, learning by doing and a collaborative effort between learners and teachers.

2.1.6 Malaysia

Zubaidah Awang et al., in their study aimed at determining the non-technical skills namely, functional and adaptive skills required by entry-level engineers in the manufacturing industry. They have categorized the required skills into seven categories i.e. four functional skills categories (communication, creative thinking and problem solving, information management, leadership and organizational skills) and three adaptive skills categories (group effectiveness and teamwork, work-related dispositions and attitudes and personal traits and self-management). A total of 162 manufacturing firms participated in this study.

Questionnaire was the main instrument used while interviews were used to provide an insight into non-technical skills required by entry-level engineers. This study found that non-technical skills are important for entry-level engineers in the manufacturing industry. The authors in their analysis found that the ability to follow procedure was the most important skill followed by the abilities to listen, meet deadlines, manage time (time management) and work to schedule. As for adaptive skills, a majority of the respondents selected the following indicators: responsibility, commitment, self-confidence, discipline, committed to the job and willingness to learn as the most valued traits. The findings of this study can be used as a basis for developing a guideline for non-technical skills to be included in the engineering curriculum. It is recommended that the current engineering curriculum at institutions of higher learning enhance both functional and adaptive non-technical skills. In addition, university-industry collaboration should be enhanced to address the
skills gap of engineering graduates and the skills requirements of the manufacturing industry.

2.1.7 Singapore

The Institution of Engineers, Singapore\(^{36}\) (IES) in their report released in 2004, defined the following competencies as part of its accreditation criteria of engineering programs:

a) apply knowledge of mathematics, science and engineering;

b) design and conduct experiments, analyze, interpret data and synthesize valid conclusions;

c) design a system, component, or process, and synthesize solutions to achieve desired needs;

d) identify, formulate, research through relevant literature review, and solve engineering problems reaching substantiated conclusions;

e) use the techniques, skills, and modern engineering tools necessary for engineering practice with appropriate considerations for public health and safety, cultural, societal, and environmental constraints;

f) communicate effectively;

g) recognize the need for, and have the ability to engage in life-long learning;
h) understand the impact of engineering solutions in a societal context and to be able to respond effectively to the needs for sustainable development;

i) function effectively within multi-disciplinary teams and understand the fundamental precepts of effective project management; and

j) understand professional, ethical and moral responsibility.

2.1.8 Australia

Australia leads over the other nations in the direction of identifying, defining employability skills of graduates in general and engineering graduates in particular. The Australian Government has been showing keen interest in the development of employability skills of engineering graduates resulting in a number of documents. The general pressures for change in higher education relating to skills development have been identified in Australian government reports such as “Achieving Quality by Higher Education Council” 37 (HEC), “Developing Lifelong Learners Through Undergraduate Education, Commissioned Report No 28” by Candy et al.38, “Enterprising Nation”, “Renewing Australia’s Managers to Meet the Challenges of the Asia-Pacific Century, Research Report, Volume 1”, “Industry Taskforce on Leadership and Management Skills” by Karpin39, and “Crossroads: Our universities backing Australia’s future” by Nelson40.

All the reports related to skills gap of Engineering graduates, published from various nations identified the skills set, defined each of the set in standard terms. A common theme found and expressed in almost all the reports stress the need for a continuous learning process denoted by a clause namely, ‘lifelong learning and generic skills acquisition by students for economic, cultural and social development’.
The premise is that generic skills, attributes and values will be introduced through curricula. These skills include qualities such as ‘critical thinking, intellectual curiosity, problem-solving, logical and independent thought, effective communication and related skills in identifying, accessing and managing information; personal attributes such as intellectual rigour, creativity and imagination; and values such as ethical practice, integrity and tolerance’. All these reports are reviewed periodically and updated.

The Engineers Australia Accreditation Board⁴¹ (2005) identified similar generic attributes that are as follows:

a) ability to apply knowledge of basic science and engineering fundamentals;

b) ability to communicate effectively, not only with engineers but also with the community at large;

c) in depth technical competence in at least one engineering discipline;

d) ability to undertake problem identification, formulation and solution;

e) ability to utilize a systems approach to design and operational performance;

f) ability to function effectively as an individual and in multi-disciplinary and multi-cultural teams, with the capacity to be a leader or manager as well as an effective team member;

g) understanding of social, cultural, global and environmental responsibilities of the professional engineers and the need of sustainable development;
h) understanding of the principles of sustainable design and development;

i) understanding of professional and ethical responsibilities and commitment to them; and

j) expectation of the need to undertake life long learning, and capacity to do so.

Universities in Australia have nearly ten years of experience working with the concept of graduate attributes as reported in a report by Department of Education, Training and Youth Affairs (DETYA) 42. It contained a framework of generic attributes that ideally every graduate should have. Graduate attributes are defined by the Australian Technology Network 43 (ATN, 2000) as “the qualities, skills and understandings a university community expects its students to develop during their time at the institution and, consequently, shape the contribution they are able to make to their profession and as a citizen”. Since 1998 there has been much work done by universities to define these attributes and to integrate them in a variety of ways. An analysis of graduate attributes from a significant number of universities shows that employability skills, as outlined in the Employability Skills Framework, may reasonably be seen as a subset of graduate attributes. Therefore graduate attributes provide an appropriate starting point from which to further explore any future work on employability skills.

As a case study, the employers’ survey results on engineering graduates of Monash University are presented in two separate reports entitled, ‘Still Learning’ and ‘Flying high’, the former in 2002 and the latter in 2008. The 2002 report observed that “the university’s monitoring mechanisms lack systematic feedback from employers about their perceptions of Monash graduates. The 2008 report expressed. “... an
Employer Survey, if undertaken periodically, should yield valuable institutional information about graduate attributes and their relevance to employers’ needs. Monash University report brought the significance of employers survey based findings for any reform in curriculum of the engineering education.

While defining the skills needed in the workplace is important, determining the competence level of graduates to perform the skills is also relevant. In The Bases of Competence (1998), Evers et al. (1998) defined 18 competencies in which graduates needed to be proficient in order to succeed in the workplace. The authors initially assumed that technical skills were most lacking and focused their intent on defining the ways to promote and advance graduates’ technical skills and abilities. However, the participating employers concluded that recent graduates (those with less than five years of working experience) were ill-prepared in developing their “generic skills” (non-technical skills) and that these skills needed to be improved upon.

The authors developed a questionnaire to assess graduate’s perceptions of the attainment of the skills. In addition, a questionnaire was developed for the managers to assess the attainment of the skills of the graduates. In all, 442 graduates and 213 managers in twenty-seven corporations participated in the study. The average scores from both graduates and managers ranged from 3 – “uncertain” to 4 – “somewhat adequate” on a five-point scale. This assessment revealed the need to further refine and develop the “generic skills” of college graduates. Seeing the need to further understand the employability skills graduates should possess, the authors expanded their study in Phase II.

To reduce the set of 18 skills (competencies) into digestible terms, factor analysis was performed. Four “bases of competence” (constructs) were identified. The four bases of competence were: Mobilizing Innovation and...
The 18 skills identified were indicators of these bases. As a result of the interviews and discussions and a thorough review of the literature, competencies were identified. They are as follows:

1. Administrative skills (Problem-solving/analytic)
2. Quantitative and mathematical skills (Decision-making)
3. Decision-making skills (Planning and organizing)
4. Ability to organize and plan (Personal organization/time management)
5. Ability to be creative and innovative (Risk-taking skills)
6. Oral communication skills (Oral communication)
7. Ability to adapt and be flexible (Written communication)
8. Leadership skills
9. Written communication skills (Interpersonal skills)
10. Ability to initiate (be a self-starter) Managing conflict
11. Technical skills (Leadership/influence)
12. Problem-solving skills (Coordinating)
13. Ability to work independently Creativity/innovation/change
14. Visioning
15. Ability to conceptualize
16. Learning skills
17. Personal strengths
18. Technical skills

The skills inventory added a few items individually which otherwise would have gone under broader concepts of Emotional Intelligence.

2.1.8.1 Handbook on Graduate Employability Skills

A handbook on the ‘Graduate Employability Skills’ was prepared by the Precision Consultancy in Australia and was released in August 2007. This
project was initiated by the Business, Industry and Higher Education Collaboration Council (BIHECC) to review:

a) how universities currently develop and integrate employability skills into their programs of study;
b) how universities teach employability skills;
c) how universities currently assess students’ employability skills; and
d) how graduate employability skills might be assessed and reported upon.

The project, undertaken between March and June 2007, consulted a range of stakeholders including representatives from universities, business and industry to review current activities and to identify best practice for integrating, developing, assessing and reporting on employability skills nationally and internationally. Consultations with these stakeholders focused on graduates from degree programs across all disciplines of undergraduate higher education. The methodological approach was essentially qualitative. It began with desktop research and interviews, which led to the development of a discussion paper. The discussion paper was circulated and further interviews held based on the paper. Written responses to the paper were also sought and received. While no quantitative data has been generated through this research, data available from a range of reports and articles were reviewed and used to scope and support the direction of the research. The thematic analysis of data from all these sources was drawn together in this report.

Throughout this report, examples and case studies have been provided about institutional approaches and developing employability skills. These were presented to the researchers as examples of good practice. In many cases these approaches were initiated or supported by industry, by professional associations and by groups of employers. The research demonstrated many individual beliefs about what approaches are most effective in developing employability skills. Besides this report, the
Department of Education, Science and Training (DEST) prepared a number of reports on the employability skills in 2002, 2004, 2005, and 2006. Australia has been undertaking a number of studies periodically updating the knowledge and awareness on the concept of employability skills in general and graduate engineers in particular.

2.1.9 Japan

The Japan Accreditation Board for Engineering Education (JABEE) in its report of 2004 emphasized the following competency set:

a) the ability and intellectual foundation for considering issues from a global and multilateral viewpoint;

b) understanding of the effects and impact of technology on society and nature, and of engineers’ social responsibilities (engineering ethics);

c) knowledge of mathematics, natural sciences and information technology, and the ability to apply such knowledge;

d) specialized engineering knowledge in each applicable field, and the ability to apply such knowledge to provide solutions to actual problems;

e) design abilities to organize comprehensive solutions to societal needs by exploiting various disciplines of science, engineering and information;

f) Japanese-language communications skills including methodical writing, verbal presentation and debate abilities, as well as basic skills for international communications;
g) the ability to carry on learning on an independent and sustainable basis; and
h) the ability to implement and organize works systematically under given constraints.

There is a marked difference in the prescriptions of Japan regarding the communication skills. While all the nations are generic in their recommendations regarding communication skills, among the countries reviewed here, Japan alone is found to be Japanese language specific and has fixed this skill with the phrase ‘Japanese language communication skills’.

2.1.10 Switzerland: European Universities in Collaboration with US

Successful Practices in International Engineering Education (SPINE) is a benchmark study of Council of the Swiss Federal Institutes of Technology, Zurich, focusing on the analysis of successful practices in engineering education in ten leading European and U.S. universities including MIT, CMU, and ETH Zurich. In the SPINE project, 543 professors of these universities, 1372 engineers and 145 managers of European and US companies were questioned. The study attempted to measure the perceived importance and assessment of fifty-one parameters on quality of education, teaching methods, engineering competencies, general professional skills, and aspects of reputation of institute through a quantitative analysis. In their final report, Bodmer, et al., recorded the following observations about respondents’ perception of various engineering and general professional competencies:

The highest rated engineering competencies, both by professors and engineers were analysis/methodological skills, basic engineering proficiency, and problem solving skills.
Engineers and Professors also agreed on the lowest rated competencies which included development know-how and practical engineering experience. Engineers rated specialized engineering proficiency and research know-how as lesser important engineering competencies. Very important general professional competencies include communication skills, English language skills, teamwork abilities, presentation skills, and leadership skills.

Medium importance was assigned to general professional competencies of social skills, ability to maintain and develop a broad general education, and management of business processes and administration. General professional competencies of marketing, finance, and other language skills were rated as lesser important. All three groups regarded law as least important general professional competency.

2.2 International Professional Societies

International professional societies, comprising of multinational experts, had an edge over the other national bodies in their recommendations by adding one more facet namely, the curriculum guidelines for engineering education. A few noteworthy examples are provided hereunder.

2.2.1 Joint Task Force of the IEEE Computer Society and the ACM

The Joint Task Force on computing curricula of the IEEE Computer Society and the ACM has published several reports related to computing curricula. These reports make clear recommendations on this issue with reference to specific undergraduate programs in computer science, software engineering, computer engineering, and information technology. The final draft on computing curricula, 2001, suggested the following broad level characteristics of computer science graduates
a. System-level perspective
b. Appreciation of the interplay between theory and practice
c. Familiarity with common themes
d. Significant project experience, and
e. Adaptability

This report also suggested the following general skills for computer science graduates:

a. Communication
b. Teamwork
c. Numeracy
d. Self-management, and
e. Professional development

Apart from the above, the Joint Task Force of the IEEE Computer Society and the ACM in 2004\textsuperscript{55}, made specific recommendations in their final report ‘Curriculum Guidelines for undergraduate degree programs for software engineering, computer engineering graduates’ also.

In 2004, ACM, Association for Information Systems (AIS), and Association of Information Technology Professionals (AITP) published a joint report on ‘Model curriculum and guidelines for undergraduate degree programs in information systems’ and characterized this discipline as ‘Technology-enabled Business Development.’ As Gorgone, et al.,\textsuperscript{56} observed, they divided the representative capabilities and knowledge expected for Information System graduates into the following categories:

a. Analytical and critical thinking: organizational problem solving, ethics and professionalism and creativity
b. Business fundamentals
c. Interpersonal, communication and team skills, and
d. Technology

2.3 National Standards on Engineering Curriculum

As the problem of the gap between the industry needs and the skills of the engineering graduates, recommendations of various accreditation agencies in US, UK, Singapore, Australia, and Japan have already affected educational programs not only in their respective countries, but also in other countries. Many universities redefined their program objectives, delivery mechanism, and assessment systems to incorporate graduate attributes in teaching programs as reported in separate publications of Bell\textsuperscript{57}; Felder and Brent\textsuperscript{58}. Macro level reforms were being realized through micro level redesigning of every course with a focus on fostering specific competencies as found in an article by Bullen et al.,\textsuperscript{59}. Curriculum design fixed emphasis on design, practice, collaborative learning, humanities, social sciences and sustainable engineering as reported by Turner, Li, & Martinez\textsuperscript{60}.

Faculty development programs were organized to help them understand the underlying pedagogical issues, as Bigio and Schmidt,\textsuperscript{61} reported. Learning theories and epistemological frameworks are being used to shift the focus of teaching, learning, and assessment processes on competency development, as found reported in separate publications by Campbell, et al.,\textsuperscript{62}; Senini & Nouwens\textsuperscript{63}.

To sum up, the Core Skills identified in various nations are similar to the Key Skills developed in England, but slightly narrower on the surface. In the wider European context, only Scotland and England have introduced explicit key competencies alone into the general curriculum. However, a 2002 survey found that all EU countries included either explicit or implicit reference to the development of competencies.
The evidence in the published literature demonstrates that employers continue to face recruitment difficulties. One-fifth of reported vacancies could not be filled due to lack of applicants with the necessary skills contributing to an overall employability percentage ranging between 20 and 30 approximately. However, employers may not place an emphasis on developing the skills they need ‘in-house’. They need skilled, ‘ready to employ’ entrants. Confirming this fact, Jenkins and Wolf express that, “Qualifications do not appear to be important for a large number of employers and jobs, consistently ranking beneath characteristics and soft skills in recruitment frameworks”.

Overall, the evidence suggests that a focus on qualifications alone may not contribute to an individual’s employment outcomes, due to low emphasis on these in recruitment. Developing soft and generic skills, on the other hand, is likely to be more important. The common denominator regarding general key competencies comprises of Communication, Working with others and Problem solving. Numeracy is considered a general key skill in the UK alone as compared with mathematical competence which is viewed as a subject specific competence with its ‘transversal’ nature seen as important for problem solving, reasoning and communication. ICT is seen as a Key Skill in the UK but is a transversal tool in Portugal. Portugal and Belgium are alone in considering the ability to take charge of one’s own physical wellbeing as a general key competence. ‘Learning to learn’ is again treated differently, being implicit in problem solving in Scotland.

Most of the reports did not see the light of implementations beyond their recommendations. They are subjected to a few criticisms. Clanchy and Ballard pointed out that problems existed in implementation because definitions of what constitutes generic skills, attributes and values are neglected. They contend the ‘fogginess’ of definitions in the HEC report can affect successful reviews or audits of quality in undergraduate university education. To overcome this problem necessary definitional work needs to be
carried out first before a university can undertake assessment of skills. Further they stated that there was very little evidence of definitional work. Such initiatives from the government side paved the way to studies by Engineering bodies and universities in Australia.

Australian employers are clear in their view that a highly skilled workforce is a key competitive requirement both nationally and internationally. Australia leads many developed countries and many of their reports on industry needs of engineering skills are cited in many of the documents and reports in USA and UK. Reports and Standards from world nations confirm the existence of skills gap periodically while they are yet to arrive at the *modus operandi* of introducing and training the graduates. Thus, available literature justifies the choice of the problem while guiding the research investigation in the various aspects of the methodology.

### 2.4 Review of Indian Studies

Under the caption “9 Indians adorn”, Times of India, an English daily enlisted top 100 investors under 35 in the world and among them nine were Indians. Vikram Sheel Kumar, one among those nine, expressed that the biggest challenge that Indian students today face is finding the space to develop an independent mind. However, another inventor of Indian origin in the same list, Chaitali Sengupta expressed that engineering education in India was at the same level as the best in the world. But, some of the senior industry managers in some industrial sectors felt concerned about lack of positive attitude, behavioral aspects, ability to cope up with challenges, sincerity, integrity, ethics, self-analysis, discipline, and independent thinking amongst fresh engineering graduates, as expressed by Arya. It is very ironic that while ‘availability of highly skilled manpower’ has been identified as the most important factor that is driving the increasing momentum of R&D offshoring/outsourcing industry in India, ‘quality of higher education’ has been
identified as one of the main inhibitors as found stated in Value Notes, 2004\textsuperscript{68}. This paradox needs some deeper analysis as experts believe. Every country has committees working on the norms of employability skills of graduates. In India, this assignment comes under NASSCOM which functions in accordance with the Human Resource Development Ministry. NASSCOM has been taking initiatives in this direction besides a number of research analysis and situation audit, though with much less initiatives towards solutions.

\subsection*{2.4.1 NASSCOM-KPMG Study}

A study report from National Association of Software and Services Companies - Klynveld Peat Main Goerdeler (NASSCOM-KPMG), argue that key skills required by the industry are not met by the current educational system. It quotes the following observations from a World Bank Study on Science and Technology Manpower in India published in 2001:

a) Faculty lacks industry rigor, R&D background and exposure to tools.

b) Students lack opportunity and encouragement for creative thinking.

c) Inflexible and rigid curriculum is not exposed to innovation/industry.

d) Teaching is exam oriented without focus on communication and problem solving skills.

e) Continuous evaluation is often not systematized.

f) Examinations are often memory based and encourage partial studying through ample choice.

NASSCOM-KPMG (2003, p. 36) and the Government of India Task Force\textsuperscript{69} (Task Force on Meeting the Human Resource Challenge for IT and IT enabled Services) identify written English, logical reasoning, problem solving and numerical ability, programming skills, listening/empathy, assertiveness and confidence, integrity, values and discipline, sociability, dependability, and reliability as necessary skills for IT professionals. These reports identify spoken English, foreign language, accent understanding,
comprehension/creativity, initiative/enthusiasm, team working, multitasking and time management, and motivation/drive as desirable skills.

2.4.2 A Study from All India Council for Technical Education (AICTE)

R. Natarajan, of AICTE undertook a Strength, Weakness, Opportunities, Threat (SWOT) analysis that provides a glimpse into the national technology education system. The role of the All India Council for Technical Education (AICTE) has been highlighted. The National Mission for Technical Education has provided the strategic directions for the future. A SWOT analysis of an Engineering Professional, a comparison of the XX and XXI century Engineers, and the distinctive characteristics of XXI century Learners and Teachers illustrate the challenges ahead. The globalisation and internationalisation perspectives and the cultural impact of globalisation have also been discussed. The National Quality and Accreditation initiatives have been described, and the challenge of the Digital Divide has been highlighted. The importance of Partnership and Collaboration, in general, and of nurturing Alumni-Alma Mater Relationship are found stressed.

2.4.3 Global Status and India

India is gradually emerging as a hub of the knowledge industry and aims to make strides through larger contributions. Studies reveal that the Indian IT industry’s success is not matched by its engineering education. India has not yet developed as a preferred engineering education destination for international students even for IT related disciplines. India is also trying to get provisional membership of Washington Accord signatories’ consortium, which recognizes the substantial equivalency of accreditation systems of organizations holding signatory status, and the engineering education programs accredited by them. A comparison of the global perspective with resource-based accreditation process being followed by NBA reveals the urgency of a debate on defining essential competencies that Indian
engineering education must develop. Systematic identification of core engineering and general professional competencies and a focus on developing these amongst Indian students will help in achieving these objectives.

The low quality of higher education is a matter of great concern, especially as India hosts approximately 400 universities with more than 1,300 engineering colleges producing nearly half a million engineering graduates every year. In terms of student's enrolment, four of its universities are amongst the world's ten largest universities. In spite of an impressively large university and engineering education system in India, Indian Institute of Science and Indian Institute of Technology, Kharagpur are only to be found in the ranked list of the world's top 300 universities compiled by Shanghai Jiao Tong University for 2009. This ranking is based on several indicators of academic or research performance and gives “40% points to research output, 40% points to quality of faculty measured on the basis of Nobel prizes, Field medals, and highly cited researchers, 10% points to Quality of Education measured on the basis of Nobel Prizes and Fields Medals won by alumni, and 10% points to size of university. Only three Indian universities are able to find a position in this list of the world’s top 500 universities. Interestingly, Indian Institute of Sciences (IISc.), the top Indian university as per this list does not offer undergraduate programs.”

Accreditation agencies in USA, UK, Australia, Japan, and Singapore have transformed their accreditation process from the traditional resource-based approach to outcome-based approach. Competencies such as ability to apply knowledge, design skills, problem solving skills, technical competence, ability to work in multidisciplinary teams, communication skills, sensitivity towards global, societal, and environmental issues, and sensitivity towards ethical and professional issues, and readiness for lifelong learning have been identified as necessary. These accreditation agencies, IEEE, ACM,
NAE, and other professional agencies have further identified a large number of other competencies such as systems level perspective, analytical skills, critical and creative thinking, as essential.

2.5 Scaling Graduate Engineers’ Skill: DAT Battery

There exist psychological tests to measure virtually every aspect of human behaviour, the most popular of which are those that measure cognitive abilities and personality. Psychological tests can be used to form hypotheses about the way people behave and function and to forecast how they will behave in the future. For this reason, psychological tests are generally considered to be useful personnel selection tools. They are particularly useful when there are many applicants for a position, and for assessing inexperienced people, because they provide standard measures (in terms of their uniform administration and scoring) against which to evaluate applicants. For selection purposes, it is common to use more than one test in the form of a battery. Test batteries provide more information about an individual’s behaviour and increase the chances of making valid selection decisions as expressed in the papers of Anastasi\textsuperscript{73}; Raven\textsuperscript{74}.

DAT [battery] stands for Differential Aptitude Tests which belong to the category of psychological tests. It is ‘a device for obtaining a sample of an individual’s behaviour’. Allen & Yen\textsuperscript{75}, Cronbach\textsuperscript{76} add to this definition by noting that tests are systematic procedures which describe human behaviour using numerical scales or prescribed categories.

The Differential Aptitude Tests (DAT) consist of ability tests designed for determining educational placement and vocational counseling in schools. Hailed as one of the most comprehensive multiple ability batteries, Forms A and B of the DAT were originally developed in 1947 to measure the aptitudes of students from Grade 8 through to Grade 12 for the purpose of vocational
guidance. It was found that rather than measuring school learning, the tests were designed to measure intellectual abilities independent of the content of school subjects.

2.5.1 DAT Battery Application: Indian Study

PurpleLeap, an Indian research organization undertook a study entitled, ‘Low Employability Skills among Engineering Students’ and released the results over the net in February 2009. The startling revelation from study conducted by PurpleLeap on the ‘Employability Skill index’ of Engineering students found most students ‘un-employable’. The study conducted across the country covered 95 colleges (15 colleges in Andhra Pradesh) and among 9000 students (600 in AP), 36 per cent of the sample totally failed on all major skill counts namely, communication, problem solving and technical skills. Only 7 per cent was found employable when all factors were considered. In a major surprise, more than 80 per cent of the students did not meet the requirements on the problem solving skills. Despite the popular myth that engineering students are naturally good at problem solving, it was found that the biggest skill gap in engineering students were from Andhra Pradesh in the area of problem solving. The study revealed that the average score of students was less than 25 per cent against national average of 35 per cent. There are more than 50 per cent of the students who scored less than 25 per cent in problem solving, making them fall in the ‘hard-to-train’ segment. Lack of adequate problem solving skills is one of the biggest gaps leading to students not getting enough technical jobs in the industry and in many cases having to settle for ‘non-technical’ roles, after an engineering education. It was found that just by raising Problem Solving Skills, it might be possible to raise the employable pool more than double of the existing strength i.e., from 7 to 16 per cent.
More than 60 per cent of the students did not meet the employability criteria on technical skills for the IT industry. The study also revealed that 11 per cent of the students were found employable when organizations did not include technical skills as a criterion. Even the (30+ %) students who did meet the Technical Skills criteria were still not ‘ready-to-deploy’ as far as employers were concerned. After recruiting these students also, most organizations usually had to spend 3 to 4 months on technical training to make these students workplace ready.

The latest in the series of the national survey in India is that of FICCI-CVOTER 2010 Survey\textsuperscript{78} of Decision Makers of India Inc. The investigation team included CEOs, MDs, Human Resource Directors and others. It was a national sample survey. The study covered the undergraduates in general including those from engineering disciplines. The study results confirmed the lack of employability skills, emphasized that the entry level graduates should also be able to work well with others, know how to lead a team, prepare a quick power point presentation and in general a good communication skill besides non-technical skills expected of, by the industry.

2.6 Summary

Literature, in the form of books and journal articles, Conference proceedings, National standards and reports, and many online resources are available in abundance on the concept of the industry needs and engineering graduates’ generic and non-technical skills gap. Almost all the publications speak in a global tone of the skills gap of entry level engineers. Many developed and developing countries have appointed councils and committees to go into the problem and as a first step have enumerated list of skills and standard definitions for each of the skills in the set. Periodical publications from nations mark the development and interest of the nations world over.
Though India has appointed Commissions and Working Groups, it has not come out with standards for skills and their definitions. Among the many working groups of the Knowledge Commission, the one on the Technical Skills took up the polytechnic level education only. A recent publication from the Working Group on Engineering Education of the Knowledge Commission speaks on the Engineering Graduates’ skills. The document is found to be descriptive and more of narrative in nature. A document equaling the standards of publications from nations like Australia, USA, UK, New Zealand and many others is yet to come out from India, though India plays a vital role in the global knowledge industry, having a huge engineering workforce potential.
2.7 Notes and References


