This chapter consists of the following sections:

- Prologue
- Engineering Education
- Engineering Education and IT Industry – What is the Relationship?
- Learning Style of Engineering Students
- Teaching Methodology for Engineering Education
- Approaches to Learning
- Formal and Informal Learning
- Androgogy and Pedagogy
- Concepts Closer to Learnability
- Psychometrics
- Summary
CHAPTER 2 – LITERATURE SURVEY

2.1 Prologue

An elaborate secondary research was conducted to understand the research topic in depth. Some details about the same follow. The source for the survey of literature was the internet, journals, periodicals, books and magazines. Since there is a plethora of literature, we have confined our focus to the current literature that has a direct bearing on our research investigation. At a macro level, the literature survey was broken down into the below nine parts.

1. Engineering Education
2. Engineering Education and IT Industry – What is the relationship?
3. Learning style of engineering students
4. Teaching methodology for Engineering education
5. Approaches to Learning
6. Formal and informal learning
7. Androgogy and pedagogy
8. Concepts closer to learnability
9. Psychometrics

Discussion on each of the above elements is dealt with in detail in the following pages.
2.2 Engineering Education

If a man empties his purse into his head, no man can take it away from him. An investment in knowledge always pays the best interest – Benjamin Franklin

Change is constant, but, on an absolute basis, the world has changed more in the past 100 years than in all the preceding years. The impact of this change in the engineering arena has been tremendous. By the end of the twentieth century, the developed world has had “engineering” forge an irreversible imprint on the lives and our identity of every human being.

2.2.1 Engineering Education – the Global Scenario

The NAE attempts to prepare for the future of engineering by asking the question, “What will or should engineering education be like today, or in the near future, to prepare the next generation of students for effective engagement in the engineering profession in 2020?”. The report on Educating the Engineer of 2020 (NAE, 2005a, p. 59) suggests that “the engineering education establishment should endorse research in engineering education as a valued and rewarded activity for engineering as a means to enhance and personalize the connection to undergraduate students, to understand how they learn, and to appreciate the pedagogical approaches that excite them.”

NAE (2005b) has identified the following attributes for engineers of 2020:

1. Strong analytical skills
2. Practical ingenuity - skill in planning, combining, and adapting
3. Creativity (invention, innovation, thinking outside the box, art)
4. Communication
5. Business and management
6. Leadership
7. High ethical standards and professionalism
8. Dynamism, agility, resilience, and flexibility
9. Lifelong learners

Successful Practices in International Engineering Education (SPINE) is a benchmark study 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 the final report (Bodmer, Leu, Mira, & Rütter, 2002), the following observations have been made about respondents’ perception of various engineering and general professional competencies:

1. 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 agree on the lowest rated competencies: development know-how and practical engineering experience.
2. Engineers rated specialized engineering proficiency and research know-how as lesser important engineering competencies.
3. Very important general professional competencies include communication skills, English language skills, teamwork abilities, presentation skills and leadership skills.

4. 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.

5. General professional competencies of marketing, finance, and other language skills were rated as lesser important.

6. All three groups regarded law as least important general professional competency.

Inline with the need for competency focused education, the engineering curriculum in many countries is being continuously redefined. 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 have redefined their program objectives, delivery mechanism, and assessment systems to incorporate graduate attributes in teaching programs (Felder.R.M & Brent.R, 2003).

In summary, the curriculum content as an accreditation criteria is being replaced by core competencies expected from a graduating engineer – this has resulted in engineering education being more “outcome focused” than being “input focused”. Thus a major shift has taken place from input-based criteria to outcome-based approach.
2.2.2 Engineering Education in India

While there has been a significant change in the engineering academic landscape, what is India doing? Let us try to answer that question.

India launched a massive program for planned development soon after becoming independent. Apart from shortage of material resources, the country faced acute shortage of technicians and graduate engineers. Thus, there was a rapid boom in engineering education. Furthermore, Engineering and technology education has a direct impact on the industrial growth, infrastructure development and socio-economic advancement of a country. Thus, Engineering became a preferred career choice for a large number of students at the 10 + 2 level in India.

Admissions are based either on competitive exams at National/State levels or on the merit of the marks of 12th standard. Many of the reputed engineering colleges (IITs and NITs) are highly selective in their admission process. The intake capacity is very less in these institutes in order to improve the quality of education. Each of the streams in IITs in the first year course has a capacity intake of a maximum of 25-30 students. Less number of students in a classroom enhances the student - teacher interaction and also helps in qualitative education. The engineering branches are allotted according to merit and choice. Earlier there was a craze for electrical, mechanical and civil engineering but the present trend shows that students prefer to study computer science, followed by electronics and communication.
Education policy is formulated by a number of bodies under the Central Advisory Board of Education (CABE). In engineering and other technical disciplines, the central policymaking and regulatory body is the AICTE. The AICTE determines the requirements for new universities and programs of study, and outlines curriculum standards and norms. It also accredits programs through the NBA.

In 1945 the Sarkar Committee (SC) was appointed to suggest options for advanced technical education in India. The Sarkar committee recommended the establishment of higher technical institutes based on the Massachusetts Institute of Technology (MIT), in India. This resulted in the setting up of the Indian Institutes of Technology (IIT). The IITs are widely considered to offer the highest-quality technology and engineering programs in India, especially at the undergraduate level (Banerjee. R. et al, 2007).

Before 1947 engineering education in India trained students for basic and traditional industries of the time and for such government run organizations as those dealing with irrigation and power, public works, railways and roads. Engineering education was know-how oriented. It dealt a great deal with procedures and practices. The curriculum was by and large static but it fulfilled the objectives of imparting core knowledge.

A present study on Indian engineering and technical education reveals that the leading institutions have adopted standard competitive research and object-oriented engineering study programs. Its benefits to the students can be summarized as: gaining confidence in decision making, relating theory with practice, increased job opportunities, realization of responsibility, opportunities to know one’s weaknesses and strengths, and opportunities
to work with modern equipment and on problems of current importance

2.2.3 Quality of Engineering Education in India

While studies indicate that there have been some changes in the engineering education scenario, questions of interest are has this resulted in the graduating engineers contributing to the growth of the Indian economy? Have the graduating engineers enhanced the knowledge base in the society? A direct indication of the growth in engineering education is the number and quality of graduates and post-graduates. A proxy for quality would be the employability, salary and feedback from industry and society. So we need to focus on the standards of input and output of engineering education. Figure 2-1 gives a clear picture of the factors determining the engineering education.

![Schematic of inputs and outputs for engineering education](source: Draft Final Report, Banerjee, R., & Muley V.P. 2007)
According to Engineering Professors Council (EPC, 2002), the ability to exercise key skills is expected of all engineering graduates and these should be encouraged and developed during the degree course. These key skills comprises communication abilities, general IT user abilities, application of number, working with others, problem solving and improving own learning and performance. In addition, graduates should also demonstrate attributes of drive, motivation and innovation (Natarajan, R, 2002).

Establishing a set of employability skills is deemed necessary in a climate of economic challenges and globalization. Hence, quality of engineering education needs to bestow employability skills in the future engineers. Employability Skills for the Future are defined as: the skills required to gain employment or establish an enterprise, but also to progress within an enterprise or expand employment capability, so as to achieve one’s potential and contribute successfully to enterprise strategic directions.

Despite a projected labor crunch in certain sectors, the rate of unemployment among first-level engineering graduates is significant. When compared to annual economic growth of 6 percent to 8 percent, the Rao committee report argues that an annual graduation growth rate of 15 percent to 25 percent among engineering students is unsustainable. High levels of unemployment are not, however, entirely the result of oversupply. The committee points out that there needs to be greater interaction between industry and the education system so that institutions of higher education can better understand the manpower needs of the marketplace and tailor their academic programs accordingly (Viswanadhan, K.G, 2006).
An exploratory study has shown (Goel, S., 2004; Goel, S. & Sharda, N., 2004) that the kind of activities that a typical engineering student in India is generally engaged in, does not help in enhancing creativity, critical thinking, and innovative problem solving. Further, there are many technical universities that have affiliated a very large number of AICTE approved engineering colleges. Some of these universities have affiliated more than hundred engineering colleges. All of these colleges under a single university follow a common syllabus and curriculum and have a common examination organized by the university. In an attempt to bring objectivity and impartiality, the assessment system is mostly dependent upon final written exams (up to 80% in theory subjects). This even defies the NBA’s stated emphasis on continuous evaluation procedure. Every semester, thousands of engineering students of a university undertake a stereotype common final semester examination. Semester after semester, students are repeatedly tested at the lower cognitive levels of knowledge, comprehension, and application as per Bloom’s taxonomy.

In summary, quality is non negotiable and an ever changing process. AICTE needs to focus on ensuring that the quality of graduating engineers in India is on par with global standards.

### 2.2.4 Learning Outcome of Engineering Education

Most of the accreditation boards for engineering programs around the world follow an outcome based assessment process wherein the main criteria is the program educational objectives and the achievement of the program outcomes. Irrespective of the level of generality, outcome statements describe the skills, knowledge and values that students
should be able to demonstrate at the end of a planned teaching-learning process (Bjorklund.S.A et al., 2007).

Learning outcome helps to (Maringer-Cantu. J, 2008.):

- Focus on the student's behavior that is to be changed
- Serve as guidelines for content, instruction, and evaluation
- Identify specifically what should be learned
- Convey to learners exactly what is to be accomplished
- Learning outcomes should flow from a needs assessment.
- The needs assessment should determine the gap between an existing condition and a desired condition.
- Learning outcomes represent the solution to the identified need or issue.

Learning outcome can be categorized as Technical or Social. Technical learning outcomes are those learning outcomes that fit within the traditional concept of “hard” skills. They denote the ability to conceptually understand and apply the solid mathematical and scientific tools of analysis, experimentation and design on which the practice of engineering is built. The Social learning outcomes category neither means “hard to characterize” nor “non-essential but a good idea anyway.” These outcomes reflect the very real need for engineers to have “soft” people skills in addition to the traditional “hard” cognitive/technical skills (Cupp. S et al., 2005).

The Engineer of 2020 report begins by asserting that “technology is the outcome of engineering.” It then explains that engineering “has been a key force in the improvement of our economic well-being, health, and quality of life” precisely “through its role in the
creation and implementation of technology.” Emerging technologies are the main subject matter of future engineering. And, engineers need to respond to calls from society as technical problem solvers.

Early engineering education literature covered a wide variety of subjects, but usually lacked scholarly rigor; many papers dealt with “classroom tips and tricks” and the data analysis - limited to “The students liked it, and so did I.” More recently, standards of scholarship have increased. Papers include careful literature reviews, draw on learning theories from cognitive science, and base conclusions on careful statistical analysis of adequate data – a sounder basis for deciding “what works” (Prados, J.W.). Thus, the shift from an education mainly focusing on the inputs, teacher centered and content based gave way to output, student-centered and competence based learning.

To implement this kind of a system, the academia should provide a conducive environment to the faculty. The stakeholders in engineering education should know what set of teaching and learning practices by faculty and students will lead to desired student learning outcomes.

2.3 Engineering Education and the IT Industry – What is the Relationship?

* When you hire people that are smarter than you are, you prove you are smarter than they are - R.H. Grant *

On an average about one third of fresh Indian engineering graduates seek employment in the IT industry irrespective of their specialization. However, the success of the Indian IT industry has not yet been leveraged for developing India as a preferred destination for
engineering education. In the last ten years, there has been an enhanced appreciation for the transformation of engineering education across the globe. Many accreditation agencies have even transformed their accreditation criteria in the last few years from a resource-based approach to an outcome-based approach. But this does not seem to have made any difference to the Indian scenario.

Jalote P, 2001, summarizes its growth as follows: “It started primarily as a subcontractor for technical manpower. Later it gradually shifted to doing complete parts or phases of projects, usually the later phases of coding and testing. From this, it matured to providing complete solutions offshore. Today most leading companies are operating in the high-end software services business. ... a large number of software companies matured to CMM level 4 or level 5...”

His observation on the human resources related factor to the growth and maturity of IT industry in India follows:

“Due to the opportunities the software industry offers (a higher financial remuneration, overseas travel opportunities, respect in the society, etc.) best of the people started going to software (e.g. in the Indian Institutes of Technologies, the highest rankers in the entrance test choose to go to computer science....this manpower is ambitious and wants improvement in the way the organization works.”

“Average age of the engineers is in 20s and that of managers is late 20s to early 30s in the Indian software industry. The high growth rate ensures that people move up faster, keeping the average age of engineers and project managers low. This helps in various
ways, one of them being that engineers and project managers are quite receptive to change, youth allows for hard work, positive approach to life, etc…”

In spite of the huge number of engineering seats, estimates suggest that the current manpower resources will not be sufficient to meet the aggressive growth targets. By 2009, based on current human resource supply trends (NASSCOM-KPMG, 2003), it is estimated that there will be a shortfall of over 0.5 million personnel for the IT and ITeS sector. IT companies have hence expedited the rookie’s recruitment process. However, reforms in engineering education are not keeping up to this pace. Felder R.M, 1982, remarked, “We teach primarily mechanics, and not reasoning methods; memorization and routine application, and not analysis, synthesis and evaluation. We don’t encourage creativity and independence of thought, and in fact often do our best to discourage them.”

By 2009, based on current human resource supply trends (NASSCOM-KPMG, 2003), it is estimated that there will be a shortfall of over 0.5 million personnel for the IT and ITeS sector. IT companies have responded by increasing the intake of engineering graduates. These graduates then enter a finishing school within the Corporate to get transformed into IT professionals. However, the number of unemployed graduates is also high. Hence attempts to overcome the manpower shortage without addressing the core issue of skill shortage are not likely to yield expected results. Hence, Indian engineering institutes have a new additional challenge of preparing students to sufficient maturity levels within the first five semesters and equipping them with the required core competencies.

For this to happen uniformly and quickly, the Indian accreditation system needs to be redefined from the traditional resource-based approach to Outcome based approach. The
Indian accreditation agency, universities and engineering institutes should undertake serious requirement analysis for curriculum design by involving all stakeholders. Further, faculty’s unfamiliarity and inexperience with real life engineering projects as well as research on learning also need urgent attention. These suggestions, if implemented, will vastly improve the quality of engineering education in India. This can augment the Indian IT success story, and make India a preferred destination for engineering education (Goel, S, 2006).

2.4 Learning Styles of Engineering Students

*Learning is not so much an additive process, with new learning simply piling up on top of existing knowledge, as it is an active, dynamic process in which the connections are constantly changing and the structure reformatted.* - K. Patricia Cross

Learning styles are “characteristic cognitive, affective, and psychological behaviors that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment”. To enhance the skill of engineering students teaching methodology should be designed to meet the needs of students.

There are several models of learning style but five of them have been the subject of studies in the engineering education literature. These are:

1. Myers-Briggs Type Indicator (MBTI)
2. Kolb’s learning style model
3. Felder and Silverman model
4. Herrmann model
5. Dunn and Dunn model

Let us now discuss each one of them in detail.

2.4.1 The MBTI

The best known of all the models is Jung's Theory of Psychological Type as operationalized by the Myers-Briggs Type Indicator (MBTI). Strictly speaking, the MBTI assesses personality types, but MBTI profiles are known to have strong learning style implications (Figure 2-2). Students may be:

- **Extraverts** (try things out, focus on the outer world of people) or **introverts** (think things through, focus on the inner world of ideas);
- **Sensors** (practical, detail-oriented, focus on facts and procedures) or **intuitors** (imaginative, concept-oriented, focus on meanings and possibilities);
- **Thinkers** (skeptical, tend to make decisions based on logic and rules) or **feelers** (appreciative, tend to make decisions based on personal and humanistic considerations);
- **Judgers** (set and follow agendas, seek closure even with incomplete data) or **perceivers** (adapt to changing circumstances, resist closure to obtain more data).
The MBTI type preferences can be combined to form 16 different learning style types. For example, one student may be an ESTJ (extravert, sensor, thinker, judging) and another may be an INFJ (introvert, intuitior, feeler, and judger).

**Applicability to Engineering Education**

Engineering professors usually orient their courses toward introverts (by presenting lectures and requiring individual assignments rather than emphasizing active class involvement and cooperative learning), intuitors (by focusing on engineering science rather than design and operations), thinkers (by stressing abstract analysis and neglecting...
interpersonal considerations), and judgers (by concentrating on following the syllabus and meeting assignment deadlines rather than on exploring ideas and solving problems creatively).

In 1980, a consortium of eight universities and the Center for Applications of Psychological Type was formed to study the role of personality type in engineering education. Predictably, introverts, intuitors, thinkers, and judgers generally outperformed extraverts, sensors, feelers, and perceivers in the population studied. In work done as part of this study, Godleski reported on grades in four sections of the introductory chemical engineering course at Cleveland State University taught by three different instructors.

The emphasis in this course is on setting up and solving a wide variety of problems of increasing complexity, with memory and rote substitution in formulas playing a relatively small role. Intuitors would be expected to be at an advantage in this course, and the average grade for the intuitors in all sections was indeed higher than that for sensors.

Godleski obtained similar results for other courses that emphasized intuitive skills, while in the few “solid sensing” courses in the curriculum (such as engineering economics, which tends to be formula-driven) the sensors scored higher.

2.4.2 The Kolb’s Learning Style Model

This model classifies students as having a preference for concrete experience or abstract conceptualization (how they take information in), and 2) active experimentation or reflective observation (how they internalize information).
The four types of learners in this classification scheme are:

1. **Type 1** (concrete, reflective). A characteristic question of this learning type is "Why?"
   
   Type 1 learners respond well to explanations of how course material relates to their experience, their interests, and their future careers. To be effective with Type 1 students, the instructor should function as a *motivator*.

2. **Type 2** (abstract, reflective). A characteristic question of this learning type is "What?"
   
   Type 2 learners respond to information presented in an organized, logical fashion and benefit if they have time for reflection. To be effective, the instructor should function as an *expert*.
3. *Type 3* (abstract, active). A characteristic question of this learning type is "*How?*"

Type 3 learners respond to having opportunities to work actively on well-defined tasks and to learn by trial-and-error in an environment that allows them to fail safely. To be effective, the instructor should function as a *coach*, providing guided practice and feedback.

4. *Type 4* (concrete, active). A characteristic question of this learning type is "*What if?*"

Type 4 learners like applying course material in new situations to solve real problems. To be effective, the instructor should stay out of the way, maximizing opportunities for the students to discover things for themselves.

**Applicability to Engineering Education**

Traditional engineering instruction focuses almost exclusively on formal presentation of material (lecturing), a style comfortable for only Type 2 learners. To reach all types of learners, a professor should explain the relevance of each new topic (Type 1), present the basic information and methods associated with the topic (Type 2), provide opportunities for practice in the methods (Type 3), and encourage exploration of applications (Type 4). The term "teaching around the cycle" was originally coined to describe this instructional approach. Most studies of engineering students based on the Kolb model find that the majority of the subjects are Types 2 and 3.
2.4.3 Herrmann Brain Dominance Instrument (HBDI)

This method classifies students in terms of their relative preferences for thinking in four different modes based on the task-specialized functioning of the physical brain. The four modes or quadrants in this classification scheme are (Figure 2-4):

- **Quadrant A** (left brain, cerebral). Logical, analytical, quantitative, factual, critical;
- **Quadrant B** (left brain, limbic). Sequential, organized, planned, detailed, structured;
- **Quadrant C** (right brain, limbic). Emotional, interpersonal, sensory, kinesthetic, symbolic;
- **Quadrant D** (right brain, cerebral). Visual, holistic, innovative.

![Whole Brain Model](source)

*Figure 2-4 Whole brain model*

*Source: The Theory Behind the HBDI and Whole Brain Technology, Herrmann.*

**Applicability to Engineering Education**
Engineering professors on the average are strongly Quadrant A dominant and would like their students to be that way as well, according to Edward and Monika Lumsdaine (see references). Most engineering instruction consequently focuses on left-brain Quadrant A analysis and Quadrant B methods and procedures associated with that analysis, neglecting important skills associated with quadrant C (teamwork, communications) and quadrant D (creative problem solving, systems thinking, synthesis, and design). This imbalance is a disservice to all students, but particularly to the 20-40% of entering engineering students with strong preferences for C and D quadrant thinking.

2.4.4 Felder-Silverman Learning Style Model

This model classifies students as:

- **Sensing learners** (concrete, practical, oriented toward facts and procedures) or **intuitive learners** (conceptual, innovative, oriented toward theories and meanings);
- **Visual learners** (prefer visual representations of presented material—pictures, diagrams, flow charts) or **verbal learners** (prefer written and spoken explanations);
- **Inductive learners** (prefer presentations that proceed from the specific to the general) or **deductive learners** (prefer presentations that go from the general to the specific);
- **Active learners** (learn by trying things out, working with others) or **reflective learners** (learn by thinking things through, working alone);
Sequential learners (linear, orderly, learn in small incremental steps) or global learners (holistic, systems thinkers, learn in large leaps).

Applicability to Engineering Education

For the past few decades, most engineering instruction has been heavily biased toward intuitive, verbal, deductive, reflective, and sequential learners. However, relatively few engineering students fall into all five of these categories. Thus most engineering students receive an education that is mismatched to their learning styles. This could hurt their performance and their attitudes toward their courses and toward engineering as a curriculum and career. In the section "Teaching to All Types" we suggest some instructional methods for addressing the learning needs of the full spectrum of learning styles. According to Richard Felder, Many or most engineering students are visual, sensing, inductive, and active, and some of the most creative students are global.

2.4.5 Dunn and Dunn Learning Style Model

This model encompasses five strands as follows:

1. **Environmental**: The environmental strand refers to elements like lighting, sound, temperature, and seating arrangement.

2. **Emotional**: The emotional strand includes the following elements: motivation, persistence, responsibility, and structure.

3. **Sociological**: The sociological strand represents elements related to how individuals learn in association with other people: (a) alone or with peers, (b) an
authoritative adult or with a collegial colleague, and (c) learning in a variety of ways or in routine patterns.

4. **Physiological**: The elements in this strand are: perceptual (auditory, visual, tactile, and kinesthetic), time-of-day energy levels, intake (eating or not while studying) and mobility (sitting still or moving around).

5. **Psychological**: The elements in this strand correspond to the following types of psychological processing: hemispheric, impulsive or reflective, and global versus analytic. The hemispheric element refers to left and right brain processing modes; the impulsive versus reflective style describes how some people leap before thinking and others scrutinize the situation before moving an inch. Global and analytic elements determine processing styles like sound, light, seating arrangement, persistence, sociological preference, and intake.

The concept of learning styles has been applied to a wide variety of student attributes and differences. Some students are comfortable with theories and abstractions; others feel much more at home with facts and observable phenomena; some prefer active learning and others lean toward introspection; some prefer visual presentation of information and others prefer verbal explanations. One learning style is neither preferable nor inferior to another, but is simply different, with different characteristic strengths and weaknesses (*Felder.R.M & Brent.R, 1988*).

Unfortunately, there is very less work done, if any, to understand the learning styles of engineering students in India.
2.5 Teaching Methodology for Engineering Students

Instruction begins when you, the teacher, learn from the learner. Put yourself in his place so that you may understand what he learns and the way he understands it - Kierkegaard.

Students have different levels of motivation, different attitudes about teaching and learning, and different responses to specific classroom environments and instructional practices. The more thoroughly instructors understand the differences, the better chance they have of meeting the diverse learning needs of all of their students. Figure 2-5 illustrates the relationship between leaning styles and teaching methods.

Figure 2-5 Learning styles and teaching methods

Source: Acadia institute of teaching and technology
The goal of teaching is to improve student learning by maximizing opportunities for learning in every lesson. Such improvement reduces wastage of university resources such as time, effort and money by producing students with the right skills and knowledge that delight the employers.

Figure 2-6 is a simplified model developed by Fui Tong LEE and Boon Han YEAP, to show how lecturer and student interactions should take place in the T&L process. Adopting this model requires lecturers to be more open to change in the methods of teaching and delivering course materials to students through the use of innovative teaching strategies and appropriate technologies. In this model, the lecturer takes steps to add value in the T&L process by transforming inputs that include actions, methods and operations into effective outputs for student learning. A strong feedback loop providing useful information about the degree and quality of learning perceived, is included and directed to the lecturer. The lecturer shall listen to the students in order to make continuous improvement to the design and delivery of information that is able to cause student to learn continuously in the acquisition of knowledge, experience, know-how, wisdom and character.

The model empowers students to initiate actions to learn whereas the lecturer, through the process of assessment, makes continuous efforts to identify changes for the T&L process improvement. This model also requires the lecturer total commitment in teaching that takes full responsibility by actively causing the student to learn. The lecturer communicates the information of the subject matter to the students by simultaneously focusing and interacting with the students to motivate and get their attention to learn as well as continuously analyzing and determining the desired and necessary actions to
improve the quality of T&L process. However, this improvement can only be effective when both lecturers and students work together to identify, analyze and make improvements to the T&L process. For ensuring success, this T&L process requires the support and the simultaneous working together of several resources from appropriate technology tools, academic and supportive staff, departments and faculties, student affairs, resource centers, and financial services. The use of better quality resources and positive environment will lead to better quality of T&L process.

Innovative teaching methods and effective instructional materials can lead to excellence in engineering education. This would require one to change the traditional way of delivering engineering education. In the traditional teaching methods, lecturers offer course materials in a classroom where students listen, take notes, copy materials, execute homework and complete assignments. In many cases lecturers fail to transfer knowledge
to students effectively despite personally having sound technical knowledge in the subject area. This occurs because it is often hard for students to take notes and listen with good comprehension simultaneously. In fact better teaching techniques do exist but often difficult and time-consuming. The literature on active learning is replete with methods of engaging students to promote more effective learning than the traditional lecturing approach. Some educationists stressed the importance of cooperative learning, problem-based learning, and presenting information in various learning styles.

Siddiqui. M.S. et al states that being a faculty member of an engineering program is a great opportunity. If the teacher fills his allotted time with drilling his students in routine operations, he kills their interest hamper their intellectual development, and misuse his opportunity. But if he challenges the curiosity of his students by setting them problems proportionate to their knowledge, and helps them to solve their problem with stimulating questions with an insight of its application in professional life, he may give them a taste for and some means of independent thinking.

But what is the current reality?

An exploratory study has shown (Goel.S & Sharda.N, 2004) that the kind of activities that a typical engineering student in India is generally engaged in, does not help in enhancing creativity, critical thinking, and innovative problem solving. Further, there are many technical universities that have affiliated a very large number of AICTE approved engineering colleges. Some of these universities have affiliated more than hundred engineering colleges. All of these colleges under a single university follow a common syllabus and curriculum and have a common examination organized by the university. In
an attempt to bring objectivity and impartiality, the assessment system is mostly
dependent upon final written exams (up to 80% in theory subjects). This even defies the
NBA’s stated emphasis on continuous evaluation procedure. Every semester, thousands
of engineering students of a university undertake a stereotype common final semester
examination. Semester after semester, students are repeatedly tested at the lower
cognitive levels of knowledge, comprehension, and application as per Bloom’s
taxonomy. Higher cognitive thinking at the level of analysis, synthesis, and evaluation is
not tested through these exams.

According to Goel, S, 2006, most of Indian engineering institutes produce a very large
number of engineering graduates without offering them enough opportunity and
challenge for intellectual growth through their academic program. Consequently, the
learning approach of many students for many subjects remains stagnated at reproduction
directed level as per Vermunt’s framework for classifying learning styles. 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 significant amount of creative energy of the bright and talented students remains
untapped and unexpressed. A very large number of students are awarded 60% to 80%
marks without giving them sufficient experience of design. The drop out rate from Indian
engineering institutes is very low. Almost all admitted students easily manage to
complete the program of study. Unfortunately, many large IT companies do not demand
the institutes to transform their processes. They also indirectly encourage the institutes to
do inflated marking as they short list only high achievers for recruitment process. It is sad
that the existing short-listing criteria and recruitment process of many companies also fails to encourage institutes, faculty, as well as students to focus on developing design skills. The teaching and assessment methods adopted by most of the Indian engineering colleges and universities 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. Indian universities have a great opportunity to become a key partner and contributor in actively forwarding the Indian IT industry’s success story. India’s engineering education system needs to take a proactive approach to harness and nurture the talent of potentially hardworking, disciplined, creative, and enterprising students.

The challenges arising from the new modes of engineering practice and the transformation of the engineering workforce over the coming decade offer the opportunity to create new forms of engineering education. These go beyond conventional programs and courses and embrace many facets of engineering capability development from school to practice. The changes in the external world of engineering work are accelerating and traditional engineering education structures will struggle to respond to these changes in a meaningful and timely manner. It is likely that many new approaches will emerge from outside conventional engineering colleges and universities. These innovations will then be taken up once they have been proven to be successful.

Radcliffe, D.F., 2006 has described the ten principles of effective instruction as follows:

1. Encouraging student-faculty interaction
2. Developing reciprocity and cooperation among students
3. Communicating high expectations
4. Providing prompt feedback
5. Using active learning techniques
6. Emphasizing time on task
7. Respecting diverse talents and ways of thinking
8. Building on correct pre-existing understandings; dispelling false preconceptions
9. Providing factual knowledge, facilitating understanding of the facts and ideas in context of a conceptual framework, and organizing knowledge that facilitates retrieval and application
10. Encouraging students’ motivation to learn

If some or all of above to be followed we need innovative teaching methods. Some of the teaching techniques researcher’s quote as being very effective follows:

- **Active learning** is a common technique used to improve student’s comprehension and retention of material (*Astrachan, O. 1998*). Active learning environments are an effective style of teaching. Research suggests that active learning is especially effective for Computer Science students who tend to be visual/intuitive learners. Techniques such as frequent in-class problem solving, lab sheets and discussions were used to create an active environment to appeal to a broad range of learning styles. The active learning approach helped students move up from the lower levels of Bloom’s taxonomy (simple knowledge and comprehension) into the highest levels (analysis, synthesis, and evaluation). Students attained a greater level of understanding of the material because they had the opportunity to interact with it demonstrated through test scores and student feedback. Students were
guided through the development of a hypothesis, testing their particular hypothesis, and explaining how the results support or refute their theory. This process helps students test their knowledge and understanding of a problem (Briggs T, 2005).

- **Collaborative learning** fosters the development of critical thinking through discussion, clarification of ideas, and evaluation of others' ideas. If the purpose of instruction is to enhance critical-thinking and problem-solving skills, then collaborative learning is beneficial. For collaborative learning to be effective, the instructor must view teaching as a process of developing and enhancing students' ability to learn. The instructor's role is not to transmit information, but to serve as a facilitator for learning. This involves creating and managing meaningful learning experiences and stimulating students' thinking through real world problems (Gokhale A.A, 1995).

- **Cooperative learning** is quoted to be very useful in engineering studies. The research and anecdotal evidence confirming the effectiveness of cooperative learning is overwhelming. Regardless of the objective specified, cooperative learning has repeatedly been shown to be more effective than the traditional individual/competitive approach to education. Obstacles to the widespread implementation of cooperative learning at the college level are not insignificant, however. The approach requires faculty members to move away from the safe, teacher-centered methods that keep them in full control of their classes to methods that deliberately turn some control over to students. They have to deal with the fact that while they are learning to implement cooperative learning they will
make mistakes and may for a time be less effective than they were using the old methods. They may also have to confront and overcome substantial student opposition and resistance, which can be a most unpleasant experience, especially for teachers who are good lecturers and may have been popular with students for many years.

Teachers are pressed to extend their craft to prepare more diverse students for the challenge of work and life beyond school, they are challenged to provide more authentic instructional contexts and activities than traditional knowledge-based curricula. In order to be successful, teachers must be reflective and analytical about their own beliefs and practices and they must acquire a deep understanding of cognitive and motivational principles of learning and teaching (Paris, S.G et al, 1990).

Several variations of active and collaborative learning theories like Problem Based Learning, Project based Learning, Andragogy, Anchored Instruction, Constructivist Theory, Experiential Learning, Learning By Design, Situated Learning, Teaching-in-Context, Transformative learning theory and so on emphasize the importance of action and interaction for learning. Generally, engineering faculties maintain an indifferent attitude towards SOTL (Scholarship of Teaching and Learning). Possibly, most of the engineering faculties have not even heard of any of these or other theories or principles of learning. It appears that they continue to teach for decades without ever exposing themselves to the vast research and literature in SOTL. It could be seen that they carry on their teaching practice without any systematic training, study or scientific reflection about teaching and learning processes.
However, even after so much has been written about the role of action' and interaction' in classroom setting, much to the disliking of students, they remain passive (though perhaps very attentive and careful) recipients of information in the engineering lecture classroom. Lectures are being conceived and delivered with an almost singular focus on course coverage and may be seen as textbook-centric. Students are rarely engaged in activities that give them the opportunity of actively and interactively developing and expressing their ideas. The discourse in the lectures is generally not dynamic. Interaction, if any, remains limited to seeking clarifications in the teacher's presentation (Goel S, 2004).

Such lectures do not contribute to deep and effective learning. The increasingly unimaginative usage of already prepared computer slides further decreases the element of spontaneous evolution in this discourse. Because of the rapidly increasing pressure for increasing content due to the exponential rate of information explosion, information-oriented, teacher-centric lectures fail to realize whatever potential they may have of leading students to develop their creativity, critical thinking and innovative problem solving skills. This study also suggests that engineering students report much more effective learning when opportunities of action' and interaction' are created by teachers inside lecture classrooms.

According to Felder.R.M, the changes that will move engineering education in the desired directions may be grouped into four categories: (1) revisions in engineering curriculum and course structures; (2) implementation of alternative teaching methods and assessment of their effectiveness; (3) establishment of instructional development programs for faculty members and graduate students; and (4) adoption of measures to
raise the status of teaching in society and in institutional hiring, advancement, and reward policies.

Technology provides us with facilities for wide dissemination of instructional material. However, mere dissemination of information does not lead to learning. It is the main role of the teacher to ensure proper design and integration of relevant information into courses for specific groups of learners that result in assimilation and understanding on the part of the student. Only when the student is able to succeed in formative and summative evaluation tests devised according to the specific instructional objectives of the courses, can actual “learning” be deemed to have taken place. The teacher would be required to act more as a catalyst in providing inspiration, guidance and learner support to every learner in a course. In the new era, the teacher needs to move from an “instructions” to a “constructionist” role within the teaching-learning process. He has to become more of a guide, mentor and facilitator (Bhattacharya, B, 2008).

2.6 Approaches to Learning

*Learning is not attained by chance, it must be sought for with ardor and attended to with diligence* - Abigail Adams

Approaches to learning are categorized based on two approaches:

1. what a student thinks learning is all about
2. teaching or instructional approaches
The 20th century scholars held that experience plays a central role in the theories of human learning and development which is known as Experiential learning theory. The theory is, built on six propositions that are shared by these scholars (Kolb & Kolb, 2005):

1. Learning is best conceived as a process, not in terms of outcomes. To improve learning in higher education, the primary focus should be on engaging students in a process that best enhances their learning – a process that includes feedback on the effectiveness of their learning efforts.

2. All learning is relearning. Learning is best facilitated by a process that draws out the students’ beliefs and ideas about a topic so that they can be examined, tested and integrated with new, more refined ideas.

3. Learning requires the resolution of conflicts between dialectically opposed modes of adaptation to the world. Conflict, differences, and disagreement are what drive the learning process. In the process of learning one is called upon to move back and forth between opposing modes of reflection and action and feeling and thinking.

4. Learning is a holistic process of adaptation to the world. It is not just the result of cognition but involves the integrated functioning of the total person—thinking, feeling, perceiving and behaving.

5. Learning results from synergetic transactions between the person and the environment. In Piaget’s terms, learning occurs through equilibration of the dialectic processes of assimilating new experiences into existing concepts and accommodating existing concepts to new experience.
6. Learning is the process of creating knowledge. ELT proposes a constructivist theory of learning whereby social knowledge is created and recreated in the personal knowledge of the learner. This stands in contrast to the “transmission” model on which much current educational practice is based where pre-existing fixed ideas are transmitted to the learner.

Let us now discuss on popular learning and education design approaches.

2.6.1 Theory proposed by Marton and Saljo

Marton and Säljö suggest three approaches to learning (as cited in Felder.R.M & Brent.R, 2004): a surface approach, a deep approach, and a strategic approach.

2.6.1.2 Surface Approach

Students who adopt a surface approach to learning memorize facts but do not try to fit them into a larger context, and they follow routine solution procedures without trying to understand their origins and limitations. These students commonly exhibit an extrinsic motivation to learn.

2.6.1.2 Deep Approach

Students who take a deep approach do not simply rely on memorization of course material but focus instead on understanding it. They have an intrinsic motivation to learn, with intellectual curiosity rather than the possibility of external reward driving their efforts. They cast a critical eye on each statement or formula or analytical procedure they encounter.
2.6.1.3 Strategic Approach

Students who adopt a strategic approach do whatever it takes to get the top grade. They are well organized and efficient in their studying. They carefully assess the level of effort they need to exert to achieve their ambition.

2.6.2 Managerial Learning Approaches

Mumford, A. 1994 suggests the below Four Approaches to Managerial Learning from Experience.

2.6.2.1 The Intuitive Approach

The Intuitive Approach involves learning from experience, but not through a conscious process. It sees managing and good business practices as synonymous with learning. Its users claim that learning is an inevitable consequence of having experiences, and trust in learning as a “natural”, effortless process.

Typical quotes: “I’m sure I’m learning all the time but I can’t be more specific.” “I just do it but I can’t tell you how.” “I do that already without calling it learning.” “I suspect you are doing it all the time without realizing you’re doing so.”

2.6.2.2 The Incidental Approach

The Incidental Approach involves learning by chance from activities that jolt an individual into conducting a post-mortem. Mishaps and frustrations often provide the spur. Its users tend to use the benefit of hindsight as a way of rationalizing, even justifying, what happened.
Typical quotes: “I learn from the unfamiliar parts of my job, not from the bits I am already familiar with and have already mastered.” “If you know how to do something you aren’t going to learn from it.” “It’s the originality of the experience that provokes more reflection.” “You only learn from your mistakes.”

2.6.2.3 The Retrospective Approach

The Retrospective Approach involves learning from experience by looking back over what happened and reaching conclusions about it. It is especially provoked by mishaps and mistakes. Users of this approach are more inclined to draw lessons from routine events and successes.

Typical quotes: “It helps to hold things up to the light.” “Reviewing is essential to put things into perspective.” “You never really understand something until you write it down.”

2.6.2.4 The Prospective Approach

Retrospection concentrates on reviewing what happened after an experience, whereas the Prospective Approach includes planning to learn before an experience takes place.

Typical quotes: “I learn because I go there expecting to do so.” “There is no substitute for thorough planning, not only to get things done but also to learn from doing them.” “Sorting out what you want to get in advance increases your chances of getting something worthwhile.”
There are similarities between orientations to studying and learning styles. Both represent tendencies that are situationally dependent, as opposed to fixed traits like gender or handedness that always characterize an individual. Just as a student who is a strong intuitior may function like a sensor in certain situations and vice versa, a student with a pronounced meaning orientation may under some circumstances adopt a surface approach to learning, and a strongly reproducing student may sometimes be motivated to dig deep.

2.6.3 Major Approaches to Education Design

Curricular changes have closely followed shifting patterns in educational philosophy through the years. This in turn affects the approaches to learning. Let’s take a look at the major approaches to educational design.

2.6.3.1 Mental Discipline

The mental discipline approach views the mind as a muscle that should be exercised. Proponents of this approach, which dates back to Plato and Aristotle, emphasize drill and practice combined with strict discipline to buttress the learner’s attention, memory, will and perseverance. Transfer of learning occurs through mental exercise, which builds the power of the faculties so they can automatically move into action in appropriate situations. Curricular content is not important as long as it is difficult and unpleasant. Mathematics, science and Latin are typical components of this curriculum. Instructors frequently use physical and mental punishment — belittlement, harassment, denigration — to enforce study habits.
2.6.3.2 Apperception

Those who subscribe to the apperception theory view learning as a process of implanting in students’ minds a great mass of information and concepts organized by a teacher or textbook author. As students integrate new facts with old, they generate new “feelings” that lead to new behaviors. Apperceptionists like Herbart and Tichener measured knowledge retention by administering frequent tests. Transfer of learning, for apperceptionists, is a matter of simply storing ideas within the mind where they are available for recall.

2.6.3.3 Behaviorism/Neo behaviorism

Post-World War II learning theory emphasized teaching by instructional objectives. The behaviorist approach, as exemplified by Skinner and Gagné, is teacher-oriented and only rarely takes the learner’s needs into account. Behaviorism generally avoids speculation about what occurs inside the mind. Teachers concentrate on measuring overt behavior, particularly whether students are able to reach the terminal course objectives. Students’ attitudes and commitment to program objectives receive little attention.

Hull, whose particular brand of behaviorism is called “drive reduction,” says, “The teacher should not be content with teaching one solution to a problem but instead, whenever possible, should introduce a variety of techniques for solving problems.” He recommends practice of discrete parts of a sequential act until all parts of the job are equally well learned. Bandura said learning occurs through observation, such as by imitation of a model, a theory known as social learning. Bandura believes “we learn to imitate because we are reinforced for such behavior.” Teachers are models who shape or
influence student behavior; the teacher does not have to be older or even in the same discipline to act as a model. In behaviorism, transfer of learning occurs through the repertoire of conditioned responses available to the individual. The behaviorist approach is most useful when instructional objectives are unambiguous, achievement can be judged by agreed-upon criteria and a clear imbalance exists between the teacher’s and learner’s areas of expertise.

2.6.3.4 Cognitivism

This group of educators looks at schools as composed of groups of individuals with varying needs and skills and views humans as “rule-forming beings.” Teachers need to assess the learner’s abilities to discover whether he or she is ready to learn. With this approach, instructional focus begins to move away from the teacher and toward the learner. Bruner’s discovery learning method assumes that learners categorize material for use in perception, decision making and conceptualization. Learning occurs by the generalization of insights that stem from experience. A variant of cognitivism called reception learning was developed by David Ausubel. Reception learning centers around a group of stable, organized concepts. Learning occurs when new information is linked to knowledge already held by the learner. Therefore, for Ausubel the most important factor in learning is what the person already knows.

2.6.3.5 Humanism

Current educational thinking looks at the human resources potential of learners. The purpose of education is to provide learners with the tools needed throughout their lives to change and adapt to new conditions and information. The problem-based learning
curriculum is a response to this particular philosophy. Maslow maintained that the real world consists of how the learner perceives it and therefore can be known fully only by the learner. Maslow supported student-centered teaching where the purpose of the instructor was to facilitate learning, a process that involves, among other things, empathetic listening.

2.6.3.6 Constructivist Theory

Constructivism refers to the idea that learners construct knowledge for themselves---each learner individually (and socially) constructs meaning---as he or she learns. Constructing meaning is learning; there is no other kind. The dramatic consequences of this view are twofold;

1. We have to focus on the learner in thinking about learning (not on the subject/lesson to be taught):

2. There is no knowledge independent of the meaning attributed to experience (constructed) by the learner, or community of learners.

2.6.3.7 Connectivism

Connectivism is the integration of principles explored by chaos, network, and complexity and self-organization theories. Learning is a process that occurs within nebulous environments of shifting core elements – not entirely under the control of the individual. Learning (defined as actionable knowledge) can reside outside of ourselves (within an organization or a database), is focused on connecting specialized information sets, and
the connections that enable us to learn more are more important than our current state of knowing.

Connectivism is driven by the understanding that decisions are based on rapidly altering foundations. New information is continually being acquired. The ability to draw distinctions between important and unimportant information is vital. The ability to recognize when new information alters the landscape based on decisions made yesterday is also critical.

2.7 Formal and Informal Learning

I am always willing to learn, however I do not always like to be taught - Winston Churchill.

Formal learning refers to learning through a program of instruction in an educational institution, adult training centre or in the workplace, which is generally recognised in a qualification or a certificate (Figure 2.7).

Non-formal learning refers to learning through a program but it is not usually evaluated and does not lead to certification.

Informal learning refers to learning resulting from daily work-related, family or leisure activities.
The formal modes of learning occur in traditional university courses or Corporate training and tend to be highly “directed” with the instructor guiding the learning very closely. On the other hand, the informal modes, which occur naturally as part of learning to accomplish work tasks, are much more “self-directed,” in that the learner must decide what is to be learned, choose an approach to learning, and manage the learning process independently.

2.8 Androgogy and Pedagogy

*Adult education will become an agency of progress if its short-term goal of self-improvement can be made compatible with a long-term, experimental but resolute policy of changing the social order* - Eduard Lindeman

Andrology is the process of engaging adult learners in the structure of the learning experience. The term was originally used by Alexander Kapp (a German educator) in 1833, was developed into a theory of adult education by the American educator, Malcolm
Knowles. He held that Andragogy (from the Greek words meaning "adult-leading") should be distinguished from the more commonly used pedagogy (Greek: "child-leading"). Malcolm Knowles lifetime of work in adult learning convinced him that adults learn in a substantially different way from children. In fact he argued that it was so different that the term Andragogy, rather than Pedagogy, should be used to refer to adult learning activities. Andragogy places the adult learner at the centre of the learning process, and takes into account the experiences, prior knowledge and values that they bring to their learning.

Pedagogy is the art or science of being a teacher. The term generally refers to strategies of instruction, or a style of instruction. Pedagogy is also sometimes referred to as the correct use of teaching strategies.

Pedagogy literally means the art and science of educating children and often is used as a synonym for teaching. More accurately, pedagogy embodies teacher-focused education. In the pedagogic model, teachers assume responsibility for making decisions about what will be learned, how it will be learned, and when it will be learned. Teachers direct learning. While Andragogy, initially defined as "the art and science of helping adults learn," has taken on a broader meaning since Knowles' first edition. The term currently defines an alternative to pedagogy and refers to learner-focused education for people of all ages.

Paulo Freire referred to his method of teaching adults as "critical pedagogy". In correlation with those teaching strategies the instructor's own philosophical beliefs of teaching are harbored and governed by the pupil's background knowledge and
experiences, personal situations, and environment, as well as learning goals set by the student and teacher. One example would be the Socratic schools of thought.

Critical pedagogy is a teaching approach which attempts to help students question and challenge domination, and the beliefs and practices that dominate. In other words, it is a theory and practice of helping students achieve critical consciousness. "Advocates of critical pedagogy are aware that every minute of every hour that teacher teaches, they are faced with complex decisions concerning justice, democracy, and competing ethical claims. While they have to make individual determinations of what to do in these particular circumstances, they must concurrently deal with institutional morality.

A central tenet of critical pedagogy maintains that the classroom, curricular, school structures teachers enter are not neutral sites waiting to be shaped by educational professionals (Table 2-1).
### Table 2-1 Differences between Pedagogical and Andragogical Approaches


<table>
<thead>
<tr>
<th>The Learner</th>
<th><strong>Pedagogical</strong></th>
<th><strong>Andragogical</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Role of the Learner's Experience</td>
<td>• The learner is dependent upon the instructor for all learning • The teacher/instructor assumes full responsibility for what is taught and how it is learned • The teacher/instructor evaluates learning</td>
<td>• The learner is self-directed • The learner is responsible for his/her own learning • Self-evaluation is characteristic of this approach</td>
</tr>
<tr>
<td>Readiness to Learn</td>
<td>• Students are told what they have to learn in order to advance to the next level of mastery</td>
<td>• The learner brings a greater volume and quality of experience • Adults are a rich resource for one another • Different experiences assure diversity in groups of adults • Experience becomes the source of self-identify</td>
</tr>
<tr>
<td>Orientation to Learning</td>
<td>• Learning is a process of acquiring prescribed subject matter • Content units are sequenced according to the logic of the subject matter</td>
<td>• Learners want to perform a task, solve a problem, live in a more satisfying way • Learning must have relevance to real-life tasks • Learning is organized around life/work situations rather than subject matter units</td>
</tr>
<tr>
<td>Motivation for Learning</td>
<td>• Primarily motivated by external pressures, competition for grades, and the consequences of failure</td>
<td>• Internal motivators: self-esteem, recognition, better quality of life, self-confidence, self-actualization</td>
</tr>
</tbody>
</table>

#### 2.9 Concepts Closer to Learnability

*Learning is not a product of schooling but the lifelong attempt to acquire it.*

*Albert Einstein.*
2.9.1 Self-Directed Learning

'Self-directed learning' describes, according to Malcolm Knowles, a process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes.

There are three immediate reasons for self-directed learning as follows (Knowles, M.):

Firstly, people who take the initiative in learning (proactive learners) learn more things, and learn better, than do people who sit at the feet of teachers passively waiting to be taught (reactive learners). 'They enter into learning more purposefully and with greater motivation. They also tend to retain and make use of what they learn better and longer than do the reactive learners.'

Secondly, self-directed learning is more in tune with our natural processes of psychological development. 'An essential aspect of maturing is developing the ability to take increasing responsibility for our own lives - to become increasingly self-directed'.

And finally, many of the new developments in education put a heavy responsibility on the learners to take a good deal of initiative in their own learning. 'Students entering into these programs without having learned the skills of self-directed inquiry will experience anxiety, frustration, and often failure, and so will their teachers.'

A five step model for SDL proposed by Knowles, M involves:

1. Diagnosing learning needs.
2. Formulating learning needs.

3. Identifying human material resources for learning.


5. Evaluating learning outcomes.

In terms of learning, it is the ability or willingness of individuals to take control of that, which determines any potential for self-direction. This means that learners have choices about the directions they pursue. Thus it views learners as responsible owners and managers of their own learning process. SDL integrates self-management (management of the context, including the social setting, resources, and actions) with self-monitoring (the process whereby the learners monitor, evaluate and regulate their cognitive learning strategies). It recognizes the significant role of motivation and volition in initiating and maintaining learners' efforts. Motivation drives the decision to participate, and volition sustains the will to see a task through to the end so that goals are achieved.

Self-directed learning programs hold numerous advantages over traditional forms of classroom instruction for employees in the workplace, whether they are leaders, managers, or individual contributors. Problem of traditional form include: coping with the short life span of useful knowledge; passing down acquired competencies to succeeding cohorts; accommodating the demands of productivity while providing for a continuity of learning; enabling learners to pursue activities that correspond to their learning styles and needs”.

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After many years of reflection about learning, eminent psychologist, Carl Rogers, founder of self-directed therapy, asserted that “anything that can be taught to another is relatively inconsequential, and has little or no significant influence on behavior. He adds, “The only learning which significantly influences behavior is self-discovered, self-appropriated learning”.

In his paper, “Undergraduate Foundations for Lifelong Learning,” Flammer proposes a model for successful lifelong learning that has two aspects: motivation and ability. He divided each parameter into two areas. For motivation, these are “won’t do” and “will do,” and for ability, they are “can do” and “can’t do.” The successful life long learner was then one who “will do” and “can do.” This model emphasizes the two critical factors in lifelong learning: motivation and skills (cited in Litzinger.T et al, 2003).

Candy, in his extensive review of self-directed learning, summarizes the characteristics of the self-directed learner from many sources. These characteristics fall into two sets, personal attributes and skills, which are analogous to Flammer’s “will do” and can do.”

Candy’s lists are:


**Can do** Skills: have highly developed information seeking and retrieval skills, have knowledge about and skill at the learning process, develop and use criteria for evaluating (critical thinking).
Effective self-directed learning paves the way for "openness to learning opportunities, self-concept as an effective learner, initiative and independence in learning, informed acceptance of responsibility for one's own learning, a love to learn, creativity, future orientation, and the ability to use basic study skills and problem-solving skills." SDL is exemplified by attitudes like "curious/motivated, methodical/disciplined, logical/analytical, reflective/self-aware, flexible, interdependent/interpersonally competent, persistent/responsible, venturesome/creative, confident, independent/self-sufficient"; and skills like "highly developed information seeking and retrieval skills, have knowledge about and skill at the learning process, develop and use criteria for evaluating (critical thinking)". Candy frequently discusses the social context of learning and that SDL should not necessarily be solely independent (Litzinger, T et al, 2003).

Self-directed learning allows learners to be more effective learners and social beings. It develops domain-specific knowledge as well as the ability to transfer conceptual knowledge to new situations. It seeks to bridge the gap between school knowledge and real-world problems by considering how people learn in real life. It is a process of learning in which people take the primary responsibility or initiative in the learning experience, and self-direction as a personal attribute of the learner.

According to PintRich and DeGroot (cited in Hiemstra, R., 1994), self-directed learning is “a process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies and evaluating learning outcomes”.

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Self-directed training includes the learner initiating the learning, making the decisions about what training and development experiences will occur, and how. The learner selects and carries out their own learning goals, objectives, methods and means to verify that the goals were met. Self-directed learning becomes even more powerful when it's systematic, that is, when we decide:

1. What areas of knowledge and skills we need to gain in order to get something done (our learning needs and goals)
2. How we will gain the areas of knowledge and skills (our learning objectives and activities)
3. How we will know that we've gained the areas of knowledge and skills (learning evaluation)
4. What areas of knowledge and skills we need to gain in order to get something done (our learning needs and goals)
5. How we will gain the areas of knowledge and skills (our learning objectives and activities)
6. How we will know that we've gained the areas of knowledge and skills (learning evaluation)

Thus, self-directed learning is a continuous engagement in acquiring, applying and creating knowledge and skills in the context of an individual learner's unique problems. Effectively supporting self-directed learning as one of the critical challenges in supporting lifelong learning. Self-directed learning creates new challenging requirements for learning technologies. Domain-oriented design environments address these challenges
by allowing learners to engage in their own problems, by providing contextualized support, and by exploiting breakdowns as opportunities for learning.

Several things are known about self-directed learning: (a) individual learners can become empowered to take increasingly more responsibility for various decisions associated with the learning endeavor; (b) self-direction is best viewed as a continuum or characteristic that exists to some degree in every person and learning situation; (c) self-direction does not necessarily mean all learning will take place in isolation from others; (d) self-directed learners appear able to transfer learning, in terms of both knowledge and study skill, from one situation to another; (e) self-directed study can involve various activities and resources, such as self-guided reading, participation in study groups, internships, electronic dialogues, and reflective writing activities; (f) effective roles for teachers in self-directed learning are possible, such as dialogue with learners, securing resources, evaluating outcomes, and promoting critical thinking; (g) some educational institutions are finding ways to support self-directed study through open-learning programs, individualized study options, non-traditional course offerings, and other innovative programs (Abdullah. M.H., 2001).

In the twenty-first century and as the explosion of information and multiple ways of learning increase, it will become even more important that individuals know how to self-direct their learning and that fostering self-directed learning becomes an important goal for all educational systems.
2.9.2 Life Long Learning (LLL)

In the 21st century society, a long standing equity goal for education takes on new urgency due to the following four major reasons (Larsen K, 2001) Firstly, as economies and societies are increasingly knowledge-based, the price paid for missing out on learning becomes a high one. This is made worse by the decline in low-skill jobs, which have traditionally employed ones with few qualifications. Secondly, as information and communication technologies spread into all aspects of our lives a new dimension of exclusion has been created: the so-called “digital divide”. Thirdly, fragmenting families and communities too often mean weaker social bonds and identity. This emphasizes a critical mission for education that goes well beyond skills development – cementing social identity, networks and community involvement, otherwise known as "social capital". Fourthly, in our rapidly changing world, educational equity can no longer be addressed only in terms of what happens in schools and colleges but throughout our lives. The scope is now ambitious as countries aim to make lifelong learning available to all. The major problem remains that lifelong learners tend to be those who have already done well in initial education, although those who did not stand most to gain.

The ABET Engineering Criteria 2000 (EC2000) bring lifelong learning to the forefront for engineering educators. In the past, our role in lifelong learning was primarily offering courses and degree programs for practicing engineers through continuing education and on our campuses. Now EC2000 demands that we prepare engineering students to engage in lifelong learning. While this demand on faculty and curricula to prepare students for lifelong learning is new, the significance attached to lifelong learning, and in particular continuing education, within the engineering profession is not (Litzinger T et al., 2001).
The ability to engage in LLL begins with a student-demonstrated readiness for SDL. As educators our interests involve what we do with our students for four years and how that prepares them professionally, intellectually, and emotionally for post-graduation life. Because of its many dimensions it is important to understand LLL, or students' preparedness for LLL, and its connection to the curriculum. Few studies have really probed this connection. An evaluation that measures student preparedness for LLL while in college could be used to better connect academic structures and student development in the dimensions described above.

While definitions of lifelong learning differ a fairly standard one comes from Candy. "Lifelong learning takes, as one of its principal aims, equipping people with skills and competencies required to continue their own "self education" beyond the end of formal schooling". Amidst the variance in definitions, authors agree on several things. First, lifelong learning is critical for today's engineer because of the fast-changing nature of engineering content knowledge and the numerous job responsibilities that are common in engineers' careers. And secondly, although employers provided on-going employee training (which certainly is not the only type of lifelong learning) in the past, lifelong learning must be accomplished via other means — both formal and informal -- in the future.

In order to better understand how well life-long learning was addressed by the Department of Manufacturing Engineering and Engineering Technology at BYU(Brigham Young University), alumni and their supervisors were surveyed regarding characteristics of life long leaning. This survey gave a, industry perspective of what is important regarding life-long learning and a glimpse of how well these were being
developed. The results of the survey indicated that the root and essence of life long learning is simply learning. Real and deep learning. An unmeasurable but clear expression of the responses from both the alumni and supervisor was the attitude and perspective illustrated in the style and flavor of their comments. Some were optimistic and instructive, others wooden and flat. It appeared that good learners seek not just for rigor but for relevance, not just for information but for wisdom, and beyond just making a living they seek to make a life. The attitude of the student and the methods of the teacher must, therefore, not only focus on the development of the mind, i.e.: grade and graduation, but also on the growth of the heart and the soul (Hawks. V, 1998).

While there have been attempts to develop lifelong learning predictive instruments in other fields, little has been done in engineering. Studies by Livneh.C, 1988, from the human service professions have produced inconclusive results. None of these studies found learner characteristics that consistently predicted lifelong learning behaviors later in life. Livneh approached the problem from two basic research paradigms. In order to develop a profile of lifelong learning, she created an instrument, Characteristics of Lifelong Learning in the Professions (CLLP), in order to predict continuing education potential in others in those same professions. A factor analysis of the results did not predict enough of the actual measured variance in lifelong learning to create a usable profile, however factors labeled “educability” and “future orientation1” were significantly different between high and low participants in lifelong learning (Marra.R.M., 1999)
2.9.3 Self-Regulated Learning

Self-regulated learning concerns the application of general models of regulation and self-regulation to issues of learning especially within academic contexts. Self-regulated learning is an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior, guided and constrained by their goals and the contextual features in the environment (Wolters, C.A et al., 2003).

According to Chen, C.C., 2002, developing students’ self-regulatory skills in addition to teaching them content knowledge is currently considered as one of the major goals of education. The reason for this is that Self-Regulation skills support lifelong learning by making people independent learners and by favoring the transfer of knowledge and methods to different learning situations. Self-Regulated Learning (SRL) can be described as a goal-oriented process of active knowledge construction, involving the interaction of an individual’s cognitive, motivational, emotional, social and volitional resources.

Smith, P.A., 2001 provides a summary of the literature on SRL. Under her model of SRL, self-regulated learners possess three attributes that set them apart from others: (a) self-efficacy, (b) self-awareness, and (c) resourcefulness. During the learning process, self-regulated learners employ processes that enhance their learning. Smith groups these behaviors into three categories: (a) attributions, (b) goals, and (c) monitoring strategies. Lifelong learning and SRL are synonymous. SRL is used to more precisely describe the process of lifelong learning in formal educational settings (Smith, 2001). Both processes...
involve a learner who is an active participant in the learning process, pursuing strategies
that aid in acquiring knowledge and skills.

Self-regulated learners are the type of professionals many organizations seek because of
their ability to adapt to a changing environment. The ability of individuals to direct their
learning processes is the essence of SRL. SRL researchers seek avenues to develop this
ability to teach oneself. SRL researchers seek avenues to develop this ability to teach
oneself. This ability to teach oneself is important for accountants because of ongoing
changes in the profession (Schloemer, P., 2006).

Figure 2-8 represents the key components of self-regulated learning developed by
Smith, P. A. At the core of this model is the learner’s self-motivation, which is intense
determination to learn something specific or to acquire some added level of expertise.
The self regulatory attributes and the self-regulatory processes that the learner habitually
uses influence the strength of the learner’s self-motivation. Self-regulatory attributes are
constructs that include self-efficacy (“I know I can do this if I try”), self-awareness (“I’m
not getting this”), and resourcefulness (“I know where to get a tutor to help me learn
this”). Self-regulatory processes include attributions (“I was successful because I put in
the extra hours of studying, not because the teacher did it for me”), goals (“I’m
determined to be a CPA; therefore it is necessary to master the knowledge and skills that
will be tested”), and self-monitoring (“I’ve finished Chapter 1; just two more chapters
and then I’ll go back and review the sections I don’t understand”).

The next level depicts the choices that the self-regulated learner makes in pursuing
knowledge. These include the learner’s choice to participate in the learning process (e.g.,
to be in class), choice of learning strategy (e.g., working problems), and choice of learning outcome (e.g., mastery of material). Through these choices the learner sets personal learning objectives independent of those set by outside authority. A self-regulated learner does not wait for someone else to tell him or her what to learn; he or she has a personal learning agenda. Free choice is a necessary condition for self-regulation. The outside level in Figure 2-8 depicts the self-regulated learning model, which encompasses the learner's attributes, processes, and self-motivation, as well as the learner's choices. In the self-regulated learning model the learner sets goals to master the material, controls the learning environment, seeks assistance when needed, evaluates progress, and adapts behavior based upon that evaluation.

Figure 2-8 Self regulated learning

Source: Understanding Self-Regulated Learning and Its Implications for Accounting Educators and Researchers. Issues in Accounting Education, Smith, P.A
2.9.4 Tools available for measuring Self Directed Learning Readiness (SDLR)

A major issue in lifelong learning is how to assess the extent to which students are prepared to engage in it and also their willingness to do so. Two instruments for assessing lifelong learning are Guglielmino’s Self-Directed Learning Readiness Scale (SDLRS), developed in 1978, and Oddi’s Continuing Learning Inventory (OCLI), developed in 1984.

2.9.4.1 Guglielmino’s Self-Directed Learning Readiness Scale (SDLRS)

Self-directed learning readiness is defined as ‘the degree the individual possesses the attitudes, abilities and personality characteristics necessary for self-directed learning’. Inherent in this definition are several assumptions about SDL readiness. Firstly, adults are inherently self-directing, i.e. readiness for SDL exists along a continuum and is present in individuals to an extent. Secondly, competencies required for self-direction can be developed to some extent and the best way to learn autonomous behavior is to behave autonomously. Finally, the ability to learn independently in one situation or context can be generalized to other settings (Guglielmino 1989).

The instrument most widely used in educational research to measure SDL readiness is Guglielmino’s (1977) Self-directed Learning Readiness Scale (SDLRS)( Fisher.M et al 2001). Eight factors were identified as contributing to SDL, these factors were labeled as: openness to learning opportunities, self concept as an effective learner, initiative and independence in learning, informed acceptance of responsibility for one’s own learning, a love to learn, creativity, future orientation, and the ability to use basic study skills and
problem-solving skills. Thus, the scale includes factors related to skills and personal attributes required for self-directed learning.

However, the SDLRS has been going through criticism on its wordings and structure. Despite frequent references in the literature to its eight factor structure, no evidence was found to support such a structure, and the data analysis predicts that (Oddi, L. F., 1987).

2.9.4.2 Oddi Continuing Learning Inventory (OCLI)

The Oddi Continuing Learning Inventory (OCLI), a 24-item Likert scale, grew out of Oddi’s concern over the lack of a theoretical foundation for understanding personality characteristics of self-directed continuing learners. The development of this instrument was an outgrowth of the need to distinguish between personality characteristics of self-directed learners and the notion of self-directed learning as "a process of self-instruction".

Perhaps the most successful research for predicting lifelong learning behaviors came from Oddi. In initial design and validation efforts, his Oddi Continuing Learning Inventory (OCLI) was found to correlate highly with existing measures of self-directed continuing learning behaviors in adults.

OCLI has been used frequently to measure self-directed learning. OCLI's underlying dimensions are better described by four factors. This four-factor model was also identified through confirmatory factor analyses. These four underlying OCLI dimensions—Learning With Others, Learner Motivation/Self-Efficacy/Autonomy, Ability to be Self-Regulating, and Reading Avidity—provide further specificity and insights for examining and better understanding students' self-directed learning.
The OCLI was structured around three scales: Proactive Drive versus Reactive Drive; Cognitive Openness versus Defensiveness; and Commitment to Learning versus Apathy or Aversion to Learning. Higher scores in the scale indicate having greater characteristics of a self-directed continuing learner. In this scale, the reliability coefficient also achieves a higher level (Oddi. L. F., 1986).

2.9.4.3 Characteristics of Lifelong Learning in the Professions (CLLP)

Due to the rapid growth in knowledge and technology, it is estimated that within 10 to 12 years of receiving their formal education, human service professional will become approximately half as competent as they were upon graduation to meet the demands of their profession. Degree obsolescence is today’s way of life.

Livneh’s instrument (1988) assesses attitudes and behaviors towards learning. The CLLP instrument is a 36-item Likert-type scale, in which respondents are asked to describe themselves on a 1 to 7 scale from strongly disagree to strongly agree. The instruments measuring life long learning came out with an outcome of the following:

- Professional growth through learning
- Self-motivated achievement
- Educability
- Readiness for change
- Causation for learning participation
- Familial educational background
- Future orientation
Three demographic variables were also included in the discriminant function analysis as follows:

- Marital status
- Father’s educational background
- Designation of the person

The CLLP survey was administered to human service professional and the responses of the study came out with factor scales corresponding to the seven CLLP extracted factors and three selected demographic variables which were then submitted to stepwise discriminant function analysis. The two groups – lifelong learners and low participants in learning – were found to differ significantly on the discriminant function composed of the following five CLLP factors: Educability, Readiness for Change, Future Orientation, Causation for Learning Participation and Familial Educational Background (Livneh.C, 1988).

2.10 Psychometrics

Psychometrics is the technique of generating psychological profiles of individuals covering either personality and / or intellectual ability. It is the field of study concerned with the theory and technique of educational and psychological measurement, which includes the measurement of knowledge, abilities, attitudes, and personality traits. The field is primarily concerned with the study of measurement instruments such as questionnaires and tests. It involves two major research tasks, namely: (i) the construction of instruments and procedures for measurement; and (ii) the development and refinement of theoretical approaches to measurement.
Psychometric tools were devised in 1870s to measure individual performance. With many psychometric instruments available, it is essential to choose and use them correctly.

Much of the early theoretical and applied work in psychometrics was undertaken in an attempt to measure intelligence. Francis Galton is often referred to as the father of psychometrics, having devised and used mental tests. However, the origin of psychometrics also has connections to the related field of psychophysics.

Psychometric tests are measures of the mental skills, aptitudes and personality traits of people. Only tests that have been “standardized” for their “reliability” and “validity” should be used to get correct results. Psychometric Tests are behavior samples that are uniform, objective and interpretable. They are designed to gauge individual differences.

There are four types of Psychometric tests, as follows:

- **Ability test** -- measures a person's potential and sees if he/she can learn new skills and cope with training.
- **Aptitude test** -- measures specific job-related skills that a person already has.
- **Achievement test** – measures the skills and knowledge learnt at a particular point of time.
- **Personality test** -- measures the relatively stable and enduring aspects of an individual, which makes him or her unique from others.

Personality tests were developed to measure aspects of an individual’s psychological makeup and mental health. It aims to describe aspects of a person’s character that remain stable throughout a person’s lifetime, the individual's character pattern of behavior,
thoughts, and feelings. An early model of personality was posited by Greek philosopher/physician Hippocrates. The 20th century heralded a new interest in defining and identifying separate personality types, in close correlation with the emergence of the field of psychology. As such, several distinct tests emerged; some attempt to identify specific characteristics, while others attempt to identify personality as a whole. Basically, there are three types of personality tests, as follows:

**Observing Behavior (OB)** – It enables to measure personality characteristics. It is the way of testing which sets up a specific situation, place the subject in that situation, and then observe record and evaluate the response of the individual. This approach is slow and expensive and the results are hard to standardize.

**Projective Test (PT)** – It is designed to let a person respond to ambiguous stimuli, presumably revealing hidden emotions and internal conflicts. This is different from an "objective test" in which responses are analyzed according to a universal standard rather than an individual's judgment. The best known projective test is the Rorschach inkblot test, in which a subject is shown a series of irregular but symmetrical inkblots, and asked to explain what they see. Another popular projective test is the Thematic Apperception Test (TAT) in which a patient views ambiguous scenes of people, and is asked to describe various aspects of the scene.

**Self-Report Questionnaire (SRQ)** – It's an approach to personality test where individuals are asked questions about themselves, which are analyzed by the test-maker into scales norms or patterns. Some, like the Minnesota Multi-phasic Personality Inventory (MMPI), diagnose psychopathology. Some try to measure many aspects of
personality while others limit their focus. Interest Inventories are a sub-category of self-report questionnaire. Strong Interest Inventory, e.g., attempts to match person’s interests to specific occupations.

**Type approach to personality tests**

Personality type theory aims to classify people into distinct categories. Personality types are synonymous with "personality styles". Types refer to categories that are distinct and discontinuous. Carl Jung approached personality and 'psychological types' (also referred to as Jung's psychological archetypes) from a perspective of clinical psychoanalysis. Jung asserted that a person's psychological make-up is always working on two levels: the conscious and the unconscious. In psychoanalysis, it is important for the analyst to understand the structure or nature or direction of the 'psychic energy' within the other person. Jung divided psychic energy into two basic 'general attitude types': Introverted and Extraverted. Moreover Jung's Introvert and Extravert 'general attitude types' feature strongly as two opposite characteristics within very many modern personality systems.

**Trait approach to personality tests**

Psychologists define personality as: “The particular pattern of behavior and thinking that prevails across time and contexts, and differentiates one person from another.” There are five personality traits which describes the personality of a person. Everyone possesses all of these traits to a greater or lesser degree. And, all the personality tests are assessed on the basis of these personality tests. These traits can be classified as:

- **Extraversion - How “energetic” one is.** People who score high on this factor like to work in cooperation with others, are talkative, enthusiastic and seek
excitement. People who score low on this factor prefer to work alone, and can be perceived as cold, difficult to understand, even a bit eccentric.

- **Agreeableness - One’s level of orientation towards other people.** Those who score high on this factor are usually co-operative, can be submissive, and are concerned with the well-being of others. People who score low on this factor may be challenging, competitive, sometimes even argumentative.

- **Conscientiousness - How “structured” one is.** People who score high on this factor are usually productive and disciplined and “single tasking”. People who score low on this factor are often less structured, less productive, but can be more flexible, inventive, and capable of multitasking.

- **Neuroticism - Tendency to worry.** People who score low on this factor are usually calm, relaxed and rational. They may sometimes be perceived as lazy and incapable of taking things seriously. People who score high on this factor are alert, anxious, sometimes worried.

- **Openness to Experience - Tendency to be speculative and imaginative.** People who score high on this factor are neo-phile and curious and sometimes unrealistic. People who score low on this factor are down-to-earth and practical and sometimes obstructive of change.

**Tools for Psychometrics**

Psychometric tools are questionnaires or tests that help businesses to select the right people, facilitate individual and team development, and increase organizational effectiveness. Some should only be used for the development of individuals, while others are designed and validated for selection. A psychometric tool should be (Table 2-2):
### Table 2-2 Characteristics of Psychometric Tools

<table>
<thead>
<tr>
<th>Objective</th>
<th>Results obtained from it are not influenced by the administrator’s personal preferences or biases.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standardized</strong></td>
<td>It is administered and scored according to standard procedures; people’s scores on the test are compared to known benchmarks.</td>
</tr>
<tr>
<td><strong>Reliable</strong></td>
<td>It measures in a consistent way.</td>
</tr>
<tr>
<td><strong>Valid</strong></td>
<td>It measures the characteristics which it sets out to measure. A test used for job selection should predict relevant aspects of job performance.</td>
</tr>
<tr>
<td><strong>Discriminating</strong></td>
<td>Test should be discriminating, showing clear differences between individuals on the behavior being tested.</td>
</tr>
</tbody>
</table>

Individual tests are among the best single predictors of job performance and are even more powerful when combined with other tests or interviews. They provide an objective and fair method of selecting and developing staff and help to remove bias and discrimination. Psychometric instruments are essentially diagnostic in nature. They are useful in assessing the intellectual, managerial, social and emotional competencies of individuals.

**Reliability**

Reliability is the consistency of one’s measurement, or the degree to which an instrument measures the same way each time it is used under the same condition with the same subjects. In short, it is the repeatability of one’s measurement. A measure is considered
reliable if a person's score on the same test given twice is similar. It is important to remember that reliability is not measured, it is estimated.

Reliability is concerned with questions of stability and consistency - does the same measurement tool yield stable and consistent results when repeated over time. Think about measurement processes in other contexts - in construction or woodworking, a tape measure is a highly reliable measuring instrument. There are two ways that reliability is usually estimated: test/retest and internal consistency.

**Test/Retest Reliability**

One of the easiest ways to determine the reliability of empirical measurements is by the retest method in which the same test is given to the same people after a period of time. The reliability of the test (instrument) can be estimated by examining the consistency of the responses between the two tests. The three main components to this method are as follows:

- Implement one's measurement instrument at two separate times for each subject;
- Compute the correlation between the two separate measurements; and
- Assume there is no change in the underlying condition (or trait to be measured) between test 1 and test 2.

If the researcher obtains the same results on the two administrations of the instrument, then the reliability coefficient will be 1.00. Normally, the correlation of measurements across time will be less than perfect due to different experiences and attitudes that respondents have encountered from the time of the first test. The test-retest method is a simple, clear cut way to determine reliability, but it can be costly and impractical.
Researchers are often only able to obtain measurements at a single point in time or do not have the resources for multiple administration.

**Internal Consistency Reliability**

Internal Consistency provides a unique estimate of reliability for the given test administration. The most popular internal consistency reliability estimate is given by Cronbach's Alpha. In short, CA splits all the questions on one's instrument in every possible way and computes correlation values for all.

The coefficient alpha is an internal consistency index designed for use with tests containing items that have no right answer. And, just like a correlation coefficient, the closer it is to one, the higher the reliability estimate of the instrument. Cronbach's alpha is a less conservative estimate of reliability than test/retest.

This is a very useful tool in educational and social science research because instruments in these areas often ask respondents to rate the degree to which they agree or disagree with a statement on a particular scale.

The primary difference between test/retest and internal consistency estimates of reliability is that test/retest involves two administrations of the measurement instrument, whereas the internal consistency method involves only one administration of that instrument.

**Validity Tests**

Validity is the strength of our conclusions, inferences or propositions. More formally, it is defined as the "best available approximation to the truth or falsity of a given inference,
proposition or conclusion”. There are three basic approaches to the validity of tests and measures. These are content validity, construct validity, and criterion-related validity. Some researchers even go with another measure i.e., face validity, while other merges face validity with content validity.

**Face Validity:** All that face validity means is: "Does the measure, on the face it, seem to measure what is intended?" Sometimes researchers try to obscure a measure’s face validity. It is often confused with content validity. Although face and content validity are similar, face validity involves a much more casual assessment of item appropriateness. It is but the least important aspect of validity, because validity still needs to be directly checked through other methods.

**Content Validity:** This approach measures the degree to which the test items represent the domain or universe of the trait or property being measured. In order to establish the content validity of a measuring instrument, the researcher must identify the overall content to be represented. Items must then be randomly chosen from this content that will accurately represent the information in all areas. By using this method the researcher should obtain a group of items which is representative of the content of the trait or property to be measured. Identifying the universe of content is not an easy task. It is, therefore, usually suggested that a panel of experts in the field to be studied be used to identify a content area.

**Construct Validity:** Construct validity must be investigated whenever no criterion or universe of content is accepted as entirely adequate to define the quality to be measured. The term construct in this instance is defined as a property that is offered to explain some aspect of human behavior, such as mechanical ability, intelligence, or introversion (Van
Dalen, 1979). The construct validity approach concerns the degree to which the test measures the construct it was designed to measure. There are two parts to the evaluation of the construct validity of a test. First and most important, the theory underlying the construct to be measured must be considered. Second the adequacy of the test in measuring the construct is evaluated.

**Criterion-Related Validity:** This approach is concerned with detecting the presence or absence of one or more criteria considered to represent traits or constructs of interest. One of the easiest ways to test for criterion-related validity is to administer the instrument to a group that is known to exhibit the trait to be measured. This group may be identified by a panel of experts. A wide range of items should be developed for the test with invalid questions culled after the control group has taken the test. Items should be omitted that are drastically inconsistent with respect to the responses made among individual members of the group. If the researcher has developed quality items for the instrument, the culling process should leave only those items that will consistently measure the trait or construct being studied.

### 2.11 Summary

In India, the available literature on the teaching and learning styles preferences of Engineering students appears to be scanty and sketchy. Further definition of Learning Outcome involving Learnability as a parameter seems to have not received attention. A majority of the literature that has been reviewed is based on foreign scenarios. The endeavor has been to distil nuggets of valuable information from the literature surveyed and transform them into a unified mass, tailored to the Indian Engineering context.
From the literature review the below gaps were identified in the area of Indian Engineering Education.

- Very less work is done to understand:
  - The predominant learning style preference of students
  - The predominant teaching methodology
  - The alignment between the Learning style preference and teaching methodology
  - Learnability of engineering students

- Corporate awareness of using any validated instrument for measuring learnability prior to recruiting does not exist.