1.1 ENGINEERING EDUCATION IN INDIA

Historical Aspect: Engineering education in India started during the British era and was focused mainly on civil engineering. A brief history of engineering education in India is available in the Rao Committee report [73] and the Ministry of Human Resource Development website [27]. The Engineering College at Roorkee (1847), Poona Civil Engineering College at Pune (1854), Bengal Engineering College at Shibpur (1856), Banaras Hindu University (1916), Harcourt Butler Technological Institute, Kanpur (1920) were some of the earliest engineering colleges established that continue till the present day. In 1945 the Sarkar Committee [78] was appointed to suggest options for advanced technical education in India. This committee recommended the establishment of higher technical institutes based on the Massachusetts Institute of Technology, USA, in four regions of India. This resulted in the setting up of the five Indian Institutes of Technology at Kharagpur (1950), Bombay (1958), Kanpur (1959), Madras (1960) and Delhi (1961) (Delhi was added on to the original four). The All India Council for Technical Education was set up in 1945, to oversee all technical education (diploma, degree and post-graduate) in the country.

Setting up of Private Engineering Institutes: Post 1990, there has been a significant increase in the number of engineering institutions and also in their student output with total intake standing at 550986 in the year 2006. Engineering is a preferred career choice for a large number of students at the 10 + 2 level in India. Many of the reputed engineering colleges (IITs and NITs) are highly selective in their admission process with the number of available seats being only 1-2% of the number applying. A large number of private engineering colleges have been set up. Though there is a mechanism for accreditation (National Board of Accreditation) and an umbrella agency, the All India Council of Technical Education (AICTE) has been set up to monitor and control engineering education; the quality of engineering education in many institutions is still under question. Has the engineering education system been able to provide the engineers
required for the growth of the Indian economy? Has the engineering education system provided the research and development leadership required for our industry? In the context of globalization, is there a need to modify the higher engineering education system in India? There are no clear-cut answers to these questions. It is clear that since Independence, India has produced a large number of competent, qualified engineers who have contributed to the success of many Indian companies and industries. A large number of our engineering graduates have also made an impact in the corporate world internationally. Despite these positive outcomes, a critical analysis of trends is required.

**Changing Focus:** Unlike a broad-based education in the arts or the sciences, the engineering education system is designed to train engineers for the engineering profession [55d]. Hence it has to meet the challenges and needs for engineers in the economy. As the nature of technology and industry changes, the education system needs to be responsive and adapt to the changing demands. There is a need for engineering educators to be conversant with existing practices in industry while also acting as agents to bring in innovation and improvements. Initially the focus of the engineering education system in India was to produce engineering graduates to implement operate and manage the growing industry that mainly relied on imported technology. Subsequently as the economy grew, there emerged a need for technology development and then for research and development. The engineering institutions that were primarily set up for undergraduate teaching started emphasizing research and evolved Masters and Doctoral Programs.

**Huge Growth Rate:** The growth of sanctioned intake in bachelor’s degree of engineering for the period 1990 to 2001, in India, stands at 9.1, with the CAGR for the period 1996 to 2001 standing at 17.4% Out of this astounding growth rate, the growth rate in computer engineering and information technology stands at 37.7% CAGR, followed by electronics and electrical engineering. About 32% of the sanctioned strength in 2001 was in computer engineering and information technology. For 2006, Computer Science and Information Technology accounted for 34% of the total, 39% for Electronics and Electrical Engineering, 12 % for Mechanical and 4% for Civil Engineering.[96] Compare the above figures with the growth rates in the US, where the CAGR for total B. Tech. degrees stands at 27% for the period 1996 to 2006. Out of this, the highest growth
rates are for Biomedical Engineering (16.3%), Aerospace (12.8%) and Computers (7.7%) [91].

**Unemployment of Fresh Engineering Graduates:** India clearly has one of the highest growth rates in terms of sanctioned intake for engineering education. Are these high growth rates impacting quality and resulting in unemployment / under employment of fresh engineering graduates? It is estimated that about 30% of the fresh engineering graduates are unemployed even one year after graduation (based on Annual Technical manpower Reviews [92]) of a few states. Several industry leaders complain about the shortage of quality engineering graduates. Though there is no conclusive statistics, it seems that the present growth is impacting quality.

It is also possible that the quality has not been able to match the quantity. There has been long lasting and never ending debate on the parameters used for the measurement of quality of engineers and engineering education. Despite this, out of many reasons assigned for the decline of quality in engineering education, pedagogy of engineering education is considered to be at the forefront.

### 1.2 PARADIGM SHIFT IN PEDAGOGICAL REFERENCES AND PRACTICES

A look at the Table 1.1 gives a clear picture of what and how of the “Paradigm shift in Pedagogical Practices”.

<table>
<thead>
<tr>
<th></th>
<th><strong>Old Paradigm</strong></th>
<th><strong>New Paradigm</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td>Transferred from faculty to students</td>
<td>Jointly constructed by faculty and students</td>
</tr>
<tr>
<td>Students</td>
<td>Passive vessel to be Filled by faculty’s knowledge</td>
<td>Active constructor, discoverer, transformer of knowledge</td>
</tr>
<tr>
<td>Mode of Learning</td>
<td>Memorizing</td>
<td>Relating</td>
</tr>
<tr>
<td>Faculty Purpose</td>
<td>Classify and sort students</td>
<td>Develop students’ competencies and talents</td>
</tr>
<tr>
<td>Student Goals</td>
<td>Complete requirements, Achieve certification within a discipline</td>
<td>Grow, Focus on continual lifelong learning with a broader system</td>
</tr>
<tr>
<td>Relationships</td>
<td>Impersonal relationship among students and between faculty and students</td>
<td>Personal transaction among students and between faculty and students</td>
</tr>
<tr>
<td>Context</td>
<td>Competitive / individualistic</td>
<td>Cooperative learning in classroom and cooperative teams among faculty</td>
</tr>
<tr>
<td>Climate</td>
<td>Conformity / cultural uniformity</td>
<td>Diversity and personal esteem / cultural diversity and commonality</td>
</tr>
<tr>
<td>Power</td>
<td>Faculty holds and exercises power, authority, and control</td>
<td>Students are empowered, power is shared among students and faculty</td>
</tr>
<tr>
<td>Assessment</td>
<td>Norm-referenced (i.e. graded “on the curve”), Students are rated at end of the course – there is no evaluation of the instruction</td>
<td>Criterion-referenced, Students and instructions both are continuously rated</td>
</tr>
<tr>
<td>Ways of knowing</td>
<td>Logico-scientific</td>
<td>Narrative</td>
</tr>
<tr>
<td>Epistemology</td>
<td>Reductionist, Facts and memorization</td>
<td>Constructivist, Enquiries and invention</td>
</tr>
<tr>
<td>Technology Use</td>
<td>Drill and practice, Textbooks and reference books Chalk and talk</td>
<td>Problem solving, Communication, Information access, Collaboration and expression</td>
</tr>
<tr>
<td>Teaching Assumption</td>
<td>Any expert can teach</td>
<td>Teaching is complex and requires considerable training</td>
</tr>
</tbody>
</table>

**Table 1.1 : A comparison of old and new paradigm for college teaching [43]**

Just as a fish cannot see the water it lives in, students and faculty often have difficulty "seeing" the context they live in. A common fear of inexperienced faculty is whether
they will have enough material to cover during a class period. Having enough material to cover is a central tenet of the old paradigm of college teaching. A question that any faculty would ask under the new paradigm is, “how shall I structure the learning environment so that students can explore and discover the important concepts in this course?” Many novice faculties assume that students will help each other outside the class, without crossing the line of cheating. However, it is difficult for students to know where that line is if they only work independently in the classroom. The new paradigms ask “how can I help students learn to work cooperatively where each member pulls their own weight?” Practicing teamwork in class will lead to improved teamwork, without cheating, outside the class. As a final example, consider power negotiation. In the old paradigm, faculty holds power and decision-making with negotiation (if any) being done implicitly and silently. The new paradigm calls for explicit negotiation of power [86].

A very interesting survey was conducted by Susan M. Lord and Michelle Madsen Camacho of Engineering Department and Sociology Department, University of San Diego, in 2007 [54]. Here, the respondents were the attendees at “Frontiers in Education” (FIE) conferences and included a unique population of engineering educators who demonstrated interest in pedagogy, probably beyond that of the typical engineering faculty member who is focused on technical research. The results showed that there was significant amount of agreement among their sample population on what they believed were the most effective teaching practices. Some of the best practices listed by the respondents were inquiry/inductive learning, building community, self-awareness of professor and small group work. Three themes - inquiry/inductive learning, building community, and small group work, were also ranked in the top ten themes by seventy six percent or more of the participants. All interviewees described a multi-method approach for their own teaching styles, despite some variation in favored styles. Informants view the coupling of teaching practices as more effective than the individual application of each. Twenty percent of interviewees explicitly addressed how important it was to take a multi-method approach to teaching given how different styles of learning can be.
1.3 NEED OF STUDY AND OVERVIEW OF RESEARCH

This study compares the significant changes in knowledge, skills and attitude of students of undergraduate electronics engineering courses, subjected to pedagogy of Problem Based Learning to that of Direct or Traditional Teaching.

PBL is being practiced worldwide and in many universities. At McMaster University, the engineering program has used a PBL approach since last 20 years. Prior to the initiation and development of this PBL program, engineers Crowe and Woods examined the undergraduate program by participating in the classes to determine what the students were learning and where the specific difficulties were with the course content [28]. Aalborg University implemented a PBL curriculum in 1974. Monash University in Australia and the University of Manchester in England have programs and courses with PBL curriculum. In Singapore, both Temsaek Polytechnic and the Republic Polytechnic have completely PBL curricula for Computer, Electrical and Industrial Systems Engineering and Diploma programs. Other universities across the world do have courses in engineering programs that are conducted with the PBL approach [65]. The results of PBL however vary according to the subject being taught and the evaluation strategy being adopted.

Dale in his Cone of Learning Model suggests that people learn and retain 20% of what they hear, 30% of what they see, 50% of what they see and hear, 70% of what they say, and 90% of what they experience directly or practice doing [22]. PBL is believed to prepare students better, for learning and group-work; however it is yet to be fully embraced throughout our engineering education system. In India, specifically, there are very few instances of using PBL to impart education in undergraduate Engineering courses. Wherever these instances have been, they were subject and teacher specific and there has been no effort to measure the performances. There has been no effort to introduce PBL in a structured manner and there has been no published work on measurement of results.

Engineering has been to study theoretical concepts and the ability to apply them to practice. The curricula in UG courses in Engineering are made up of theoretical and analytical subjects. Although PBL can be used for all subjects uniformly, as it truly
simulates the real life situation, the idea of using PBL to facilitate learning in analytical courses is a natural choice.

The literature implied an overall need that graduates of engineering be creative. The engineering industry wants thinkers and problem solvers, so likewise we should use education techniques that foster creativity in students [45]. The Problem itself is taken as the starting point and the concept becomes the facilitator. The students search for the information and develop the requisite understanding by reading the literature, doing the required calculations, performing the practical work to verify and authenticate the calculations, applying the concepts so learned to reach at the solution to the problem. As against the traditional way of adopting traditional / routine ways, it is the process by which the students actively learn and contribute, as opposed to sitting passively in lecture hall, listening to, and memorizing facts.

Industry continuously needs and demands people who can think, innovate, notice, draw inferences, analytically work on the problems, and take corrective actions so as to continually improve the results. In other words the only two areas which are of importance are the problem solving skills and lifelong learning ability of the engineers. Engineers in the technical life need to be lifelong learners, continuously learning from the good and bad experiences on the shop floor. Simply memorizing the facts and concepts and knowing the solutions to the few problems during the graduation does not and cannot help an engineer in real technical career.

The principal reasons that constitute the need for the researcher to take up this study are:

1. Engineers need to be problem solvers. They must have the necessary aptitude, attitude, logical reasoning power and the technical know-how so that when given a problem they must possess the ability to observe & understand, gather and comprehend required data, infer and collate information, interpret the facts, form & work in team, solve & present the solution within the prescribed time, financial, resource and space constraints.

2. The present method of class room teaching, with prescribed syllabi, predefined aims of the experiments and preformatted lecture plans does give a structured and time framed method of imparting instructions, but it hardly prepares the students for developing the problem solving attitude and aptitude in them. The pedagogy has little
room for collaborative work and thus does not prepare them for team skills. All methods of evaluation have variations in testing the students on theoretical concepts and analytical methods. The skill tests are merely the end term viva-voce examinations. The evaluation strategy is based on testing individual knowledge and skills and has no component of team evaluation. The integration of all the above and extrapolation of concepts so that they are applied to real life problems are the matters which are left to the project work, which the students handle in the last year of engineering.

3. In India and particularly in the North-Western region, where approximately 169 engineering colleges are situated, with annual intake of 58304 [7], the only method of imparting education is through Lecture / Tutorial / Practical (L/T/P) methodology. Indian students are proved to be the best in theoretical concepts and mathematical abilities. However, as far as abilities of high level application of the concepts, skillful use of resources and other abilities, mentioned in (2) are concerned, they still need a lot of improvement.

4. Within the literature, we see widespread support about the benefits of PBL & its motivational effects on the students, working on open ended problems and its beneficial long term effects on lifelong learning. Success in an electronics engineering curriculum has long relied on the ability to creatively solve problems and successively apply the concepts learnt in the previous courses to the courses in the next semester. Since all the courses in the curriculum are so inter-woven and the performance of the students in one course depends on the concepts learnt in the other courses, it is very much required that the students learn to apply concepts appropriately and learn to extrapolate it, right from the beginning.

Moreover, there are instances available in the literature to use varied techniques viz. web based learning, use of animated literature, use of various simulation software to understand and facilitate learning of circuit design, signal processing and VLSI design and many more; there are however very few or no instance of designing a whole curriculum for building the abilities described in (2) above. There are also no instances available for integrating all the above facilities into PBL.

5. The All India Council of Technical Education (AICTE), University Grant Commission (UGC), Department of Technical Education, The National Board
Accreditation (NBA), Ministry of Human Resource Development (MHRD) all have suggested time and again [26] through their various regulatory acts and annual reports that there is an immediate need to revise not only the content, but the pedagogy also, in various engineering programs, to incorporate creative problem solving, engineering design and applied design. The inclusion of PBL as the method to be adopted for imparting the education at undergraduate level in technical education can be the answer to all those efforts of improvement in the education system. There is still a long way to go before PBL can be introduced on a wide scale as the teachers have to be taught to become facilitators and the students to become doers rather than just the listeners.

6. “Engineers are problem solvers”. This is a statement with which few educators would disagree. However, there is a disagreement as to how engineers are taught to be problem solvers [108]. Based on the evidence from over 30 years of engineering programs in Europe and North America, the answer to this question appears to be: using a PBL approach [65].

Embarking upon this path of curriculum revolution is not without its challenges. As stated by Glen O’grady at the Republic Polytechnic:

“It is not difficult to find educators who are sympathetic to the principles of PBL but what is challenging is having the will, capacity, opportunity, and the knowledge of how to apply these principles to specific contexts. For those embarking on the path of implementing PBL, the way is often unmapped and the light is dim.” [70]

An ancient proverb suggests: The journey of thousand miles starts with the first step. This thesis work is the first step towards redesigning the curriculum of basic courses in Electronics Engineering to incorporate PBL and evaluate the effectiveness of this improved method to problem solving techniques.

1.4 THEORY OF CONSTRUCTIVISM AND INSTRUCTIONAL PRINCIPLES

Constructivism is a philosophical view of how we come to understand and know. There are three primary propositions:

1. Interactions with the environment: Usually what is learnt is more clearly understood by knowing how it is learnt. It is also important to know, that what we understand is a function of the content, the context, the activity of learner and perhaps, most
importantly, the goals of the learner. Now, since understanding is an individual construction, we cannot share understanding but rather we can test the degree to which our individual understandings are compatible. An implication of this proposition is that cognition is not just within the individual but rather it is a part of the entire context, i.e. cognition is distributed.

2. **Cognitive conflict or puzzlement:** In a learning environment, the learner has some purpose for being there. That goal is not only his stimulus of learning, but is primary factor of determining what he intends to learn, what prior experience the learner brings to bear in construction and understanding and basically, what understanding is eventually constructed. It is the problem that leads to and is organizer of learning [23]. Learners’ puzzlement is the stimulus and organizer for learning since this more readily suggests both intellectual and pragmatic goals for learning. Alternately, it is the goal of the learner that is central in considering what is learned.

3. **Evolution of knowledge:** Knowledge evolves through social negotiations and through the evaluation of the viability of individual understandings. The social environment is critical to the development of our individual understanding as well as to the development of the body of propositions which we call as knowledge. Questions by and interaction with other individuals are primary mechanisms for testing our understanding. Collaborative groups are important because we test our own understanding and examine the understanding of others as a mechanism for enriching, interweaving and expanding our understanding of particular issues or phenomena. In a societal set up, other people are the greatest source of alternative views to challenge our current views and hence to serve as the source of puzzlement that simulates new learning [99]. The second role of social environment is to develop a set of propositions we call knowledge. We seek propositions that are compatible with our individual constructions or understanding of the world. The concepts that we call knowledge, do not represent some ultimate truth, but are simply the most viable interpretation of our experimental world. [76]. The important point in the third proposition is that all views, or all constructions, are not equally viable. Constructivism is not a deconstructive view in which all constructions are equal simply because they are personal experiences. Rather they seek viability and thus we must test understanding to determine how
adequately they allow us to interpret and function in our real world. Our social environment is primary in providing alternative views and additional information against which we can test the viability of our understanding and in building the set of propositions (knowledge) compatible with those understandings [20]. The constructivist propositions outlined above suggests a set of instructional principles that can guide the practice of teaching and the design of learning environments. The idea is to dwell and hit upon a strategy for summarizing the constructivist framework in a way that may help with the interpretation of the instructional strategies. Traditional educational technology characteristics of reliability, communication, and control, contrast sharply with the seven primary constructivist values of collaboration, personal autonomy, creativity, reflectivity, active engagement, personal relevance and pluralism [50].

The instructional principles deriving from constructivism are as follows [85]:

1. Anchor all learning activities to a larger task or problem.
2. Support the learner in developing ownership for the overall problem or task.
3. Design an authentic task.
4. Design the task and the learning environment to reflect the complexity of the environment they should be able to function in, at the end of learning.
5. Give the learner ownership of the process used to develop a solution.
6. Design the learning environment to support and challenge the learner’s thinking.
7. Encourage testing ideas against alternative views and alternate contexts.
8. Provide opportunity for and support reflection on both the content learned and the learning process.

1.5 THEORY OF PROBLEM SOLVING

What does problem solving involve? Psychologists are not totally in agreement on this basic issue [109], but many believe that four major aspects, as summarized in Fig 1.1 are central.
Fig 1.1  : Four major aspects of problem solving

The first step is problem identification: We must recognize that a problem exists and then figure out just what issues, obstacles, and goals are involved.

Second, we must formulate potential solutions: While this too might seem fairly simple, it is actually very complex [110]. Solutions do not arise out of a cognitive vacuum; they require critically thinking about a problem, and they depend heavily on the information at our disposal and the information stored in long term memory that can be retrieved. The more the availability of information, the greater is the number and the wider is the scope of potential solutions that we can generate. Formatting a wide range of possible solutions is an extremely important step in effective problem solving. Short term memory helps us to look for ideal solutions to problem solving in both traditional and problem based education. It assists the manipulation of ideas and is where the actual mental problem solving process is handled. The simple process of remembering for a short period of time is fundamental to our experience of the real world. Long term memory in contrast is a stockpile of knowledge, skill, and experience called into short term memory as the need arises.

Third, we must evaluate each alternative and the outcomes it will produce. Will a given solution work or bring us closer to the goal we want? Are there any serious obstacles to its use? Are there any hidden costs that will make it less useful than it seems at first? These are the considerations that we must take into account.
Finally we must try potential solutions and evaluate them on the basis of the effects they produce. All too often, a potential solution is only partially effective: it brings us closer to where we want to be but does not solve the problem completely or finally.

In many other situations though it is difficult to know how effective a potential solution will be unless it is implemented. Thus careful assessment of effects of various solutions is another key step in the problem solving process.

Methods of Problem Solving: Perhaps the simplest problem solving method is trial and error. It involves trying different approaches until, perhaps, one works. But such an approach is not very efficient and does not guarantee that a useful solution will be found. A second general approach is the use of algorithms. These are rules for a particular kind of problem that will, if followed, yield a solution.

Finally we sometimes attempt to solve problems through the use of analogy – the application of techniques that have worked in a similar situation in the past. People frequently solve the problems by analogy, although they remain unaware that they have done so.

To summarize, selecting an appropriate strategy is critical to effective problem solving.

Facilitating effective problem solving: Research on the “Role of meta-cognitive processing” suggests that talking through a problem helps divert attention away from irrelevant aspects of the problem and toward aspects that are important in the search for a solution. In other words talking through a problem may facilitate our ability to solve problems by expanding our level of awareness – in a sense allowing us to observe ourselves engaged in the process of problem solving. This process has been termed as metacognitive processing.

Factors that interfere with effective problem solving: Sometimes despite our best efforts we are not able to solve problems. In many cases our failure stems from obvious cause, such as lack of sufficient data or experience. We may use internal frameworks that allow us to represent the problem situation fully and effectively. As a result we don’t know which variables and factors are more important. In other cases the difficulties in problem solving stems from more subtle factors.
**Functional fixedness:** Our strong tendency is to think of using the objects, only in the ways they have been used before. Unless we avoid functional fixedness, our ability to solve many problems can be seriously impaired.

**Mental set:** Another factor that often gets in the way of effective problem solving is mind set to stick to tried and true. This is the tendency to stick with a familiar method of solving a particular type of problem – one that has worked before. Difficulties arise when this mind set causes us to overlook other more efficient approaches.

**1.6 COLLABORATIVE LEARNING, GROUP DYNAMICS AND SOCIAL ATTITUDES**

A typical public educational system has qualities and dynamics that influence how our professional knowledge, skills, relationships, and attitudes are established and informed within the system. In the social connectivity within a school and its system, we find relationships and attitudes concerned with student-teacher, student-student, teacher-teacher and teacher-administrator relationships [36].

A collaborative learning environment plays a very important role in knowledge building, sharing, and distribution, since collaboration among learners has a significant impact on learning outcomes [35] [8]. Collaborative learning is an approach to learning in which students of different abilities and interests work together in small groups in order to solve a problem or complete a project. This approach involves group activities, and active participation, interaction and communication on the part of both students and instructors [46]. The instructor organizes a class into groups and assigns specific tasks or projects to each group. The members of a group are focused on completing a task. Each group member must participate, and is responsible for the successful completion of the group’s assignment. Before the group work starts, the instructor should present students with their assignments and responsibilities, the regulations for group work and the rules for the evaluation of assignments. Group work is organized into several stages: the initial stage of forming groups, the distribution of group tasks or assignments, autonomous group work on assignments, the presentation of results to the instructor and the other groups, and the evaluation of group work and assignment results. The critical point at the start of group work concerns the formation of these groups. Groups can be formed according to various criteria. Some instructors let students independently choose
with whom they want to work; others prefer to assign students randomly to groups so as to maximize their heterogeneity. However, many instructors prefer to form the groups by taking into account students’ prior achievements or knowledge, and their levels of preparation, work habits, and gender [41]. Very often, homogenous groups are formed, by placing well-prepared students in groups with other well-prepared students. During the group-work on assignments, members support each other, manage their group activities and focus on their tasks. The instructor / facilitator should provide tools and techniques for the tasks, affirm their good work, and must stay in the background when not needed. The crucial part in this stage is a well-established communication between group members [46]. The last stage of learning is evaluation, which includes students’ reflection on their task as well as a task-completion check. This evaluation allows students to reflect on their own problem solving process: what did and what did not work well in the group and how could the group’s learning process be improved? The main problem with group work is that it is time-consuming. Information and Communication Technologies (ICT) can be used to minimize this disadvantage, and to facilitate collaborative learning. In particular, computer-mediated communication (CMC) gives students an opportunity to work on collaborative projects in an online learning environment [25] [42] [72]. Instructors do need to pay special attention to students engaged in online collaborative learning because of the physical and psychological separation between them [46]. This monitoring can best be accomplished by using various forms of asynchronous CMC.

1.7 COGNITIVE STYLE

Cognitive style or "thinking style" is a term used in cognitive style psychology to describe the way individuals think, perceive and remember information, or their preferred approach to using such information to solve problems. The importance of Cognitive style learning has gained increasing attention because, too often, discrepancies exist between school tasks and diverse cognitive capabilities and styles of the learners. Cognitive styles research is a significant predictor of an individual’s educational success. It remains a key concept in the areas of education and management. If a pupil has a similar cognitive style to his/her teacher, the chances that the pupil will have a more positive learning experience is said to be improved. Likewise, team members with
similar cognitive styles will probably feel more positive about their participation in the team. While the matching of cognitive styles may make participants feel more comfortable when working with one another, this alone cannot guarantee the success of the outcome.

A cognitive style dimension with implications for education is called psychological differentiation, also known as field independence or global and analytic perceptual style. Field Independent people are able to identify a specific element from within a complex field. Field independence is the extent to which a person perceives part of a field as discrete from the surrounding field as a whole rather than embedded in the field; the extent to which a person perceives analytically. People, who are high in psychological differentiation (field independent, articulate, individualistic) perceive more analytically. This ability allows the field – independent to be superior problem solvers

Field Dependent People are low in psychological differentiation and have difficulty in differentiating stimuli from the context in which they are embedded, so that their perceptions are easily affected by manipulations of the surrounding contexts. These people are thus inferior problem solvers.

1.8 PBL DEFINED

PBL education has two main components: the starting point is a problem; and a student-centered approach that affords students control over and responsibility for their own learning [74]. This is in contrast to traditional programs, which are teacher-centered, where the teacher or textbook determines what the student should know [105]. The teacher in PBL is the facilitator, coach, or guide on the side, rather than the sage-on-the-stage. The PBL curriculum is organized around a series of problems and the conditions for learning favour self-directed learning, group work, critical thinking and self-reflection [74]. Exploring the literature on PBL reveals that many words are used to describe this teaching method: research project, case method, design project, experiential encounter, project-oriented, cooperative learning, explanation-based learning, active learning, or small group learning [107]. This is not even an all-inclusive list. No matter how it is described, essentially PBL is learning which results from the process of working towards the understanding or resolving a problem [83]. PBL was originally conceived to involve small groups of five to ten students with a faculty member as the
tutor. This is the structure at many Canadian schools of nursing and medicine. However, PBL has been adapted to large groups, particularly in engineering programs [74]. For example, this is the application in the chemical engineering programme at McMaster University, Hamilton, Canada. PBL curricula can also include tutor-less groups or groups with a wandering tutor [28]. In the case of the tutor-less groups, students’ group-process and facilitation skills are developed first in order for students themselves, to lead a group. The wandering tutor scenario generally involves a faculty member as the tutor being available to many small groups that operate concurrently in one classroom. Thus, PBL can be integrated into an engineering curriculum along a continuum from completely integrated problems to a hybrid curriculum where several PBL classes are offered with lecture courses [74]. The PBL process consists of six steps, as follows:

1. Exploration of the problem and generation of hypotheses;
2. Identification of learning issues (based on prior knowledge) and information sources;
3. Information gathering and independent study;
4. Critical discussion of the knowledge acquired (in a group setting);
5. Application of knowledge to solve the problem;
6. Reflection on the process and provision of feedback [107] [74].

This process is distinctly different than a traditional approach. In a traditional programme, students embark on learning by being told what they need to know, learning it and then being given a problem to illustrate how to use what they have learned [1]. This is a linear, teacher-centered process. Conversely, in PBL, the learning begins with a problem, students identify what they need to know, they learn it, they apply it to the solution of the problem and generate more problems and more learning needs in this cyclical process. The theoretical rationale for the PBL approach is rooted in cognitive psychology. Prior knowledge is an important determinant of the amount and type of new knowledge that can be integrated and this prior knowledge needs to be activated in the context of information being studied. Thus, by starting with a problem, the student is able to identify his/her learning needs and structure the acquisition of new knowledge accordingly. The way knowledge is structured in the memory ultimately affects its ability to be retrieved. This is the dilemma often seen in traditional programs. Students
cannot use knowledge they have learned from a lecture or a textbook in the practice setting. The ability to use this memory depends on contextual cues; the use of a problem around which to organize knowledge provides such a cue and facilitates recall of the information [108]. Education based on a philosophy of PBL is a building process that is exciting and motivating to the adult learner. The PBL process was first developed as an alternative to traditional medical education and was implemented in 1969 in the medical school at McMaster University. PBL curricula have spread worldwide in many other disciplines, such as engineering, also including nursing, architecture and business [107] [74]. Due to the prevalent use of PBL, particularly in health sciences, a significant amount of published research exists to support its use as an effective curriculum design.

1.9 HISTORIC DEVELOPMENT OF PROBLEM BASED LEARNING

Problem-based learning is intrinsic to traditional apprenticeships, but apprenticeships were not assessed in a standardized way. The literature suggests problem based learning was first introduced to North American medical schools in the 1960s as a tutorial process for promoting lifelong learning. Albanese and Mitchell [1] traced its roots back to McMaster (Canada), University of Limburg at Maastricht (Netherlands), and Harvard University (USA). The traditional school acceptance of PBL is based on Harvard Medical School, which employed a hybrid problem based model of conferences, clinical sessions, lectures, and tutorials [5]. The mid-1980s saw PBL evolve as a more descriptive process than an analytical process, and the research of that period mostly relates to student perceptions and student performance in certain aspects of a course. Few impact studies of the time relate to graduates, the faculty, the institution, or the profession. Most literature evidence stems from a handful of medical schools, with no examples of coherent PBL curricula for other professions. In this period, the PBL model spread to form a network of professional schools, including Maastricht and the University of California at Berkeley. By the early 1990s, more than 50 medical schools had adopted PBL in some format. Today, over 80% of medical schools and many professional (e.g., architectural and construction) schools use PBL to teach professional cases [13]. In time, overseas universities adopted and adapted PBL for medical school training, including Maastricht (the Netherlands) and Newcastle (Australia). In the United
States, the University of New Mexico adopted the McMaster model [5]. Of all teaching methods, problem-based learning is best studied in a scientific sense. Problem-based learning as a medical teaching tool has now branched into many medical institutions, such as Boston, Georgetown, Harvard, Illinois, Indiana, Michigan State, Northwestern, Southern Illinois, Mercer, Tufts, University of Hawaii, University of Illinois, University of Missouri-Columbia, University of Pittsburgh, University of Texas-Houston, and Wake Forest-Bowman Gray (LeMaster, 1996; Robbs & Meredith, 1994). Other countries using it to teach undergraduates include Australia, Canada, Denmark (Aalborg), England, France, Finland, South Africa, the Netherlands, and Sweden [11]. These countries currently implement and use PBL in medical and professional schools. In summary, problem-based learning as a teaching tool is now used globally in many areas of higher education, such as schools of dentistry, health sciences, nursing, pharmacy, public health, veterinary medicine, architecture, building, business, computing, education, engineering, forestry, law, police science, social work, and other professional fields.

1.10 OVERVIEW OF SUBJECTS IN THE SCHEME OF ELECTRONICS AND COMMUNICATION ENGINEERING

With a number of notable exceptions, most engineering programs have been based on a very traditional curriculum and way of teaching [2]. As in the curriculum of any other branch of Engineering, there are subjects, which are very basic in nature, some are analytical, some are theoretical and some are purely demonstrational an applications of basic subjects; others are cross trait in nature, which serve as bridge or offshoots of the core branch and which are generally offered as elective courses. Almost all are taught in the very traditional classroom teaching methods; some subjects are taught in combination with the laboratory experiments [2]. Each subject is taught by an individual teacher with an examination for each subject at the end of the semester. These subjects’ cores are isolated from each other by strict boundaries and the students study the theory first and then attempt to apply it in practice [34].

Educational objectives of the Electronics and Communication Engineering Program

- To develop strong mathematical and analytical skills in the students.
• To develop in the students a good understanding of the concepts underlying the various areas of Electronics and Communication engineering.
• To develop strong analytical skills in the students that will enable them to pursue a career in any area of research & design in Electronic Hardware & Software, and Telecommunications & Control Systems.
• To provide students with the opportunities to learn teamwork and leadership skills.
• To inculcate amongst students the joy of learning so that they will be able to see each step in their career as an opportunity to learn.
• To provide students the experience of working with the latest hardware and software.
• To expose students to the experience of working on time bound projects where they will learn how to formulate and solve problems, delegate work amongst various team members, set goals and deadlines, and learn to present their results.
• To encourage students to explore the application of the skill learnt in this discipline of Electronic and Communication Engineering to multidisciplinary areas.
• To instill in students strong moral values and a good sense of work ethics.
• To develop in the students good oral and written presentation skills.
• To prepare the students to successfully compete for the best jobs in the field both within the country and in the global arena.

**Outcomes of the Electronics and Communication Engineering Program are:**

**Outcome 1:**
Students will demonstrate a fundamental knowledge in:
- AC/DC Circuit Analysis
- Login Circuits
- Semiconductor Theory

**Outcome 2:**
Students will demonstrate the ability to apply current math and science concepts in the area of electronics.

**Outcome 3:**
Students will demonstrate the fundamentals of:
- Graphical Communication Skills
- Written Communication Skills
• Laboratory Procedures

Outcome 4:
Students will demonstrate a working knowledge of:
• Linear Integrated Circuits
• Electronic Control Systems
• Communications Circuit Theory
• Computer Circuits and Systems

Outcome 5:
Students will demonstrate an advanced working knowledge of one or more of the following:
• Telecommunication Systems
• Control Systems
• Other advanced applied topics

Outcome 6:
Students will complete the “Capstone Experience” by developing, designing, reviewing, presenting and demonstrating a functioning prototype of an original intellectual property device.

Thus, every graduate of the program should be able to
○ Apply the mathematical skill and to upgrade them as necessary.
○ Use the mathematical skills to analyze and to interpret data.
○ Work independently and in a team.
○ Formulate and solve complex engineering problems.
○ Remain informed of all contemporary issues and his/her role in job and society.
○ Communicate effectively.
○ Acquire and update knowledge constantly.
○ Put each job in the context of betterment of society and humanity at large.
○ Exhibit strong entrepreneurial skills which can be used to benefit not just him but a larger section of society.
○ Understand and execute his social and professional responsibilities.

The basic/fundamental subjects of Electronics and Communication branch from which other subjects evolve are – Electronic Devices and Circuits (EDC), Analog Electronics
(AE), Network Analysis (NAS), Digital Electronics (DE), Linear Control Systems (LCS), Electromagnetic field theory (EMFT). These subjects are and will be there in the program scheme for all times to come. The application oriented courses and their contents may or may not change depending on their viability and usefulness to the parent branch and their demand in the market.

1.11 PROBLEM BASED LEARNING AND ELECTRONICS ENGINEERING

The reasons that prompt the use of problem based learning in Electronics and Communication Engineering are (a) cognitive (b) motivational and (c) functional.

Cognitive reasons deal with comprehension and learning, and the research on traditional learning indicates that rote learning may be effective in the short term for routine tasks and tests but is ineffective for deeper understanding and retention of complex problem solving. Likewise in cognitive research, students have, what is termed as inert knowledge, which in traditional learning problems is used very little, but which, in problem based learning, is used more fully. The course of Electronics Engineering is designed to prepare students to handle various jobs related to handling of Electronic Equipments, their design, development, troubleshooting, handling and extending technical support to Electronic industry. Many offshoots of this branch of engineering are into communication, control and instrumentation too.

Motivational reasons deal with incentives and attitudes and how students focus on the problem, issues, questions raised and the teacher’s assessment, nurturing, and support. Attitudes are difficult to gauge, but, if measured with care, they indicate that specific support can create a more positive attitude towards a given issue than when not supported.

PBL goes beyond this with group dynamic elements adding as a social and interpersonal angle to learning [49]. Although attitude studies are often associated with change alike or dislike, the text indicated many traditional education students move up through an academic climate of competition where success is grounded in how clearly they set themselves apart from the rest of the group and where students’ attitudes and their motivational conditions of acceptance and self awareness are often focused on themselves rather than others in the team. Also as new students of PBL come into a
learning environment, their acceptance as part of a group plays a pivotal part in their own progress and the progress of the other members of that group. It is this attitude in accepting other members of a group within PBL, where students have to take the weaknesses with the strengths, that students are likely to become much more aware of their own strengths and their own weaknesses [49].

**Functional reasons** deal with how closely the problem is aligned to the needs of the 21st century and simulate a real world concept or helps prepare students towards technology, communication and presentation skills arising out of the problem. Yet, [13] indicates that to achieve success on a test in traditional education, students seek a right answer because their performance is measured on content specific tasks, whereas in PBL faculty discouraging one right answer can instead help students learn how to frame questions, formulate problems, explore alternatives and make effective decisions.

This thesis work is done to start with using PBL approach for the basic subjects of Analog Electronics and Digital Electronics and the advanced subject of Pulse and Switching Circuits (PDSC) and to measure the effects of pedagogy, cognition and gender of the students on their knowledge and skills. It so happens that merely memorizing the facts and concepts of the basic courses does make the students pass the theory and practical end semester exams, but when it comes to the subjects like Pulse, Digital and switching circuits (PDSC) antenna and wave propagation (AWP) and more advanced subjects which are based on the basic subjects listed as above, the students do show their inability to perform, if the concepts of the basic subjects are not clear.

### 1.12 STATEMENT OF THE PROBLEM

1. The intent of this study is to impart the instructions for existing study scheme and curriculum of Analog Electronics (AE), Digital Electronics (DE) and Pulse, Digital & Switching Circuits (PDSC) for undergraduate students of Electronics and Communication Engineering, Punjab Technical University using Problem Based Learning.

2. Once PBL is incorporated and practiced, the intent would be to determine if the knowledge, skills and attitude of the students would significantly differ with problem based learning as mode of instruction from those students, who were taught using Traditional approach.
1.13 PRINCIPAL RESEARCH QUESTIONS

The major research focus for this study is: Does the use of Problem based Learning has any effect on knowledge, skills and attitude when compared to students enrolled in traditional courses?

Following research questions were identified:
1. Is there a main effect of pedagogy on knowledge?
2. Is there a main effect of pedagogy on skill?
3. Is there a main effect of pedagogy on attitude?
4. Is there a main effect of gender on knowledge and skill scores?
5. Is there a main effect of cognitive style on knowledge and skill scores?
6. Is there a significant interaction between gender and pedagogy on knowledge and skill scores?
7. Is there a significant interaction between cognitive style and pedagogy on knowledge and skill scores?
8. Is there a significant interaction between cognitive style, pedagogy and gender on knowledge and skill scores?
9. Are above results facilitator independent?

1.14 ASSUMPTIONS OF THE STUDY

1. The students would participate voluntarily in the study.
2. Students entering in the study of the AE, DE and PDSC courses would have little knowledge of those particular subjects.
3. The research sample would have little / no knowledge of PBL.
4. The environment in terms of working conditions, resources and facilitator / teacher would be uniform.
5. The research samples as students would be motivated individuals so that the study could be completed.
6. The testing instruments used in the study would accurately measure the achievement, performance and attitude of the students.

1.15 DELIMITATIONS OF THE STUDY

Since the curriculum put to test is being followed by as many as 102 institutes (affiliated to Punjab Technical University) across Punjab, India, but the since the research work
The study was carried out at one particular institute, the research samples were taken from this particular institute only.

The Study was conducted in six batches with approximately 67 students taken each time, out of which PBL group and Traditional groups were made. The study, thus, might not adequately represent the total population across the North India or all the students who might undergo the same course and curriculum across North India.

The classifying variables were only two – cognitive style and gender. There can be many other ways of classifying the sample.

The research was carried out in the three subjects of AE, DE and PDSC only. The results thus found after this study should be extrapolated to other subjects and engineering programs with caution.