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Problem-based Learning: Influence on Students' Learning in an Electronics & Communication Engineering Course

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Keywords: PBL, Learning, Cooperative, Self directed, Well Structured, Deep Content, Knowledge, grounded

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PROBLEM-BASED LEARNING INFLUENCE ON STUDENTSLEARNING IN AN ELECTRONICS COMMUNICATION ENGINEERING COURSE

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Priyanka Mahendru [α],Prof. D.V.Mahindru [Ω]

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The main problem within engineering education is the gap between the active field and the passive classroom experience (Palmquist, 2007). In general, the traditional lecture method within engineering education is deductive, "beginning with theories and progressing towards application of those theories" and the instructor presents information without a discussion of why the mathematical models are being developed and what practical problems they will solve (Prince & Felder, 2006). and not specific to the situation in which the task needs to take place. This pedagogical approach falls short because the knowledge is not grounded. Dewey suggested that educators needed to encourage inquiry and that education should be grounded on experience and linked to real-life activities in order to motivate and develop students into upstanding citizens. The problem-based learning (PBL) has the potential to help students to cope with the demands of complexities of the field and problems they will face in their future careers.

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This appears initially to make complex tasks more manageable; but we pay a hidden price: we can no longer see the consequences of our actions, and we lose our intrinsic sense of connection to a larger whole. When we want to see the big picture, we try to reassemble the fragments and organize all the pieces. The task is futile– similar to trying to reassemble the fragments of a broken mirror!

In addition, while science and engineering jobs experienced annual average growth rate of 6.7% (compared to 1.6% for total employment) between1950-2000, the attrition rate for students has steadily increased and the annual graduation rate decreased by 20%, (Felder, Felder, & Dietz, 1998; NSB, 2008). One of the complaints from engineering students is that the current teaching pedagogies (such as, traditional lecture format) emphasize explicit instruction, working individually, and norm-reference grading, which can make learning extrinsically motivating rather than intrinsically motivating(Felder, et al., 1998). The main problem within engineering education is the gap between the active field and the passive classroom experience (Palmquist, 2007). To study the impact of problem-based learning (PBL) on undergraduate Electronics & Communication engineering students' conceptual understanding and their perceptions of learning using PBL as compared to lecture. Fifty students enrolled in an Electronics & Communication course at SRMGPC, Lucknow, volunteered in this research project. Results found out that participants' learning gains from PBL were much higher their gains from traditional lecture

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I. Introduction

PBL, or Problem Based Learning, is an instructional method of group-based learning centered on utilizing each member of the group's own information, resources, and personal experiences. The group must then compile their knowledge in an effort to solve the open-ended problems. What makes this method of teaching interesting is that there is no one, real "right" answer.

Problem-Based Learning Process

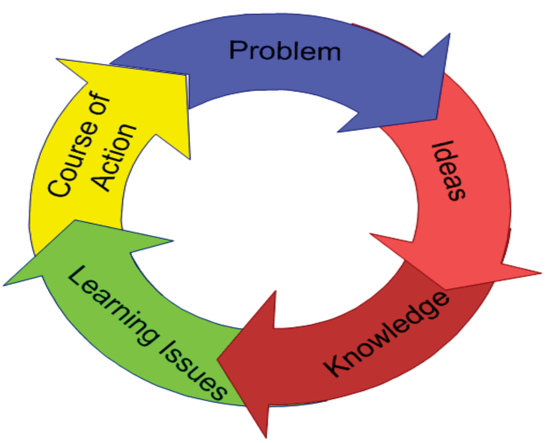
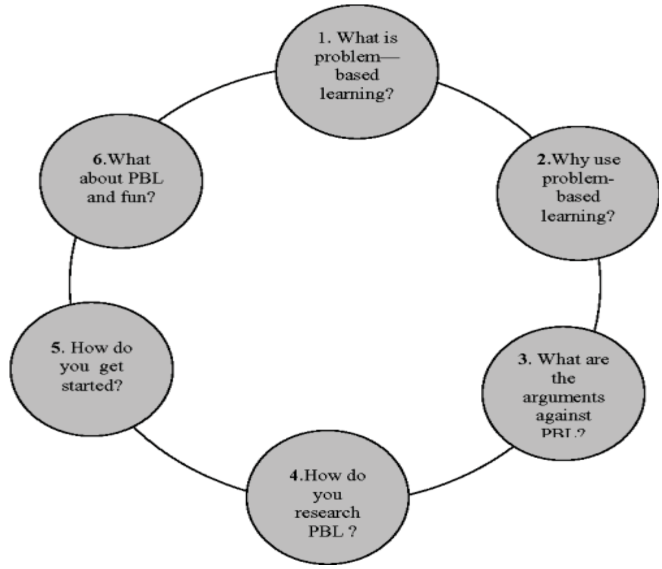


Figure 1: Problem Based Learning Process

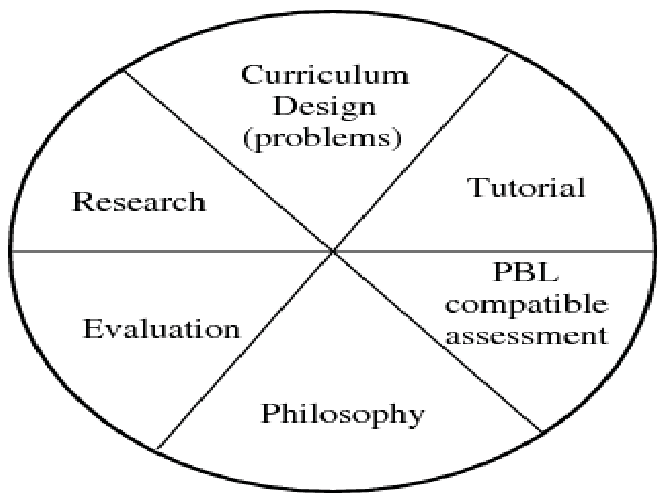
The following diagram gives you a visual overview of the structure of the PBL



II. Definition

Barrows defines PBL as follows:

The learning that results from the process of working towards the understanding of a resolution of a problem. The problem is encountered first in the



learning process (Barrows and Tamblyn 1980:1 my emphasis)

An operational definition of problem-based learning is as follows:

i) First students are presented with a problem.

ii) Students discuss the problem in a small group PBL tutorial. They clarify the facts of the case. They define what the problem is. They brainstorm ideas based on the prior knowledge. They identify what they need to learn to work on the problem, what they do not know (learning issues). They reason through the problem. They specify an action plan for working on the problem.

iii) Students engage in independent study on their learning issues outside the tutorial. The information sources they draw on include: library, databases, and the web and resource people

iv) They come back to the PBL tutorial (s) sharing information, peer teaching and working together on the problem

v) They present and discuss their solution to the problem

vi) They review what they have learnt from working on the problem. All who participated in the process engage in self, peer and tutor review of the PBL process and each person's contribution to that process.

a) Problem-based learning is "Problem"+"based" +"learning". Let us look at each of these words. A problem is something that is problematic to the student; something that cannot be resolved with the current level of knowledge and/or way of thinking about the issues. The nature of effective problems in problem-based learning is that they are ill-structured as opposed to well structured. The characteristics of PBL ill-structured problems are that they are real-life and authentic not teacher's exercises, messy not tidy, incomplete in the sense of lacking information needed for their resolution and iterative in the way that they produce further ideas,/hypotheses and learning issues (Barrows 1989; Stephen and Pyke 1977; Margeston 2001). It is vital that the problems are engaging, that they "smell real", are interesting and challenging to students. This engagement stimulates further learning and requires research, elaboration, further analysis and synthesis together with decisions and action plans.

The word "problem" in problem based learning needs to be interrogated. Problems are not always about something that is in difficulty that needs to be sorted out. An ill-structured design brief for an artist or an architect can be a problem. A dilemma for a doctor or a challenge for an engineer can be a problem. Problems are not always how to do something immediately practical in professional practice. Problems can also be about how to understand something. Problems can be presented to students in a variety of formats including: scenarios, puzzles, diagrams, dialogues, quotations, cartoons, e-mails, posters, poems, physical objects, and video-clips

One of the most important points about problems in problem-based learning is that it is not a question that first the students receive inputs of knowledge e.g. lectures, practicals, handouts etc. and then "apply" this knowledge to a problem they are presented with later in the learning process. This type of a situation is nor problem-based learning it is problem solving (Savin-Baden 2000). It is like making a cake when you have already been given the recipe and all the ingredients. One of the defining characteristics of the use of problems in problem-based learning is is that students are deliberately presented with the problem at the start of the learning process. This is like getting the challenge of preparing a celebratory meal for a special occasion where no recipes or ingredients are given.

III. Review of Previous Work

The engineering profession requires engineers to deal with uncertainty and solve complex problems of the field, sometimes with incomplete data (Mills & Treagust, 2003; NAE, 2004). In addition, engineers need to be able to function as effective members of teams and have strong communication and problem-solving skills (NAE, 2004). However, today's engineering graduates lack these skills and have difficulty applying their fundamental knowledge to problems of practice (Mills & Treagust, 2003; NAE, 2005; Nguyen, 1998; Vergara, et al., 2009). In addition, while science and engineering jobs experienced annual average growth rate of 6.7% (compared to 1.6% for total employment) between1950-2000, the attrition rate for students has steadily increased and the annual graduation rate decreased by 20%, (Felder, Felder, & Dietz, 1998; NSB, 2008). One of the complaints from engineering students is that the current teaching pedagogies (such as, traditional lecture format) emphasize explicit instruction, working individually, and norm-reference grading, which can make learning extrinsically motivating rather than intrinsically motivating(Felder, et al., 1998). The main problem within engineering education is the gap between the active field and the passive classroom experience (Palmquist, 2007).

In general, the traditional lecture method within engineering education is deductive, "beginning with theories and progressing towards application of those theories" And the instructor presents information without a discussion of why the mathematical models are being developed and what practical problems they will solve (Prince & Felder, 2006). and not specific to the situation in which the task needs to take place. Dewey (1938) argued. This pedagogical approach falls short because the knowledge is not grounded in context that such a traditional learning environment is too abstract and dull, leaving students with a sense of boredom and lack of motivation because they are presented with random information with no unifying factor. Instead, Dewey suggested that educators needed to encourage inquiry and that education should be grounded on experience and linked to real-life activities in order to motivate and develop students into upstanding citizens. Dewey also equated learning with doing and viewed learning as an activity, a process of discovery, where students need to be actively engaged in all aspects of the learning process (Savin-Baden, 2000).

Brown, Collins, and Duguid (1989) further emphasized that unless knowledge is developed in the context in which it is to be used, students will gain an understanding of abstract concepts, algorithms, and procedures; thus, the knowledge remains inert and students are unable to use it. Brown and colleagues stated, "the activity in which knowledge is developed and deployed, is not separable from or ancillary to learning and cognition. Rather it is an integral part of what is learned" (p. 32). This is even more so the case for a complex enterprise such as engineering, which involves making decisions with real-world implications that carry risks and uncertain outcomes.

The teaching in undergraduate courses in the STEM disciplines has increasingly started adopting the more learner-centered teaching, such as problem-based learning (Lattuca, Terenzini, Volkwein, & Peterson, 2006). This shift is fueled by the need for future engineers to demonstrate the use of higher order thinking, problem solving, and more interpersonal aspects of a career, such as communication, social, and team-work skills (NAE, 2005). Specifically, the engineering field is seeing shifts in the types of engineers needed to emerge from college who are ready to participate as active and effective members of a global society. The National Academy of Engineers (NAE, 2004) developed a set of attributes future engineers will have to possess to be a competitive force within the field. Hence, it is important for engineering education to reexamine the use of typical lecture-based teaching methodology and consider incorporating learner-centered teaching. One such approach, problem-based learning (PBL) has the potential to help students to cope with the demands of complexities of the field and problems they will face in their future careers.

IV. Problem-based learning-a possible Solution

Problem-based learning (PBL) was developed in the 1950s to respond to criticism that traditional lecture failed to prepare medical students for problem-solving in clinical settings (Hung, Jonassen, & Liu, 2008). PBL is a non-traditional, active, inductive, student-centered approach that centers on the introduction of a real-life problem (Ehrlich, 1998). The problem is "a complex task created by the need to design, create, build, repair, and/or improve something" (Burgess, 2004, p. 42). The goals of PBL include fostering active learning, interpersonal and collaborative skills, open inquiry, real-life problem solving, critical thinking, intrinsic motivation, and the desire to learn for a lifetime (Barrows, 1998;

Hmelo-Silver, 2004; Savin-Baden, 2000; Springer, Stanne, & Donovan, 1999). Hmelo-Silver argued that PBL allows students to construct an extensive and flexible knowledge base, which goes beyond factual knowledge, allowing them to fluently retrieve and apply this knowledge in varied situations. Hence, PBL allows students to move beyond the mental understanding of information and learn to apply concepts to real-life formats. In addition, since the knowledge is also grounded in context, which requires the use of problem solving skills, educators purport that the conceptualization of knowledge better prepares students for future careers. Research on problem-based learning in the medical field has suggested that PBL leads to higher problem-solving skills as compared to the traditional lecture method while being equally effective at increasing students' factual knowledge.

For example, Antepohl and Herzig (1999) investigated whether students learned more and were more satisfied in a PBL course than a traditional lecture-based course using a post-test-only control group design. One hundred and twenty-three students were randomized to either a PBL section (N _63) or lecture-based section (N _60) of the same pharmacology course. All participants completed a written examination for pharmacology, which included 20 multiplechoice and 10 short answer questions to measure student performance, and a questionnaire that measured students' preferences for PBL or lecture-based instruction. The PBL group also completed a second questionnaire to assess their satisfaction with the PBL approach. The authors found no significant difference between the PBL and lecture students on the multiple-choice questions, but PBL students scored significantly higher than lecture students on the short answer questions. In addition, greater numbers of students preferred the PBL approach and PBL students also reportedhigher overall satisfaction for the course as compared to the control group. These results demonstrate that PBL provides similar learning benefits to lecture in terms of factual knowledge; however, PBL also leads to gains in complex levels of knowledge, such as comprehension and analysis of problems. Similar results were supported by a meta-analysis conducted to investigate the effects of problem-based learning in terms of impact on knowledge and skill acquisition (Dochy, Segers, Vanden Bossche, & Gijbels, 2003). Dochy and colleagues reviewed 43 empirical articles on problem-based learning in real-life classroom settings.

These studies had a variety of assessment measures that could be categorized into factual knowledge and application of knowledge, and included measures such as the NBME licensing test, modified essay questions, essay questions, multiple choice, oral exams, performance-based testing, free recall, standardized patient simulation, and cases. Thirty-three studies reported data on knowledge effect; while 25 studies reported data on application of knowledge (numbers do not add up to 43 because several studies reported data on more than one category). The authors found that PBL was better in allowing students to apply their knowledge (skill development), while there were no differences on the factual knowledge.

a) Problem-based Learning in Engineering Education

One of the main aims of engineering education is "to produce broad-based, flexible graduates who can think integratively, solve problems and be life-long learners" (Engineering Professors' Conference as stated in (Matthew & Hughes, 1994), p. 234).

Given that engineers need more than just factual technical knowledge to be successful in an ill-structured and complex environment, problem-based learning seems well suited to prepare future engineers. Problem-based learning in engineering is a natural fit since it espouses developing students' ability to solve ill-defined problems, increasing critical thinking skills, and broadening their communication skills (Johnson, 1999; Prince, 2004). Additionally, PBL provides students with life-long learning skills that they can use to effectively and efficiently acquire new skills and knowledge required in their career as engineers (Woods, 1996). Some of the classes in engineering curriculum, such as design and capstone courses, already incorporate (unintentionally) aspects of problem-based learning (Johnson, 1999). Several authors have also reported explicitly implementing PBL in their engineering courses; however, such use is still limited (Mills & Treagust, 2003). In one study, Bizjak (2008) described the incorporation of PBL in an electrical engineering graduate program in Slovenia. The authors found that students gained more substantial knowledge than with traditional methods, as evidenced by higher test scores. PBL also received positive feedback from students and faculty, who completed a survey questionnaire Specifically, students reported that PBL allowed them to gain confidence in their problem-solving abilities, prepared them for their future careers, and improved their interpersonal and collaborative skills.

In another electrical engineering example, de Camargo Ribiero (2008) conducted a qualitative study of student evaluation of the PBL approach in a classroom at a university in Brazil. Students reported that the PBL approach was more engaging and interesting as it allowed them to construct their own knowledge instead of absorbing teachers' words and they were able to seek information on their own to solve problems. Students also reported that they developed specific work skills such as, ability to research, produce syntheses, express ideas, communicate, and effectively work in teams to develop solutions to problems.

These results suggest that PBL is an effective pedagogical tool to engage and increase students' interest in problem solving as well as beneficial for their knowledge gains. There have also been some programmatic implementations of problem-based learning.

For example, Polanco and colleagues (2004) conducted a three-year evaluation of a problem-based learning integrated curriculum in a second-year engineering program at a Mexican university. The longitudinal data suggested that students taught with PBL achieved significantly higher grades and performed better than students who received traditional instruction in advanced engineering courses. Similarly, Woods (1996) examined the influence of a PBL curriculum on students in a chemical engineering program at McMaster University in Canada.

The results suggested that PBL students had more positive course perceptions and scored higher on the written three-hour exam as compared to the control group of engineering students. The author also found that PBL students' confidence in problem-solving skills and their willingness to solve challenging problems also increased substantially compared to traditional students, suggesting that PBL students' attitudes aligned with open-ended problem solving and self-directed learning.

Canavan (2008) also examined problem-based learning applied to electronic and electrical engineering at three universities in the United Kingdom. The results from the questionnaires and interviews suggested that students preferred the PBL approach because it allowed them to engage in deep thinking skills and assume more responsibility for their learning. The students also reported the PBL approach fostered more generic skills, such as communication skills, group work, critically evaluating information, and time and task management, which are crucial in "developing versatile and confident engineer of the future" (p. 179).

In spite of the recent use of more problem-based learning, research on the impact of these approaches on students' conceptual understanding is limited (Hung, et al., 2008;Mills & Treagust, 2003). Gijbel and colleagues (2005) argued that claims about the effectiveness of PBL have been exclusively based on the research from medical field and there is dearth of research on PBL outside of medicine related fields. This is especially true within engineering education with regard to the effectiveness of PBL on students' problem-solving and conceptual understanding (Mills & Treagust, 2003; Prince, 2004). Research on the use of problem-based learning within engineering has mainly involved student and/or faculty perceptions of effectiveness of this approach rather than empirically collected data on actual student outcomes (Mills & Treagust, 2003). Given the little research on the impact of problem-based learning on engineering students' conceptual understanding, it is important to provide empirical evidence for what educational innovations, such as PBL work, and create an empirical base for their use in engineering education. Such an empirical base is imperative to improve engineering education as highlighted by a recent American Society for Engineering Education report, which suggested the need to develop a "scientifically credible and shared knowledge base on engineering learning" (Jamieson & Lohmann , 2009).

November 2011
5
Global Journal of Researches in Engineering (F) Volume XI Issue VIII Version I

The problem-based learning approach described in the study is based upon the floating facilitator model and is similar to self-directed, interdependent, small group problem-based learning (Prince & Felder, 2006; Woods, 1996). Within this PBL approach, students work in teams of 3–5 students with the instructor facilitating students' understanding of the material and students are responsible for their own learning (Prince & Felder, 2006).

The problem-based learning approach used in this study is different from project-based learning. During project-based learning students have gained the required knowledge base through formal instruction and central focus is on the final product, whereas problem based learning typically requires students to work on ill-structured problems while acquiring necessary knowledge base to complete the task and focus is on the learning process rather than final product (Prince & Felder, 2007).

In addition to assessing learning outcomes, researchers have tried to examine student perceptions of the PBL approach and how they match with actual learning. Research from psychology has suggested that students' judgments of learning are not accurate predictors of their actual learning outcomes (Dunlosky & Lipko, 2007; Glenberg, Wilkinson, & Epstein, 1982).

As per Dr Khaled Zehry; Dr. Neel Halder Problem based learning (PBL) is a teaching strategy to promote self-directed learning and critical thinking through problem solving. This educational approach has become a distinct methodology and has been widely adopted within medical education as a method of teaching.

PBL as an effective learning method is still debatable. Several systematic reviews have investigated this particular issue with no conclusive evidence 1. Although, the debate on measuring its effectiveness in disciplines is unlikely to cease2 and the concept of causal relationship to improvements has been questioned 3, more research on PBL should be done to shed more light on its effectiveness over traditional teaching methods. It will also be important to conduct more students' surveys on their views on PBL. A key to implement PBL successfully is for tutors to understand the learning theories behind it and to be able to adapt efficiently to the facilitator role rather than a traditional teaching Glenberg, Wilkinson, and Epstein found that students have an "illusion of knowing" and tend to be overconfident in their understanding of the material. Given that the majority of the research on problem-based learning has focused on student perceptions, it is important to examine whether perceptions are an accurate predictor for learning. Hence, our purpose in this study was to examine the impact of problem-based learning on students' learning and conceptual understanding. Specifically, this study addressed the following research questions:

a) What is the influence of a problem-based learning approach on undergraduate engineering students' conceptual understanding in an Electronics and Communication engineering course?

b) What are engineering students' perceptions of problem-based learning and how do they match with their learning outcomes?

V. Challenges

a) Engineering Landscape In India (Iit Bombay Study)

To get a better handle on the problem, IIT Bombay undertook a study on the engineering landscape in India.

The study aimed to answer questions such as:

- Has the engineering education system been able to provide, quantitatively and qualitatively, the engineers required for the growth of the Indian economy?
- Has it 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?

The study shows that against the sanctioned seats of 6.57 lakh for Under Graduate Engineering education in India, only 2.37 Lac engineering degrees were awarded in 2007-08. This very clearly highlights the shortfall. In2006, India awarded about 2.37 lakh engineering degrees, 20,000 engineering Masters Degrees and 1000 engineering PhDs, which means a total of 2.58 lakh engineering degrees of all types. This is clearly not enough! The awarding of degrees is also not evenly distributed across India. Five states – Tamil Nadu, Andhra Pradesh, Maharashtra, Karnataka and Kerala are said to account for almost 69% of the country's engineers. It is estimated that about 30% of the fresh engineering graduates are unemployed even one year after graduation; and this is even as many sectors complain of lack of talent. This clearly points that there is definite scope to improve quality of engineering education. Let us also look at the gender factor. At IIT Bombay, the percentage of women graduates to the total is about 8% at the B.Tech. level, 9% at the M.Tech level and about 17% at the Doctoral level including Science, Humanities and among the faculty – only about 10% of the IIT Bombay faculty comprises women. Gender disparity in the engineering stream exists around the world, not just in India, and special efforts are being made by institutions, Governments and professional organizations to rectify these. Some Indian states have provided incentives like free tuition for women studying engineering. Overall, the study rightly points out that India has the potential to be a leading research and design hub in the world. For this, we need to have a mechanism to identify important areas and develop policies and institutions accordingly.

Situations and problems we confront today demand composite responses and solutions.

b) New Kind of Engineer

Globalization has resulted in highly dynamic and complex market leading to the requirement of a new kind of Engineer.

c) Systems Thinking

This complexity demands a new way of thinking – it requires a Systems Thinking approach to macro level challenges and requires Engineers to keep one eye on the big picture even as they tackle specific tasks. Systems thinking provides a conceptual framework that helps make full patterns clearer and helps one to see how to modify these patterns more effectively.

This type of thinking is tricky to most of us because As Peter Senge says, it is a "discipline for seeing the whole". We are taught to break problems apart, to fragment the world! This appears initially to make complex tasks more manageable; but we pay a hidden price: we can no longer see the consequences of our actions, and we lose our intrinsic sense of connection to a larger whole. When we want to see the big picture, we try to reassemble the fragments and organize all the pieces. The task is futile– similar to trying to reassemble the fragments of a broken mirror!

d) Multi-Disciplinary Approach

Today's Engineers must also be able to view management activities through different lenses and work with people from different disciplines and diverse fields such as business, banking services and medicine.

We also have great minds, great thinkers. We just have to look for ways to bring them together. It is this fraternity of Engineers that will determine

"INDIA OF TOMORROW ".

We have travelled a very long journey and our "Intellect" is second to none. What we need is to mould young professionals to the needs of our Industry. The eyes of the world are on us. We have the opportunity to become a superpower. We all owe it to ourselves to shoulder the responsibility.

"Yesterday's collaborators are today's Competitors".

We will decide our role on the global stage. To meet this challenge we need engineers with "MULTI-DISCIPLINARY APPROACH"

e) Innovation-Led Growth

India's future growth will be driven not by cost but by innovation in terms of product offerings, process efficiency, value engineering and cost reduction.

f) Developmental Challenges

Even as we reach for the moon, there are millions here on earth for whom basic needs are elusive. No country can afford a skewed growth. If India has to achieve a 7% to 8% sustained growth, it needs not just "Corporate India" but the rural sector, the agricultural sector to grow as well. It is these areas that badly need the above cited engineering talent. The government, we and all of us together have to find ways to produce the above brand of Engineers motivated enough to make it an attractive option for them to take up these challenges.

However, today's engineering graduates lack these skills and have difficulty applying their fundamental knowledge to problems of practice (Mills & Treagust, 2003; NAE, 2005; Nguyen, 1998; Vergara, et al., 2009).In addition, while science and engineering jobs experienced annual average growth rate of 6.7% (compared to 1.6% for total employment) between1950-2000, the attrition rate for students has steadily increased and the annual graduation rate decreased by 20%, (Felder, Felder, & Dietz, 1998; NSB, 2008). One of the complaints from engineering students is that the current teaching pedagogies (such as, traditional lecture format) emphasize explicit instruction, working individually, and norm-reference grading, which can make learning extrinsically motivating rather than intrinsically motivating(Felder, et al., 1998). The main problem within engineering education is the gap between the active field and the passive classroom experience (Palmquist , 2007).

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VI. Methodology of –PBL

Problem-based learning (PBL) is a better alternative to traditional classroom learning.

With PBL, the teacher provides a problem to the students, usually a small group. In this system, teacher does not provide any kind of lectures, course contents, assignments or exercises.

The learning depends solely on the student's efforts, the sense he has to discover and work with content that is necessary to solve the problem. Hence the learning becomes active

A well designed problem provokes students to encounter and struggle with the control concepts and a principle of discipline. These skills include presentation

Global Journal of Researches in Engineering (F) Volume XI Issue VII Version I November 2011

and communication skills, self assessment and reflection skills, group participation and leadership skills. PBL is generally done by small groups of students working together for a common goal. Finally the choice of the students based upon various factors makes them take decisions that result in effective solutions and learning process in general.

In PBL, the teacher acts as facilitator and mentor rather than a source of solutions.

a) Problem based learning helps the student to:

- Develop Skill of discovering different facts and develop habit of collecting latest information and updates in all fields
- Freedom to express the problem and solution in one's own way
- It helps in developing team spirit
- Help in improving communication skill
- Makes the student flexible in processing information and handling different problems

b) Problem-Based Learning follows following steps:-

(These steps can be repeated and recycled)

i. Understand the problem:

The teacher introduces an "ill-structured" problem to a group of students.

The group discusses the problem statement and lists its significant parts.

The problem may appear as very tough for the group to solve but that is the real inspiration source to work hard on it. The group has to work using their vision and technical skill to find solution.

ii. List the information already known to the group which can help the solution.

This includes both what each member of the group actually knows. Each information and idea of every group member is important.

iii. Develop, and write summary of, the problem statement in your own words.

Every person can understand the thing better in his own way expressions. Thus, a problem statement should come from the group's analysis of what the group knows, and what the group will need to know to solve it.

iv. List all possible solutions.

The problem is discussed in group. Various possible solutions may appear together, now to search which solution is best, the group can list them all, then order them from strongest to weakest

Now, they can choose the one which appear them the best, or most likely to succeed.

v. Prepare list of actions to be taken with a "time bound" Solution.

Now, when the possible solution is decided, the group should prepare a list of necessary actions to be taken to reach to the solution. All these actions must have a time limit to avoid any kind of delay and all team members should work together or the work can be divided also depending on the kind of actions needed.

vi. List information necessary to know.

Any information can be useful to fill in the missing gaps. Discuss possible sources like experts, books, web sites, etc.

vii. Submit the possible solution with data.

Usually the group has to present their findings and/or recommendations to their classmates. In short, the" process" and the "outcome".

viii. Presenting and defending your conclusions.

The group has found a good solution but to present it confidently and convincingly is more important than any other thing. Otherwise all labor will go waste. The group should be preparing to state both the problem and the conclusion clearly as well as summarize the process and difficulties encountered.

VII. Conclusions

a) *Deep Content Learning*

PBL supporters argue that PBL students remember more content over longer periods of time (i.e., 1-2 years or more) than conventional students who studied the same content (Gallagher, 1997; Hmelo & Ferrari, 1997). Thus, when evaluating if PBL leads to deep content learning, researchers should evaluate if PBL students Understand and are able to apply unit content to real-life situations (e.g., use information learned about chemical reactions when determining the chemical properties of different substances).

b) Problem-solving Ability

Another intended learning outcome of PBL is increased problem-solving ability. A problem exists when there is a discrepancy between our expectation and what we get. Specifically, PBL is designed to increase students' abilities to solve ill-structured problems (Gallagher et al., 1992). Ill-structured problems "have many alternative solutions, vaguely defined or unclear goals and unstated constraints, and multiple criteria for evaluating solutions" (Jonassen, p. 21).

c) Self-Directed Learning

Self-directed learning is "any increase in knowledge, skill, accomplishment, or personal development that an individual selects and brings about by his or her own efforts using any method in any circumstances at any time" (Gibbons, 2002, p. 2). PBL is specifically designed to increase students' abilities to direct their own learning

d) It is concluded that the impact of problem-based learning (PBL) on undergraduate Electronics &

Communication engineering students' conceptual understanding and their perceptions of learning using PBL as compared to traditional lecture is far better. Fifty students enrolled in an Electronics & Communication course at a SRMGPC, Lucknow, participated in this research. Retention was found to be fantastic.

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