Chapter 1 Introduction

The primary goals of education revolve around effective teaching and learning. Measuring the effectiveness is a herculean task. This is mainly because the basic concepts are complex and the processes are not well defined. Hundreds of extraneous factors affect teaching and learning process. Facilitating mechanisms of acquisition, retention and transfer of knowledge, are essential and thus learning processes need methods, techniques and tools that support these goals. Several quality techniques have been introduced to enhance learning experience and Project Based Teaching/Learning is one of them. Mathematics, Statistics and Operations research are some of the subjects that greatly suffer from student aversion.

Problem based learning is subset of Project based learning. Project-based learning is often multidisciplinary and longer, and problem based learning is more likely to be a single subject and shorter. General steps are followed in project-based learning whereas specific steps are followed in problem-based learning (Larmer, 2014). As the present study is conducted in specific subjects hence the scope is reduced to Problem based Learning. Further the word teaching and learning can be used interchangeably as same process is viewed differently from students’ or teacher’s perspective. Learning is more important than teaching in education as per Constructivist theories. Hence good learning will indicate good teaching.

Problem based learning (PBL) is grounded in principles of learning. The three learning principles describe learning as cognitive, metacognitive and social and contextual factors (Albanese et al., 1993 and Gijselaers, 1996). These principles explain that PBL is experiential learning process which is self-directed, activity based, group based and exemplary learning takes place through real or hypothetical problem. The assimilation theory of learning is a cognitive learning which assumes that new learning experiences are always integrated into preexisting knowledge structures (Seel, 2012).The learning can take place if there is acceptance, routinization and assimilation.

The efficacy of PBL method for these subjects needs to be understood, measured and monitored. Mainly statistical techniques have been used by several researchers to study the impact of PBL in the past. Powerful data mining techniques that extract hidden knowledge
can be very effective to study the impact of PBL which has been felt that not have been explored adequately.

National survey on student engagement conducted by Indiana University in 2003 have emphasized on measurement of student engagement. They have also set benchmarks for various related challenges. Details are discussed later in Chapter 2.

1.1 Problem Statement

Learning is a process that brings changes in a learner’s temperament and competencies that are reflected in behavior. Educational system facilitates intentional learning in order to accomplish goals that would take much longer time without instruction. The instruction is a set of events embedded in purposeful activities that facilitate learning. However, the teacher or trainer's role includes lecturing or demonstrating, selecting materials, assessing students’ readiness to learn, managing class time, monitoring instructional activities, and finally serving as a content resource and a learning facilitator (Gagne et al., 2005; Gagne 1996).

Education deals with students from different backgrounds and varied expectations hence teachers should be careful in selecting methods of teaching, assessment and course design to bring about the types of learning they desire. Teaching should be grounded in and aligned with theories of learning (Fry et al., 2008). The extent to which student learns in a class is determined by both student’s ability to learn, student’s learning style and the instructor’s teaching style (Felder et al., 1988; Gagne et al., 2005). The learners become bored and inattentive in class if there is mismatch between common learning styles of students and traditional teaching styles of professors. Hence teaching style has to go hand in hand with learning style. The learners can be classified as inductive and deductive learners. Induction and deduction are the natural human learning and teaching styles for technical subjects at the college level. An effective way to reach both groups is to follow the scientific method in classroom presentations: first induction, then deduction. Inductive teaching and learning is an umbrella term that encompasses a range of instructional methods, including inquiry learning, problem-based learning (PBL), project-based learning, case based teaching, discovery learning, and just-in-time teaching (Prince et al., 2006). All these methods are inductive and learner-centered than the traditional lecture-based deductive approach.
The Problem Based Learning (PBL) can be defined as ability to (1) think critically, analyze and solve complex, real-world problems (2) find, evaluate, and use appropriate learning resources (3) work cooperatively, to demonstrate effective communication skills (4) use content knowledge and intellectual skills, to become continual learners (Savery, J.R., 2006, 2015). Learning abilities of a student is an independent aspect which needs to be taken into account while planning pedagogy (Felder et al.,1988, Frick, 2012; Biggs, 1993;, Fry et al.,2008).

Math avoidance, math anxiety and misconception regarding relevance of the subjects seem to be the main reasons which are responsible for reduced learning abilities in many learners (Ackoff ,1979). Hence it is a challenge to teach mathematical subjects, Statistics and Operations research (OR), especially to under graduate management students. The impact of adoption of innovative techniques in teaching needs to be established. The impact of PBL can be seen through knowledge, skill and attitude as suggested by Anderson et al.(2001) in revised bloom’s taxonomy. It is a challenge to extract these latent learning outcomes using statistical techniques when data comes from In-situ situation.

Hence current research problem is to establish that
1. Incorporation of PBL can be effective solution through analysis based on data mining approach and
2. At implementation level teacher’s problem is to define proper metrics to keep track of individual learning outcomes.

1.2 Background
Performance of students’ in Statistics and Operation research has always been a worry in management schools. This will be evident from the discussions in the next chapters. One of the prominent reasons coated in literature is that students of management faculty do not see any relevance of these subjects in their day to day activities in the field. Teachers seem to be unable to provide proper motivation. PBL seems to be alternative tried by many specially in the medical education at higher level. At school levels teachers have been experimenting PBL. Use of PBL in teaching is not new. Evidences of using PBL are found as early as 1986 in chemical engineering. Earlier attempts which researchers were not able to find out or which are not recorded cannot be ruled out.
The student learning outcomes can be defined in terms of the knowledge, skills, and attitude. Abilities that students have attained as a result of their involvement in a particular set of educational experiences.

1.3 Need for More Research

PBL is used in multiple domains of medical education, MBA programs, higher education, chemical engineering, economics, architecture and pre-service teacher education (Savery; 2006, 2015). But rare evidence have been observed for PBL based teaching in Statistics and Operations Research specially for techno-management students.

In this study researchers have analyzed the performances of students when problem-based learning (PBL) is integrated with traditional classroom teaching to teach Statistics and Operations Research. The effectiveness of PBL can be measured by various statistical methods. However it can be further strengthened by combining it with appropriate data mining techniques.

The various data mining techniques used to analyze students’ are discussed by Romero et al.(2010). Hence data mining approach is appropriate for identifying hidden patterns of learning from PBL which involves latent constructs.

1.4 Research Questions and Objectives

Our major objective of present study being to demonstrate that data mining approach can give far more information about how PBL has been effective. This objective leads to many research questions. Details of which are discussed in Chapter 4.

1.5 Research Methodology

The research method adopted for present study consists of four components namely an experimental approach, data mining approach, survey based research and conceptual approach. Their usage is not mutually exclusive and appear in combination depending upon the context. Though this is not designed experiment, experiment happen as per the academic calendar of the institute, the division of batches, duration of class hours and proportions of PBL that were part of regular academic program. Hence it is an In-situ experiment. However
tabulated outcomes resembled to a large extent to observation table of quasi designed experiment. The use of term quasi experiment is not out of place.

The process of data generation in above situation can also be considered equivalent to Extraction, Transform and Loading (ETL) process used in data mining terminology.

Minor requirements of transformation were required to balance the change in scale during the research period. Transforming variables to normalized variate was a normal exercise. The preprocessing was used as per requirements whenever machine algorithms were used.

The university has given the freedom to facilitators for incorporating innovative practices in teaching hence PBL was implemented for students in Statistics and Operations research which were allocated to researcher. PBL approach is a treatment. The applying PBL is an intervention. The differential levels of PBL treatment were natural. Some students were not exposed to PBL in any semester whereas some students were exposed in all the three semesters when Statistics and Operations research subjects were offered.

To gather learning outcomes Knowledge, Skill and Attitude (KSA), pre and post surveys were conducted. The surveys were conducted by designed instruments.

The conceptual part constituted of clearly defining Input, Output, Process, transition diagrams, indicators of students’ background, measures of engagement and an independent KSA extraction model using data mining approach.

1.6 Overview of Thesis

The present chapter gives brief introduction to the present research.

Chapter 2 reviews literature on teaching-learning problems and solution for mathematics based subjects and need for adopting innovative pedagogy. Literature focuses on how to measure effectiveness of implementing PBL.

Chapter 3 discusses derived conceptual model where PBL as an instructional method with well-defined Input, Process and Output (IPO) according to learning theories. PBL uses appropriate problems to increase knowledge and understanding. PBL in group learning facilitates gain of knowledge, enhancing of skills for example communication skills, teamwork, problem solving and builds attitude such as independent responsibility for
learning, sharing information and respecting others. Researchers have adopted problem-based taxonomy as suggested by Barrows (1986).

The research methods adopted for the research problem and the data collection and analysis plan is discussed in Chapter 4. The conceptual model and the measurement model as discussed in previous chapter clearly defines the different types of indicators for the latent variables which are measured during present study using questionnaires. Research questions, objectives, research hypothesis, and the experimental setup for PBL experimentation is presented in this chapter.

Chapter 5 contains the analysis of unstructured data and structured data. The syllabi of Statistics and Operations Research collected from various universities are subjected to similarity analysis. The variables under consideration for research, descriptive statistics of students’ demography, students’ performances during semester, analysis of these students’ performances using shape parameters skewness and kurtosis, correlation analysis and Chi-square analysis for quantitative and qualitative variables are presented in this chapter for the two undergraduate courses considered for present study.

Chapter 6 presents course wise and batch wise ANOVA and factor analysis to study variation among the categorical variables related to students’ backgrounds with respect to their performances from preadmission to current performances for students under study. This helps in identifying the indicators affecting students’ performances with respect to student background.

In Chapter 7, researchers have applied k-means clustering to educational data, to the students’ academic performance data. Batch wise analysis of performance of students is carried out using data mining techniques classification, decision tree and pattern analysis in two sections. In the first section, shape parameters are used along with classification technique in classifying batch wise performance of students using decision tree. Student wise analysis of performance is done in the second section using clustering, dynamics of performance through link analysis over semesters’ performances and decision tree. Batch wise and student wise performance analysis using data mining approaches identify the impact of PBL in Statistics and Operations research.
Chapter 8 extracts knowledge, skill and attitude scores batch wise and student wise analysis of pre, post survey and semester performance data. Path analysis is used to get a model between student academic performances, student engagement and learning outcomes of PBL. The impact of PBL in learning statistics and operations research using students’ performances via shape parameters, decision tree has shown positive results both batch wise and student wise. The knowledge, skill and attitude scores obtained from survey have shown significant impact of PBL in learning statistics and operations research. Results and discussion are presented in Chapter 9.