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Fostering Progressive Experiential Learning Approach to Make Engineering Students Future Ready

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Abstract: With the increasing rise in competitiveness and the rate at which technologies are growing, Engineering Education is facing challenge in equipping its students with the potential to deal with real life, complex problems and providing innovative solution for them. Educators report that the teaching process requires new pedagogical approach in fostering its students the skills required by the new globalized world. It is envisaged that engineering education needs shift in Teaching Learning Process (TLP) from Teacher-Centric approach to Learner- Centric environment. The traditional teaching approach may not provide students with the required skills and life-long learning. The student is not able to retain knowledge after exams. Due to the advancement in technology and exposure to the Internet, students are having many sources of information and learning centers. Due to this, students are drifted from the lecture-based teaching learning process towards the technology driven education. To meet the requirements of rapid changes and developments in technology, the biggest challenge is to use of knowledge into the recent teaching learning process, to produce professional engineers, who are globally accepted, skillful and industry ready. Today's demand to implement innovative teaching methodologies and initiatives towards student professional development with a holistic approach.

Experiential learning (EL) or Learning by doing will begin a modern perspective towards teaching-learning process. The National Education Policy (NEP) 2020 emphasis more on experiential learning to help students to apply their knowledge in real world situation. This paper emphases on how EL helps to improve engineering student's academic performance and overall development with global acceptance through hands-on laboratory experiments based on design and development (DnD), Professional Skill (PS), Project Based Learning (PBL) and Multidisciplinary Projects. Student's survey was conducted, and Prediction model is designed to measure the outcome of these activities. This paper attempts to get a hands-on experience of concepts which will enable students to think out-of-box and become a competent engineer. Experimental results showed that Logistic Regression performs better than Support Vector Machine to predict the outcome of Experiential Learning. Logistic Regression provides 83.87 % of Accuracy, 83.33 % of Precision and 95.23 % of Recall.

Keywords: Teaching Learning Process, Experiential learning, Project Based Learning, Professional Skill, Multidisciplinary Projects.

1. Introduction

Technology has been driving the rapid changes in world around us. The biggest challenge today is to create graduates who can succeed in the progressing landscape and who are well equipped with various skills. To create global leaders, we need to transform our teaching and learning approach and be open to changes in our academic community. Traditional teaching learning process does not encourage out of box thinking, instead it only focusses on knowledge delivery by teacher. This approach does not allow student's deeper levels of understanding which are required for real time problem solving and lifelong learning. The focus of teaching learning should move from Teacher centric towards Learner centric environment. So, it is expected the change should be made from the start of the design method. Use of a learner-centric approach for the design process helps for overall development of students. Due to the advancement in technology and the availability of information on their fingertips, the retention power of student is going low day by day (Keiler, 2018).

As per the Annual Employability Survey conducted in 2019 by Aspiring Minds, it has been announced that 80% engineers in India are not industry ready. There is more focus on theoretical concepts than practical approach. Though internship is mandatory for engineering education, but less than 50% students successfully accomplish internships. And a smaller number of students are interested in project development activity. On an average 5.5% of engineers acquire the necessary

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skills and are industry ready. The survey was conducted to analyze the reason behind this lack of ability and interest, as they have little industry exposure. Very few organizations conduct industry training and student development programs. Throughout engineering course most of the faculty do not discuss "How Engineering concepts apply to industry".

Although the traditional teaching approach provides learning through strengthening the base and foundation of the subject through theoretical knowledge, there is a need to enhance the experimental knowledge of the students. Hence, the biggest challenge is to bring the usage of technology into the current Teaching Learning process and make the students globally accepted, skillful and industry ready (Raja & Nagasubramani, 2018).

The traditional teaching could face a serious issue related to the learning ability of the students as syllabus is 100% covered but the learning scale could be below 50% for many students. Due to this, Graduate Engineers lack expertise and exposure to society (Fazilah Idrisa, 2011).

To overcome this problem, we have implemented the Outcome Based Education (OBE). As per the accredited bodies such as NBA, NAAC, etc. all engineering students should achieve 12 Program Outcomes (PO's). Therefore, to achieve the 12- PO's, we have adopted Experiential Learning (EL) through various Best and Innovative Practices for Holistic Student Development (HSD).

1.1 Experiential learning (EL)

Experiential Learning is the process of learning through experience or action or learning by doing. Experiential Learning promotes active and effective learning within and beyond the classroom. EL is a learner centric approach. It helps to develop better compression, knowledge, and life skills. Proficiency can be reached through experience, reflection, conceptualization, and experimentation. EL is an involved learning process whereby students "learn by doing" and by reflecting on the experience (Antonio & Albort-Morant, 2018). National Education Policy (NEP) define "Pedagogy must evolve to make education more experiential, holistic, integrated, inquiry-driven, discovery oriented, learner-centered, discussion based, flexible, enjoyable." (Aithal, 2020). According to NEP guidelines, experiential learning should be adopted in all phases of education. EL has been adopted through various activities such as hands-on laboratory experimentations, Internships, Workshops, Seminars, Project Based Learning (PBL), Activity Based Learning (ABL), Bridge Courses, Technology Based Learning (TBL), Research Based Learning (RBL), Real field Practice, Program Specific Research (PSR) Activities, Multidisciplinary Projects, Professional Skills (PS), Employability Development Skills (ESD) etc. Fig.1 shows stages of experiential learning while doing activities.

Fig. 1 The Experiential Learning (EL) cycle

2. Literature Survey

Kolb's Experiential Learning principle describes EL as "the process whereby knowledge is created through the transformation of experience" (Kolb, 1984). It is pedagogical method that provides students with the opportunity to apply their learnings from the classroom in real world scenarios **(Moore, 1981) (Kolb, 1984).**

Kolb's EL model consists a sequence of four components: Concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation. The cycle starts with a concrete experience where learn by experiencing such as game playing, role playing. Second element is a reflective observation in which learn by reflecting such as gained knowledge is demonstrated. After that students may conceptualize and draw conclusions about what they experienced and observed. Students create ideas that are clear and well structured. Followed by student's experimentation where they learn by doing. They practice and come up to new things. **(King, 2010).**

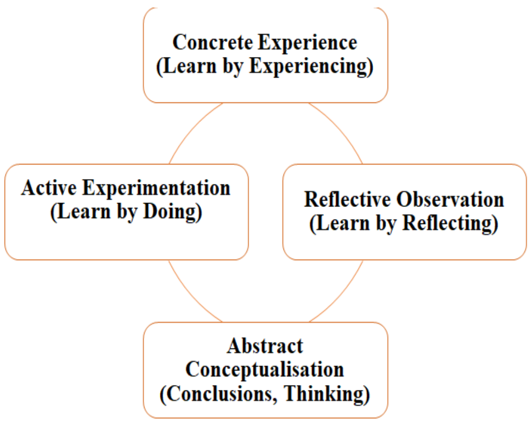


Fig. 2 Kolb's Experiential Learning Model [3]

Eyler et.al. Described the need of internship and how it helps to bridge the gap between industry and academics. Internship is offered to give students an exposure to the new skills and develop competency, higher order cognitive skills and ability to simplify work. It will also help them to develop a platform to learn these skills from faculty mentors and industry experts. It will also give an experience to the students in a specific domain of Engineering (Eyler, 1993; Eyler & Giles, 1999; Eyler& Halteman, 1981; Giles, 1995). Parilla describes EL through Internship to meet industry requirements through hands on practice on modern tools and thereby work collaboratively on projects (Parilla & Hesser, 1998).

Veselov proposed an experiential learning through Project-based learning and its effect in education system. He further explained how PBL a multidisciplinary approach that plays a considerable role in the project-based learning cycle (Vaselov, 2019).

Study shows that, experiential learning is essential to connect students' emotions and boosting their knowledge and skills to face real life problems (Bransford & Brown & Cocking, 2000). Experiential Learning is beneficial in different ways.

A Few major benefits of this approach of learning are:

1. Enriches student’s ability to adopt to new situation.
2. Bridges the gap between theory and practice.
3. Allows for accurate assessment of skills.
4. A depth understanding of subject.
5. Improves students’ proficiencies for out-of-box thinking and application of knowledge to solve real world problem.
6. The ability to involve in lifelong learning, including learning in the workplace.
7. Enhance decision making and problem-solving ability.
8. Promoting interdisciplinary learning, social awareness, career development, cultural development, leadership, collaboration, and required professional and intellectual competences.

3. Adopted Modern Experiential Learning Approach

It has been observed that moving systematically over the years from strengthening the practical knowledge in each subject (DnD approach) to further enhancing the professional skills required in each domain (PS), the Project Based learning approach (PBL) is built up strongly resulting in innovative and constructive ideas coming from the collaborative efforts of student focus group. As a result of this, it has been observed that slowly and steadily the research component, which is very crucial in building the graduate attributes required by an Engineer, is being strengthened (Moore,1981).

This paper mainly focuses on the three experiential learning approaches which was tried on three batches of Second year, Third year and Final year respectively in the form of hands-on laboratory experiments (DnD), Professional Skill (PS) and Project Based Learning (PBL).

3.1 EL through Hands-on laboratory experiments based on Design and Development (DnD)

Engineering students learn through experimentation. We experimented this by modifying our Laboratory experiment design and categorizing them in three different stages based on design and development approach. As with any course, experience-based learning courses require attention to four basic tasks: Objective, Conduct, Evaluation, and Feedback.

A. Objectives:

1. To promote learning by doing.
2. To inculcate the experimental skill.
3. Deeper understanding of course.
4. Apply theoretical concepts practically.
5. Design and development of experiments.
6. To examine and interpret data.

B. Conduct / Implementation:

To improve attainment, Lab Experiments are divided into 3 categories Basic Experiments, Design and Development Experiments and Group Learning Activity (Case study, Mini Project, Presentation). Every experiment is mapped with RBT level of Blooms Taxonomy. L1: Remember, L2: Understand, L3: Apply, L4: Analyze L5: Create. Template of lab experiment is given in the fig 3. All the students were graded by implementing evaluation rubrics. Lab evaluation rubrics is given in the fig. 4. The twelve Program Outcomes (POs) for engineering are attained through various direct and indirect tools. Practical is one of the important direct evaluation tools.

Subject: System Programming and Compiler Construction

Practical Number	Type of Experiment	Practical/ Experiment Topic	Hrs.	RBT Levels
1	Basic Experiments	Apply first and follow rules to compute First () and Follow() set of given grammar.	2	L1, L2, L3
2		Apply various optimization techniques to optimize intermediate code.	2	L1, L2, L3
3	Design Experiments	Design and develop two pass Assembler.	2	L1, L2, L3
4		Design and develop two pass Macro Processor.	2	L1, L2, L3
5		Design and develop a handwritten Lexical Analyzer.	2	L1, L2, L3
6		Design and develop Intermediate Code Generator using 3-Address code.	2	L1, L2, L3
7		Design and develop a Lexical Analyzer using LEX / Flex tool	4	L1, L2, L3
8		Design and develop calculator using YACC tool.	2	L1, L2, L3
9	Case study:	1. Optimizing Compiler 2. Compiler Construction Open-Source Tools 3. Java Compiler 4. Cross Compiler	4	L1, L2, L3, L4
10	Mini Project:	1. Design and development of editor. 2. Design and Development of Linker and Loader. 3. Design and development of Predictive Parser. 4. Design and Development of LR parser.	8	L1, L2, L3, L4
		Total Hours	30	

Fig. 3 Template of Lab Experiments

LAB EVALUATION SHEET

Cycle-1 — Roll No.: ______

Experiment/Tutorial No.:

Parameters	Weightage	Category	Performance					
			Excellent (5)	Very Good (4)	Good (3)	Average (2)	Below Average (1)	Score
Technical Knowledge (Preparedness and Execution)	30	Prerequisites (2)						
		Skills in performing experiment (2)						
		Learning (1)						
Technical Documentation (Developing skills for Journal Writing and Maintenance of Lab Notebook)	30	Format (1)						
		Contents as per Format (2)						
		Quality (2)						
Level of Interaction (Developing Expression Power)	10	Level of Understanding (2)						
		Questions & Answers (2)						
		Application (1)						
Behavioral (Attitude Towards Learning)	10	Attitude (1)						
		Regularity (2)						
		Teamwork / Group Activity (2)						
Compliance (Attainment of Objectives / Outcomes)	20	Course Objective Attainment (3)						
		Learning Objective Attainment (2)						
Total	100							

Signature of Subject Teacher

Fig. 4 Rubrics for Lab Evaluation

C. Outcomes:

1. Basic experiments improve the understanding of course.
2. Design experiments expand the learning experiences and fosters the innovativeness and creativity among students.
3. Group activities develop the student's ability to work effectively as an individual and in a group as a leader as well as team member.

Survey was conducted to check student's satisfaction level whether lab experiments based on design and development and group activities helped them to enhance their subject knowledge and learning beyond the curriculum. The overall students' feedback is positive.

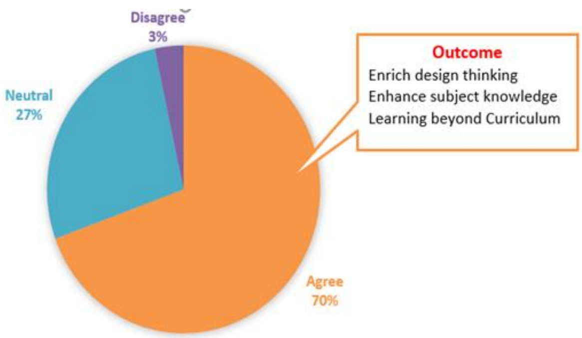


Fig. 5 Student's Survey to measure outcome of Practical

3.2 EL through Professional Skill (PS)

Over the course of time and timely feedback from Recruiters, it was observed that the Engineers which we produced lacked the skills required by Industry. To strengthen the skills required by Industry and abreast them with current technological trends, Professional skills were introduced in the curriculum though which students could learn the various technologies and the same will be applied to implement real life applications through PBL. (Gibson & Molloy 2012). The outcome came in various domains like Web development, Core and advanced Java, Python, Cloud Computing, Software Testing etc.

A. Objectives:

To develop a professional skill necessary for becoming technically skilled personnel.

B. Conduct / implementation:

The planning of the PS activities is done before start of semester. The hands-on sessions were conducted to learn programming languages and the evaluation conducted throughout the semester. Final presentation or evaluation based on the mini project or case studies of the PS is taken at the end of the semester.

C. Outcomes:

Understand and apply fundamental programming language constructs to solve the real-life problems by using various tools such as Java, Android Studio, and Firebase etc.

Students' Survey was conducted to measure outcome of Professional Skill (PS) activity and student's involvement to build solution for real time problems by applying technical skill.

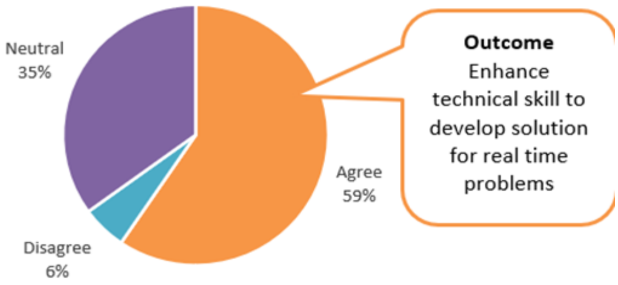


Fig. 6 Students' Survey to measure outcome of PS.

3.3 EL through Project based learning (PBL)

After many deliberations and discussions with various regulatory bodies, advisory committee, and other stakeholders, it was observed that engineering education that emphasizes on theoretical knowledge is not adequate to sustain in Industry. Industry needs to invest a lot of time and money for industrial or professional training. During Institute - Industry Interaction (3I), Industry professionals demands engineering graduates should be able to think critically, analyze problems, create innovative solutions, and communicate effectively (Schwartz & Bransford & Sears,2005). Hence Project based learning was introduced to promote effective learning in engineering education. Subject wise hands-on laboratory experiments improve students learning, programming skills and logical thinking and creativity (John McManus, 2019). Further they apply these skills for domain wise project development under PBL. Fig. 7 shows detailed Project Based Learning (PBL) Process. PBL involves critical thinking, problem solving ability, teamwork, and oral and written communication. To answer a leading question and create high-quality work, students need to achieve all levels of Bloom's Taxonomy. They need to develop higher order thinking ability and learn to work as a team (Caulfield & Woods, 2013).

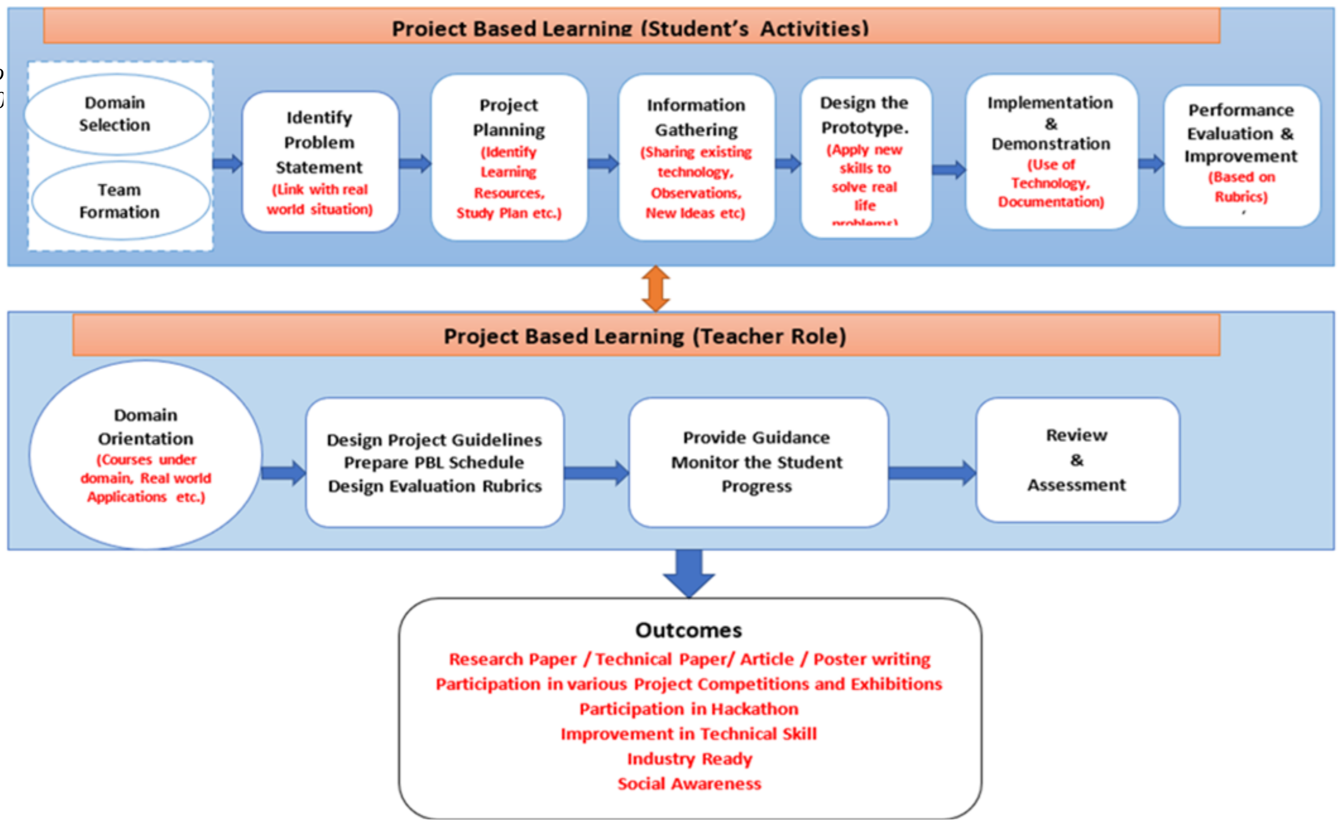


Fig. 7 Project Based Learning (PBL) Process

A. **Objectives:**

1. To identify real world problems and apply computing fundamental and technical skill to find solutions to them.
2. To apply the learnings of the curricular courses to the real word problem to give the students hands on experience of project life cycle and thus making them employable engineer.
3. To design and synthesis application and validate the obtained results through experimental methodology.
4. To explore Self-directed learning ability and overall learning experience. To inculcate out of box thinking, teamwork, verbal, and written communication.

B. **Conduct / Implementation:**

1. Introduction of Mini project for Second Year and Minor project for Third Year engineering.
2. Selection of domain interest.
3. Preparation of Statement of Purpose (SOP).
4. Classification of projects into four categories such as Research based, Application based, Industry based and Core.
5. Guide allocation and Idea presentation.
6. Project development as per software engineering life cycles.
7. Research paper / Technical Paper / Poster paper writing.
8. Mapping of project with National Relevance / Societal Benefits / Hackathon and possible
9. Convergence of Mini project to Minor (SE) and Minor project to Major Project (TE).
10. Outcome is measured by conducting Project Competition / Exhibition.

C. **Outcome of PBL:**

1. Interpret the basic real time problems and apply appropriate technologies and programming constructs to solve them.
2. Students remember their project experiences better and can identify their own strengths and areas for personal development.
3. Collaborative learning also takes place, as students learn from their own team members, and from observations of other teams.
4. To implement solution using multidisciplinary approaches.
5. Inspect the results obtained from documentation and presentation.
6. Based on experience achieved during project development students participation increase in project competition, project exhibition, research development, Hackathon etc

Students' Survey was conducted to measure outcome of Project Based Learning (PBL) activity. PBL has changed mindset and role of students and teachers (Clayton, 2004).

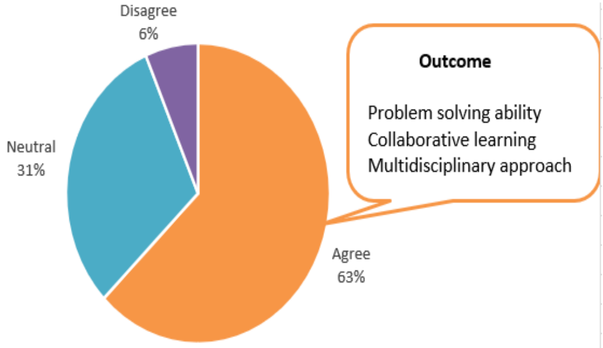
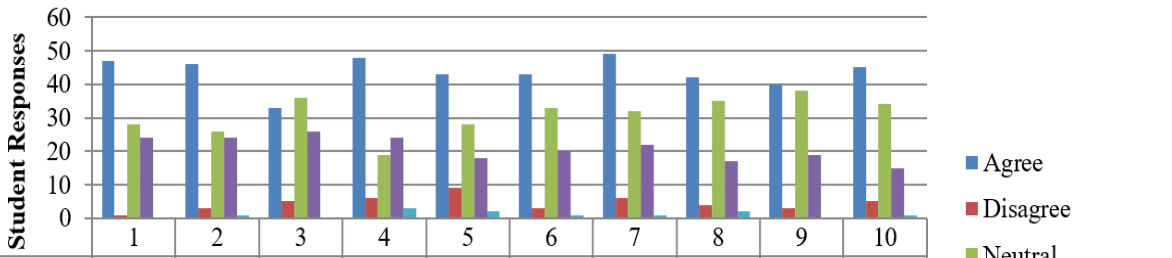


Fig. 8 Students' Survey to measure outcome of PBL.

4. Survey and Analysis of Experiential Learning (EL)

Student's survey (100 participants) was conducted to measure impact of experiential education through hands-on experiments, PBL and PS.

3. Has the inclusion of Professional Skill (PS) helped you to develop technical skill?
4. Has the inclusion of PBL (Project Based Learning) helped you in enhancing your Technical & Collaborative Skills?
5. Has the inclusion of PBL helped you to strengthen your Domain Knowledge?
6. Has the inclusion of PBL helped you to update with new technology & understand about industry trends?
7. Has the inclusion of PBL helped for your overall Professional Development?
8. Has the promoting Experiential Learning (EL) through PBL helped you to create new knowledge from existing?
9. Has the inclusion of Multidisciplinary Projects helped you to promote collaborative learning?
10. Has the fostering EL through PBL encourage you to participate in various project competitions, Hackathon, and research activities?



	1	2	3	4	5	6	7	8	9	10
Agree	47	46	33	48	43	43	49	42	40	45
Disagree	1	3	5	6	9	3	6	4	3	5
Neutral	28	26	36	19	28	33	32	35	38	34
Strongly Agree	24	24	26	24	18	20	22	17	19	15
Strongly Disagree	0	1	0	3	2	1	1	2	0	1

Student Questionnaire

Fig. 9 Student's Survey to measure impact of Experiential Learning (EL)

The overall feedback is positive, and the students have shown great interest in taking part in above mentioned activities. Students have earned a lot from this and have got a great learning experience. They have been able to understand the latest technological requirements and have been able to prepare themselves to face the competition globally. (Peter D. (2006); Lee & Hung (2012)).

A survey was conducted with the following questionnaires:

1. Has the inclusion of Design Based Experiments helped you to enrich Design-Thinking and develop technological solutions as per the expectations?
2. Has the inclusion of Group-Activities such as Mini-Projects/Case-Studies/Presentations helped you enhance specific subject knowledge and provided an opportunity to learn beyond curriculum?

5. Result and Discussion

Machine Learning based prediction models Support Vector Machine (SVM) and Logistic Regression are used to predict the outcome of Experiential Learning (Hussein & Osama Ali & Samir Qaisar 2019). Performance Measure- Accuracy, Precision and Recall are used to measure the performance of prediction model. Accuracy is the ratio of correctly predicted value to the total number of predictions. Datasets consist of 154 student's assessment score based on evaluation rubrics. We have split our total data into training and testing dataset. We have applied our model to the training dataset. These students have participated in various activities such as hands-on experiments, Professional Skills and Project Based Learning.

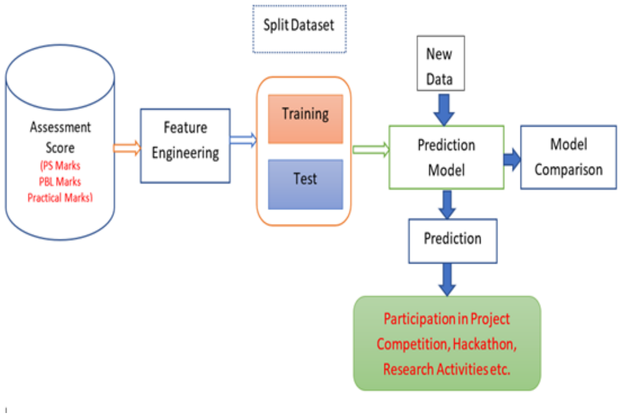


Fig. 10 Prediction model to predict the outcome of E

Fig.11 shows comparative performance of SVM and Logistic Regression. We have attained an overall testing accuracy of 80.64% and 83.87% respectively. We have also calculated recall and precision for better understanding and examining the result. Precision indicates the ratio of properly predicted true positives to the total predicted positives. Recall indicates the correctly predicted true observations to all observations of the actual class.

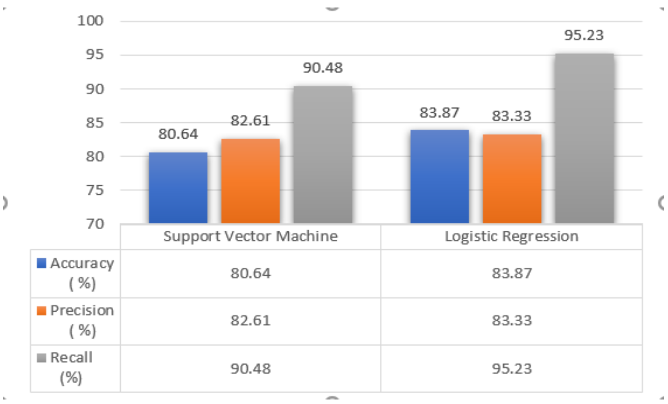


Fig. 11 Comparative performance of prediction model

5.1 PO-Attainments using Best Practices

Based on experimentation results, the students have been able to develop themselves in a holistic manner. This outcome paves way for creating more successful professionals. Fig. 12 shows 12-Program Outcomes (POs) achieved through best practices (Kavitha & James & Harish & Rajamani 2018).

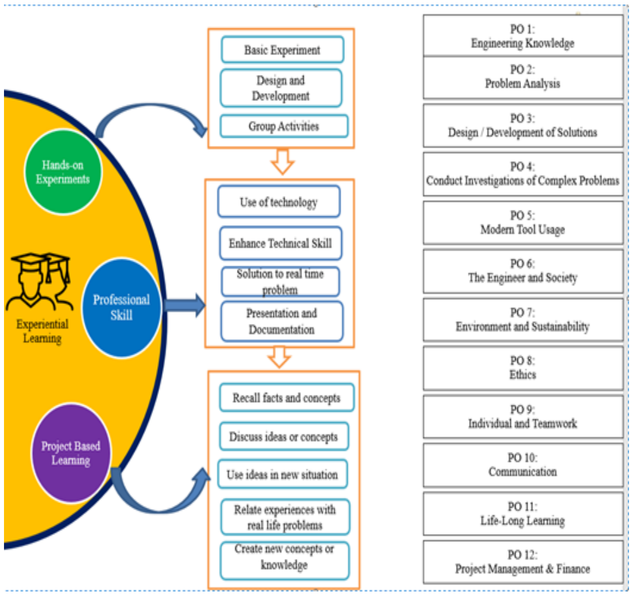


Fig .12 POs attainment through Best Practices

5.2 Future Scope:

In this competitive age, it is necessary to bring about new developments at frequent stages to bridge the gap between Academia and Industry (Tim Mazzarol ,1999). Hence, the need of the hour is to add value to these courses and allocate credits for the same through Autonomy. This will encourage students to take up new courses which will make them more competent enough to face the challenges globally.

In this paper survey and experimentation conducted only for Computer Engineering students. This work can be extended to other disciplines by adding more questionnaires.

6. Conclusion

Experiential learning (EL) is a well-designed paradigm in education. Experiential learning helps students transition from engineering graduates to industry professionals. Experience-based learning or Learning by doing is so effective because it helps to develop lifelong learning. Through our model of Experiential Based Learning, an attempt is made to link all the three experiential learning methodologies which we incorporated so that, the skills and aptitude of the individual student is developed. On top of it, it was also observed that in this journey, peer learning, self-learning and collaborative learning was also indirectly fostered among the students. This lead to the overall personality development of the student. Experiential education through hands on experiments, Project Based Learning, Multidisciplinary project, and professional Skills improves students' critical thinking, problem solving ability, collaboration, project management, verbal, and written communication.

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