Project Based Learning: An Industry Perspective

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Abstract— **This paper describes a collaborative model between industry and academia to implement project based learning effectively in engineering education. We have come up with a viable Learning Framework for the execution of projects in engineering institutions. This would help the faculty to plan and facilitate the projects for enhanced learning among the students. The proposed Learning Framework structure would help the students to acquire essential engineering attributes that includes deeper subject knowledge and much needed "industry-relevant experience" for them. Further, a collaborative model between industry and academia is proposed to bridge the gap between industry expectations and academic accomplishments. A pilot implementation of such collaborative model based learning framework is also presented here, and the experience has been very encouraging.**

Keywords—Project Based Learning; Engineering Attributes;Learning framework; Industry Academia Collaboration

I. INTRODUCTION

There has been an increase in demand for engineering graduates across various industries in India over the last decade. The number of graduating engineering students has also increased with a rise in number of engineering institutions across the country. However, the biggest challenge for the industries today happens to be that while the incoming graduates have required credentials, there seem to be a dearth of attributes which are essential for the engineering profession. Consequently, the industries are spending enormous efforts towards transforming a hired engineering graduate to become "industry-ready".

In particular, problem solving ability, communication and team work are the key attributes that any engineering industry looks for among the incoming engineering graduates. This has been emphasized time and again from several industry leaders, as in 21st Century Skills [1]. The same has been corroborated by Washington accord [2], National Board of Accreditation, India [3] and Royal Academy of Engineering [4].

One practical way of inculcating the required engineering attributes is through project based learning. This paper presents a framework to implement project based learning in the engineering institutions under the existing curriculum structure. To effectively implement such a framework, a collaborative model between industry and academia is proposed. Further, our experience through a pilot study conducted at one of the premier institutes is presented.

II. PROJECT BASED LEARNING FRAMEWORK

A. Project Based Learning

Project Based Learning enables students to gain practical knowledge and skills by working on a problem/challenge to be solved. This is analogous to real-life situation of an engineer who solves problems as part of a project and thus is an experience of "practicing engineering" for the students.

Proponents of project-based learning cite numerous benefits to the learner such as a greater depth of understanding of concepts, broader knowledge base, improved communication and interpersonal/social skills, enhanced leadership skills, increased creativity, and improved writing skills. Educationists have been encouraging this through elementary to higher education. Specific to engineering context, it has been identified as signature pedagogy in the Royal Academy of Engineering report [4]. David Miller emphasizes the need to solve a real life problem for enhanced learning and advocates this to be the first principle of instruction [5]. As engineering profession is all about "solving day to day problems of life", the need for project-based learning in engineering education is very much important.

While the existing curriculum of engineering institutions includes "projects", there seem to be lack-of-clarity with respect to the expected learning outcomes for a student. Most of the time, the focus is only on end result whereas the experience of structured engineering practices adopted is more valuable for a student. Due to this most of the academic projects fail to provide real life Engineering Practice experience. Further, the number of projects carried out by a student throughout the engineering course is usually as few as one, which leads to substantially low "Engineering Practice" experience for the student. All in all, there is a need to transform the "academic project experience" to "real-life industry project experience" for enhanced learning for an engineering student.

In this context, this paper presents a "Learning Framework" that can be used by the faculty to design the entire project experience for the student. The framework will help to inculcate the essential engineering attributes in an integrated way through the execution of a project and thus makes the entire "project" more realistic as well as industry-relevant.

The details of the "learning framework" proposed are presented below.

B. Learning Framework

The Learning Framework proposed here is a tool as illustrated in Table 1 and can be used to plan a project in detail by the faculty.

The first column of learning framework indicates the different phases of a project execution. This can be made to match the typical phases of an industry project i.e. identifying requirements, design, implementation/development, testing and release/conclusion. This will in turn ensure that the student will experience the nuances with respect to different phases of a project in a realistic manner.

The second column is to set the expected Learning Outcomes (LO) for each phase of the project and is to be defined by the faculty guide. These learning outcomes need to be defined in SMART [6] format which will make it easier to measure the achievements at the end of the project. It is crucial that these LOs are in line with the expectations from the industry. For example, identifying design alternatives before finalizing one, can be a LO during the design phase. Similarly, systematic coding practices and configuration management are important LOs during the implementation phase. If LOs are set in accordance to such industry practices, the students now get an opportunity to learn and practice the same.

The third column describes the teaching –learning activities to achieve the expected LO. This involves both faculty and student. The role of the faculty is to facilitate such that the student carries out a given activity to meet the expected LO. It is essential that the faculty "facilitates" rather than "instructs" so that the student learns by doing and constructing knowledge for himself/herself. For example, as illustrated in Table 2, during the design phase, the faculty facilitates by providing required resource materials/ brainstorming sessions and discussion which helps the student to identify design alternatives and choose an appropriate one that meets the user requirement.

The fourth column corresponds to the measurement of the LOs achieved in each of the phases. Here, different/ multiple assessments could be designed by the faculty to make it more meaningful and relevant. For example, a quiz or a comparison chart can be used for assessment of the LOs as illustrated in Table 2. Such continuous assessment throughout the project helps the faculty to give relevant feedback to the students at regular intervals, which helps the students to learn/perform better. Further, the overall evaluation at the end of the project can be cumulative/weighted combination of these assessments, which makes it more detailed as well as significant. This is also very important from industry perspective as any real-life project goes through such continuous assessment for improving performance/output. All in all, the importance of such continuous assessment through the project cannot be overemphasized.

C. Overall Project Evaluation

While learning framework provides continuous assessment through the project, a quantitative measure about the overall project achieved can be designed by the faculty. This overall measure is a weighted combination of the key attributes i.e. communication, team work and problem solving ability of the student as observed and recorded by the faculty throughout the project.

III. Industry-Academia Collaboration Model

A collaborative model between industry and academia to implement the above discussed learning framework based project execution is presented here.

Before the commencement of the project a faculty guide and an industry guide are identified for the project. Faculty guide helps the student team to identify a real life problem around them which needs to be solved. Once this is frozen, faculty guide designs a Learning Framework relevant to the project based on the format as illustrated in Table 1. This is reviewed by the industry guide to incorporate inputs from the industry perspective (specifically in setting different phases of project execution and their respective LOs). The learning framework is to be jointly agreed upon between the two guides, after incorporating necessary changes resulting through discussion.

Once the students begin their project, responsibility of the faculty guide is to manage the day to day activities of the project whereas the industry guide participates through two review sessions (one mid-review and one final review) apart from any discussion with the faculty guide as and when required.

Faculty guide makes a continuous assessment of the project as discussed in the earlier section. After the completion of the project the faculty guide will submit the updated Learning Framework to the industry guide indicating details of the extent to which learning outcomes are achieved. The industry guide and faculty guide jointly conduct a final review of the project at the institution wherein the industry guide provides industry-perspective to the students. The students receive detailed feedback about all aspects of their project by both the experts, in addition to an overall evaluation.

Table 1: Learning Framework Template

Different Phases of the Project	**Expected Learning Outcome(LO)**	**Teaching-Learning Activities to achieve expected LO (includes role of both faculty and student)**	**Measurement of extent of achievement of LO**

Table 2: Example Learning Framework Filled for the "Design" phase of the project "Automatic Vending Machine"

Phases of the Project	Expected LO	Activities to achieve expected LO (both faculty and students)	Measurement of extent of achievement of LO
Design	a) Identify the design alternatives with details of hardware and software involved, for the set of features finalized in the previous phase of the project. b) Select one of the alternatives and justify the selection	Learners will, a) Acquire the pre-requisite knowledge on design concepts and methods through study material/resources provided by the faculty. b) Brainstorm and discuss with faculty and the team members to identify alternatives for the design of Automated vending machine. c) Choose one of the design alternatives for implementation based on parameters identified as per the user expectations.	a) A quiz is conducted by the faculty on the background required for the design activity. b) The number and details of the alternatives generated through brainstorm and discussion. c) Are the parameters chosen for comparison enough to meet user expectations? d) Comparison chart of solutions against each of the identified parameters.

IV. Pilot Implementattion

A pilot study for the above discussed collaborative model for project based learning was carried out at PES Institute of Technology, Bangalore. Mrs. Geetha Prakash, Associate Professor in the department of Electronics and Communication Engineering Department kindly agreed to partner in this pilot study and act as faculty guide.

The study was conducted across two summer internship (of duration 2 months) student batches during successive years. The pilot study started with a meeting between Wipro team, faculty guide and students who were part of the pilot to carry out projects. The expectations from each of the stake holders' was set in this meeting. Faculty guide designed the Learning Framework, for the projects being executed, which was reviewed and agreed upon after necessary changes.

In the first batch a mid-review was conducted by industry guides who helped them to fine tune the project. At the end of the project completion the faculty guide submitted a report on each project about the extent to which the project has achieved learning outcomes. A simple excel based template was used to consolidate all the outcomes of a project. The output of this format was a grade point out of 10.

A total of 18 projects in the first year and 13 projects in the second year were part of the study. Out of these 11 projects in the first batch and 6 projects in the second batch met the expected criteria after final project evaluation. The feedback about the project evaluation was provided to the students. Response from the students and the faculty guide, Mrs. Geetha Prakash has been encouraging. In particular, students voiced that they are now clearer on the expectations from industry with respect to a project execution. From our part, we could observe continuous and enthusiastic involvement from both the faculty guide and the students involved.

Regarding the projects that did not meet the required criteria, following are our key observations, which could have enhanced the quality of the project as well as learning for the students.

1. **Understanding the users and their expectations**: This is a very important aspect of any project and is often ignored in a hurry to move over to implementation. This was observed in several of the projects - as lack of understanding of user requirements or missing or unnecessary features.
2. **Design alternatives**: Considering design alternatives and evaluating them against identified parameters to meet user expectations is a crucial step in any project. However, it was observed that some of the projects did not consider alternatives at all, which led to incorrect implementation/rework in the projects executed.
3. **Analysis and Debug of problems**: whenever the students encounter a problem through the project, it is important for them to analyze the same deeply and solve the problem. Instead, many students seem to have given up at the first hurdle and taken other routes, which may not be an optimum solution.
4. **Systematic Implementation**: Structured coding, version control and documentation are essential to ensure that the implementation sustains for long. However, students seem to give very less weightage to such disciplinary practices through the development.
5. **Demonstration of output**: It is important that the students are able to demonstrate adequate output at the end of the given project. Instead some of the project outputs seemed trivial and could have been worked upon (in the given time and resources)for more significant outcomes.

All in all, it is observed that essentially students need to practice more and more of "**problem solving**" (as evident from points 1, 2, 3), "**communication**" (point 4) and "**team work**" (point 5) – integrated with their subject, as these happen to be the key professional attributes for the engineering profession.

It was gratifying for us to observe considerable changes in some of the student's approaches towards project implementation after this pilot experience.

V. Conclusion and Future Work

Learning Framework along with collaboration model provides an effective way of implementing the "Project Based Learning" for enhanced student learning as evident from the encouraging results of the pilot. It is observed that the faculty guide and industry guide need to be in sync throughout the project for this model to be successful. This is currently being broad based across our partner institutions across India. The analysis of these implementations will help in fine tuning the Learning Framework and the collaboration model further to ensure enhanced learning in students. We could assess the "Problem Solving" and "Communication" attributes to our satisfaction at the time of evaluation. The assessment of "Team work" attribute needs more strengthening as it currently depends on the observation of the faculty guide which is subjective. We urge all the stakeholders to ensure that the students carry out projects based on our suggested framework or similar frameworks to acquire the essential engineering attributes.

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