

A Systematic Approach for the Conduct of Engineering Design Projects

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Abstract: The engineering design process is a methodical series of steps that engineers use in creating functional products and processes. The process is highly iterative process involving a cyclical process of idea generation, evaluation, and design improvement until the design requirement is met. It is a widely used design strategy due to its intuitive nature and effectiveness in facilitating design improvement, hence calls for the need of the hour to enhance students' cognitive levels. Engineering design courses can be best learnt through practical learning (often termed as Project Based Learning) by course projects, thus delivering this course in the early stages of mechanical science engineering students by offering projects as pedagogy is often a challenge on the part of the tutor. This paper collectively presents simple techniques adapted in conducting the projects for third semester undergraduate Industrial Production engineering students. A systematic approach was followed in the formation of the student teams, proposing the problem statements, students preparing for the reviews according to scheduled timelines, modeling the prototypes, conducting the reviews and preparing the PowerPoint presentations and project reports. By following this pedagogical method Program Outcome (c: Ability to design systems, components, or processes to meet customer needs) and (g: Ability to communicate effectively in both oral and written forms and to become proficient in working with diverse teams) were mapped for the assessment. It was also observed that there was an improvement in the PO attainment, a better team dynamics were observed, the quality of the projects was enhanced in terms of better idea generation, report writing and power point presentation also proved a better quality.

Keywords: Engineering design, Course projects.

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1. INTRODUCTION

The territory of engineering design is simple, comprising two parts. The first, conceptual design- the way that something 'just has to be' has a pure perspective of inductive human thinking. It is fair to say that its solutions are helped along by a certain amount of fantasy.

The second half is practical design, which is just the opposite; its roots are in practical and possible engineering. There are often conflicts and gaps between these two parts, so much of the engineering design 'territory' of a product is about managing imbalances between the conceptual and practical approaches. Here comes the main first challenge on the part of the engineering design tutor to train the students to think and work to bridge the balance between conceptual and practical approaches. The best method is followed by practicing both the approaches simultaneously by offering self study/course project along with theory. A second main challenge on the part of the tutor is to conduct projects at very early semesters of the engineering students who are unaware of the process of handling projects right from idea generation, model building to report writing. This paper presents the experiences and approaches followed by the course teacher in conducting the engineering design projects in the department of Industrial and Production Engineering, third semester students.

2. METHODOLOGY

To execute the design projects, simple initiatives were followed. They are: group formation, generation of project ideas, work planning and monitoring the weekly work, rubric based timely reviews, structured power point and word report templates; and prototype building. Each of these initiatives has been briefed in the following lines.

A. Group Formation^[2]

Student groups for the project teams were formed based on the following manner:

- Students were divided in groups of five each by the course teacher.
- The Regular students were divided in four groups referring to student's results from the first year.
- Each group had at least one student from each of above tier and one diploma student such that every group was balanced equally.

This procedure motivated each student to work effectively in homogenous groups and also gave sufficient opportunity for diploma students to express their practical knowledge and capability to take better decisions.

B. Generation of Project Ideas

Generation of project ideas within the academic boundary is yet one another, challenge on the part of a tutor, it is often practised that tutor provides fixed problem statements on which students have to work.

In this initiation, each student had to generate one problem statement on three domains that were given viz. Agriculture, Health and Hospitality and General Utility; student group of 5 could generate 15 problem statements amongst themselves by brainstorming. Further, each team's problem statement were collectively taken, reviewed by the tutor and one best problem statement was finalized in discussion with every respective team.

C. Work plan and weekly monitoring^[1]

As these engineering design projects were offered as self study projects, the work needed to be monitored regularly, weekly activity sheet was prepared and shared with students, weekly work was allotted to students as per the plan, students prepared gantt charts to plan their work. Work allotted was such that students could co-relate the knowledge gained in theory classes with their projects. A two hour slot of self study session was fixed per week, which was used to discuss and evaluate the work done by students.

Weekly work plan and schedule was planned as follows taking care of 14 working weeks.

Table 1: Work Plan and Schedule

Weekly Activity	Details
Week 1	Introduction to self study projects. Why do projects? Evaluation techniques (reviews, marks split up, etc.) Sample of projects Three roles in design process Explanation for three roles in the design process, identifying Internal client, external client, designer and user taking examples
Week 2	Need analysis The Client's Need The User Needs Survey

	Brainstorming Conducting a need analysis with an example Writing problem statement
Week 3	Gantt Charts Identifying the phases of the project Allocation of time for each phase and planning of activities Constructing Gantt chart in MS Excel or using a Android applications
Week 4	Literature review What is literature review? Significance of literature review Identifying keywords Choose appropriate databases Your understanding about the review

Week 6	PCC and Objective Tree Students identify the objectives for their projects, and develop pair wise comparison charts to prioritize their objectives Also, students need to identify first level and second level objectives to draw the objective tree for their self study projects
Week 7	Functions Identify functions of the design project using various methods available
Week 8	Patents What are patents? Types, Significance of patents How to apply for a patent How to refer to a patent with example?
Week 9	Morphological charts Constructing morphological charts for student's design projects to generate alternatives Evaluation of alternatives Applying one of the numerical methods to evaluate the alternatives Cost Estimation
Week 10	Fabrication specifications Students identify and list the fabrication specifications for their design projects
Week 11	Bill of Materials Significance of Bill of Materials Parts of Bill of materials Writing Bill of materials for the student's design project
Week 5	User objectives, requirements and constraints Define objectives, user requirements and constraints. Identify objectives, list the user requirements and constraints for a design product And hence distinguish the differences amongst each of them Also, students shall identify and write user objectives, requirements and constraints for their self study project

D. Rubric based timely assessment

Project assessment was done in four timely phases; PO c- 'Ability to design systems, components, or processes to

meet customer needs', and PO g- 'Ability to communicate effectively in both oral and written forms and to become proficient in working with diverse teams' were identified and mapped for outcomes.

Review Phases and marks distribution was planned as discussed in Table 2.

Table 2: Marks split up and phase wise review description

Review No.	Weightage in marks	Activity
1	20	Team formation, project proposal (Identification of Problem,) gant chart, and objectives, need analysis, identifying functions
2	20	Generating different alternative solutions for selected problem using morphological charts and choose best alternatives
3	30	Design, model and analyze the selected alternative and fabricate the model
4	30	Testing of model, final presentation and report submission
Total	100 (reduced to 25 marks)	

E. Structured Word and Power point templates

Communication and documentation is the most essential activity in any project, here to equip students with better communication and documentation skills at the third semester level, a well structured word template was provided consisting all the parts of the report chapter wise, also to enhance their presentation skills and to aid them with proper slides preparation, a power point template was provided, where students had to use the same format for presentation in reviews. These templates had all the explanations written for students to write the report, all the topics were collectively covered chapter wise.

Thus, this activity met the challenge of improving the quality of project reports; this shall also aid them to improve their report writing skills in mini projects and capstone projects.

F. Final review

To invoke seriousness amongst students and to meet the industry expectations, a new practice of inviting an industry person for the final review of engineering design projects was adapted. Students presented their work to the review committee and obtained a feedback on their work. This also gave the course teacher a better insight of probable improvements and better scope to be implemented in conducting of projects.

3. EFFECTIVENESS

Effectiveness of the above initiatives taken resulted in a overall improved average results, better quality and new projects, project reports and PO attainment also indicated an improvement.

A. Better Team Dynamics

In a nutshell, these initiatives have been found to be effective in improving the student's skills like leadership while handling the project teams, persuade effectively the ideas and associated methods to the teammates and also others, personal accountability to take responsibility, goal orientation and above all interpersonal skills, which are essential characteristics of an engineer.

B. Improved Average Results

Table 3 gives a comparison made of the average marks of projects during the year 2012-13, 2013-14 and 2014-15.

Table 3: Comparison of Average Marks

Sl. No.	2012-13	2013-14	2014-15
Class strength	63	69	64
Average percentage of marks	72.68%	76%	79.92%

C. PO Assessment

Program Outcomes c, e, f, g and k were mapped for project assessment for the year 2013-14 and Program Outcomes c and g were mapped for the project assessment for the year 2014-15. Figure 1 shows the PO attainment for both the years.

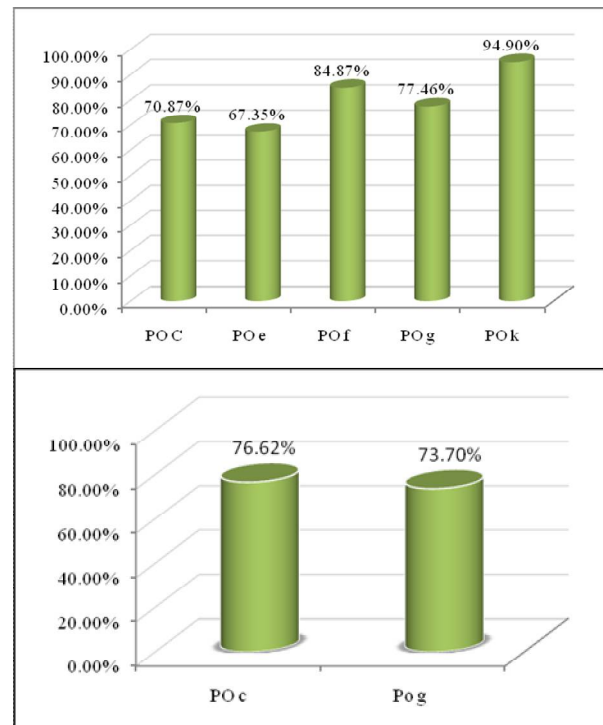


Fig. 1 PO Attainment

D. Project Titles

Table 4 shows the engineering design project titles taken up by the students.

Table 4: Project titles

2013-14	2014-15
Trash/ scrap collector	Used needle breaker and syringe disposal
Height adjustable podium	Snake catching equipment
Portable cylinder carrier	Self switching of water pump to maintain proper water level in overhead tanks
Adjustable study table	Multipurpose walking stick
Empty cylinder warning system	Rotating shoe rack
Low cost device to convert non potable water to potable water	Instrument to break coconut and collect its water
Simple low cost air conditioner	A carrier to lift heavy gunny bags and bricks
Chair with storage space	Multipurpose food stuff mixer
Foldable dining table	Portable and detachable writing pad
Weed cutting machine	LPG weight indicator cum trolley
Wheel driven pesticide sprayer	Laptop cooling pad
Electromagnetic braking system- prototype	Can crusher
Ladder convertible to a rack	Low cost water purifier
Screw jack based device to lift heavy objects.	Portable water level indicator in over head tanks
Portable briefcase cum stool	A chair convertible to short ladder with storage space
Foot operated sprayer	
Trolley to transfer LPG cylinder without lifting	

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E. Improved Project Reports/Power Point Presentations

By providing these reports, students were more efficient in writing the reports without much confusion and ambiguity. The quality of reports submitted was appreciable at the third semester level. Though a quantitative analysis of the outcome in this regard has not been done by the authors, improvements have been witnessed.

4. CONCLUSION

Handling big group of students and class for these kinds of projects is a big challenge for the course teacher. As noticed, as long as pedagogies are modified according to geography and cultural changes the learning will enhance in a measurable quantity amongst students. These initiatives practiced in the conduct of the course have streamlined the project activities and have broadened the scope of the projects.

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