Skill development in freshmen by adopting project based learning-"Introduction to Engineering" course

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Abstract: Engineering Education demands three important attributes the knowledge, skills, and attitude that the next generation engineers should possess, intern connecting to the Society. To make them Globally Competitive and efficient graduates , the next generation engineers should possess 10 top skills i.e. solving complex Engineering Problems, Critical Thinking, Creativity, People Management, Coordinating with Others, Emotional Intelligence, Judgment and Decision Making, Service Orientation, Negotiation and Cognitive Flexibility. To address these challenges the institution has been introduced "Introduction to Engineering" for freshmen in the engineering curriculum. In this paper, the authors present a case study of the course "Introduction to Engineering" which helps the students of the first year in Solving Engineering problems which include solving society problems by developing necessary modules. This course helps them to progress in the future courses to fulfill the prerequisite of few courses in the higher semester of engineering.

Keywords: Introduction to Engineering, freshmen, Multidisciplinary, World Economic Forum .

1. Introduction

The course "Introduction to Engineering" is a part of curriculum in many Western Universities [1],[3],[4],[6]. This course is activity based to develop skills and encourage them and create interest in the profession they have opted for. Such curriculum is seldom adopted in our country because of several factors such as no flexibility in revising curriculum, university restrictions in introducing these subjects, council members not accepting the inclusion. The curriculum in our country demands lot of reforms to be brought in, in order to make our graduates employable, globally competitive to attain their higher education and to face Global challenges.

SR Engineering College, after attaining autonomous status had brought in several reforms, the curriculum compatible with western Universities. The college stands first in bringing Transformation in engineering education in the state and is few among many colleges in our country.

The course Introduction to Engineering (IE) introduced for freshmen to develop creativity, innovation and entrepreneurial mind set among the students. The World Economic Forum (WEF) has expressed that the graduate should possess 10 top skills should be developed in the students community to make them globally competitive, employable and entrepreneurs.

This course introduces engineering design process, and helps students of various disciplines to understand multidisciplinary concepts in an interactive mode. This is an active learning method of teaching and learning in the class.

A. *Motivation*:

Majority of the faculty follow the traditional lecture mode which include chalk board, power point presentation which have proved as low efficient way to present information. During lecture time students seems to be listening but reveal significant proportions

i. Day dreaming
ii. Attending casually to the lecture it's like. "All work and no activity makes Jack a dull boy" similarly the proportion of students visibly engaged in taking notes in most classes has become all too often rather small. Research finding suggests that student's concentration during lecture begins to decline after 10-15 minutes. This results need of further research in active learning methods.

Here the assessment is given to active learning rather than passive learning [2], and its assessment provides the feedback of learning process in the class room environment. In [5] an article titled, "teaching more by lecturing less", hence by class room activities, collaborative work, group discussion and assessment were observed to make significantly higher learning gains and better conceptual understanding.

B. *Multidisciplinary and its Significance*:

The concept of multidisciplinary is essential for the design of any product. This subject helps fresher men to understand the concepts of design with exposure to use of various disciplines in designing proto type module [8]. Working with multidisciplinary concept makes them to think in an innovative and practical way.

2. IE Subject Overview

The curriculum includes topics like Engineering Process, Opportunity Identification, Conceptualization, Skill Development and finally develop a product prototype. In engineering process the student is exposed towards the historic relations to between Science Engineering and Technology. The students are exposed to the various stages of product development from the world of imagination to the world of objects. Most of the Design stages passes through 7 majors stages viz – Inspiration, Identification, Conceptualization, Exploration and Refinement, Modeling, Communication and finally to Product Development (Commercialization). While performing opportunity identification pain storming sections are perform.

They are also inspire in framing the opportunities and methods of evaluating opportunities by taking several case studies. Conceptualization involves generating ideas in solving customer pains. Brain storming sessions are conducted with much of interaction and discussions. Students are also introduced with techniques by adopting reverse engineering and also SCAMPER for bringing in the modifications in the existing product. Generating new ideas in existing product "Substitute, ¬¬Combined, Adopt Modify/Minimize/Maximize, Put together, Eliminate, Re arrange/Revise" in short called (SCAMPER) helps students to put in their new ideas, creativity and also confidence level.

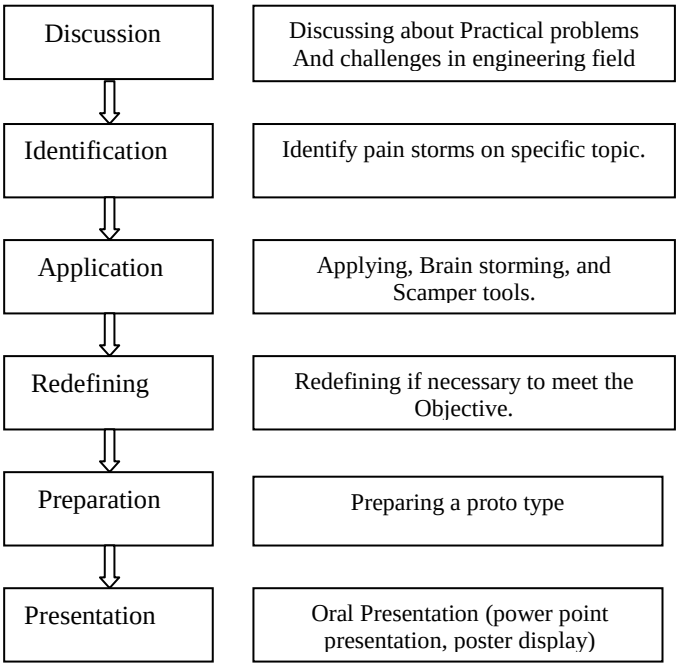


Figure:1 Interactive Teaching Methodology

Skill development helps students to explain their product by free hand sketching. Students are made to present their ideas with effective communication and team spirit. As a fresher men itself the students develop Critical thinking, Solving societal Problems [7], Negotiation, Creativity, Coordinate with their colleagues and solving simple problems. At this stage the students develops their confidence level, thinking critically by solving few of the society problems. Thus this course has brought Institutional Transformation in education and made our students as skilled Engineer, to see himself fit in the Global Scenario.

This course is now a pre-requisites for few of the future courses. The course is taught to students with hands on experience, develop ability by adopting Think-Pair-Share (TPS) with their counter parts which enlighten their minds to the world of Knowledge, Skills and Attitude making them a true engineering graduate.

C. *Overview of the Curricular Innovation at a College-Level*:

SREC developed a new curriculum based on extensive discussion with industry thought leaders, academic experts, and focus groups. The new curriculum is being implemented from Fall'2015. The curriculum is based on four fundamental skills -

i. Innovation, Creativity & Entrepreneurial Mindset
ii. Industry relevance
iii. Interdisciplinary learning
iv. Information technology

D. *Course Structure–Introduction to Engineering (IE)*:

The course structure of IE has five units.

UNIT – I

Engineering Process: A brief history of engineering and technology, engineering as a profession, science Vs engineering, stages of design – from the world of imagination to world of objects.

UNIT – II

Opportunity Identification: Opportunity Identification from inspiration – an act of creative awareness, how to find inspiration, Pain storming method for identifying opportunities. Methods of evaluating opportunities. Case studies.

UNIT – III

Conceptualization: Methods for generating ideas to solve the customer pain points including brainstorming, concept maps, and SCAMPER.

UNIT – IV

Skill Development: Sketching, Prototyping Communication. Interaction with peers, demonstration of projects developed by senior students and alumni.

UNIT – V

Project Work: A open-ended design project executed from opportunity to prototype, Culminating with a presentation, model, display and report.

3. Course Information

The main objective of this course is to develop creativity, team work, critical thinking, team spirit culminated with leader ship skills.

Being Autonomous the institute has a flexibility to modify/ introduce new subjects that make students employable after their Graduation .Looking into the needs and global standards of education the institute has taken a step to

introduce as freshmen in engineering. Majority of the students admitted are from rural background, lack behind communication skills, fear to express and working with colleagues. This subject helps them to network with others to improve their confidence level and is a mandatory subject to all courses of engineering. The course is handled once in a week with two batches of students with strength of around 30. The course is delivered which much of interactive sessions. In a semester the students get 36 hours a week in which the students is required to go through the various stages and develop a prototype. The class room delivery is done in a drawing hall with much of discussion and deliberations the work is carried out outside the classroom after the college hours and the work is the presented in the next week as per deliberations.

E. *Student Demographics:-*

The course is offered at the I year of engineering itself and is mandatory subject for all the students admitted into engineering .The students of 4-5 members are made in to a batch. Each session which is of strength of 30 members has been handled by two faculty members. The batches are divided without gender discrimination so that they work in team understanding each other and importance of bilingual gender discrimination

F. *Faculty Background:-*

Faculties of all disciplines handle this course. Faculties with good communication, thoughts, openness in sharing knowledge, able to spare time, mingle with students and move friendly with the student community are usually assigned for the course. Two faculties for every strength of 30 members is assigned to handled the class. Faculties conduct interactive sessions to understand the ability of the students bring out their creativeness to outside world.

G. *Course Objectives and Outcomes:-*

The course objectives and course outcomes for the Introduction to Engineering course is defined below.

- *Course Objectives*

  1. Summarize different engineering disciplines and identify engineering challenges.
  2. Evaluating opportunities and design process applicable to real world.
  3. Mention the methods for generating ideas to improve the design of existing product.
  4. Build multi-disciplinary system perspective.
  5. Design a physical model and recognizing the importance of technical report writing.

- *Course Outcomes*

  1. Define various disciplines technology and engineering challenges.
  2. Judge the responsibilities as professional engineer in solving the societal problems.
  3. Identify new opportunities to formulate and solve engineering problems.
  4. Create personal skills and attributes at critical thinking.
  5. Predict the importance of oral, written and academic skills.
  6. Adopt social context of engineering practice.
  7. Apply engineering reasoning to problem solving.
  8. Integrate working with multi-disciplinary teams and build team work skills.

The consistency of the subject is verified from the students after completion of the course in a prescribed Performa.
The Program Outcomes (PO's) are defined by the Accreditation Board. The mapping of Course Outcomes with Program Outcomes is listed in Appendix –I.
The evaluation of the course in Semester End Evaluation (SEE) is 50 marks and Course Internal Evaluation (CIE) is 50 marks. The rubric of evaluation is given in Appendix–II.

H. *Teaching Pedagogy:-*

The subject is thought by two faculty members and 30 students. The students of group into batches with 4 members in each batch. Each batch of students are made to sit in a round table and made to discuss the topic of interest within the group. The faculty interacts and assist then in making discussion inspire them to take up the work as per their ideas. The students work after hours and come prepared with the discussions made in the previous class.

I. *Delivery and Assessment:-*

The effectiveness and impact of each unit, Learning Outcomes, delivery and assessment is given in Table1.

Table 1. Course Delivery and Learning Outcomes

Unit	Assessment	Skills Developed	Learning Outcome
I	Report on an identified technological evolution and factor s driving technological evolution.	presentation	understanding
II	Identify new potential opportunities based on the customer pain points and evaluate them to identify real opportunities.	Critical Thinking, Creativity	Remember Understanding Apply
III	Application of idea generation methods to improve an existing product	Creativity, Judgment and Decision making	Apply, Analyze
IV	work in team towards implementation with peer members	Solving Engineering Problem, Critical Thinking, people Management	Apply, Analyze, Create
V	prototype presentation	Service Orientation, Negotiation and People Management	Apply, Analyze, Create, Evaluate

J. *Course Delivery & Assessment:-*

The Course delivery and assessment is discussed in section H .The validation of the same is given in Table 2 . This mapping helps in obtaining the Mission–I of the department which is stated as " Design Curriculum that provides

effective engineering education by promoting innovating teaching-learning practices" . In the delivery process the student learn and move through the various stages of design via, Inspiration, Identification, Conceptualization, Good Communication skills.

Table.2: Validation of Parameters through students Feedback

Parameters	Performance Evaluation			
	Excellent	Very Good	Good	Satisfactory
1.Students ability to do by their own				
2.Teaching Methodology				
3.Skill Development				
4.Curriculum Framing Feedback				
5.Feedback by Students about the supervisor				
6.Subject Overall Response				

K. *Comparison with Other Courses:-*

The IE course is based on project based learning and differs from other core technical subjects in mode of delivery, interaction, and skills. This is given in Table 3.

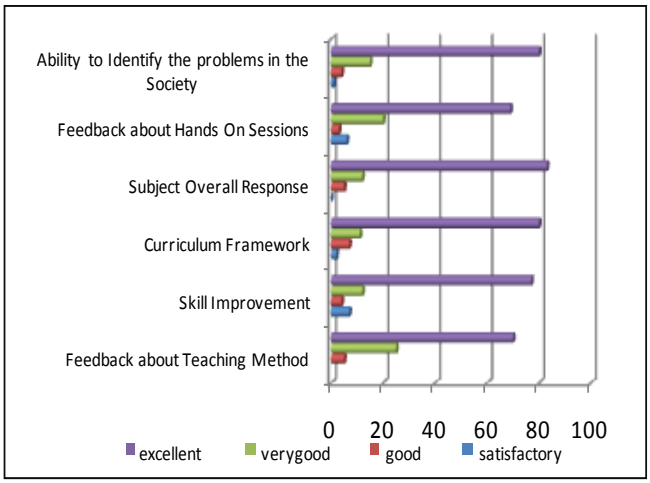
Table.3: Comparison between IE and Regular course

Regular course	Comparison parameters	Introduction to Engineering (IE)
Only faculty deliver the lecture	Pattern of Interaction	Group of students and faculty involved
Presentation by faculty	Mode of conduct	Interactive Lectures
Discipline, Scoring marks in examination,	Expectation from the Students	Acquiring knowledge, communication, Response , Skill development
3-4 hours, spread over the week	Lecture Duration	3hours in stretch with self activity throughout the week
Thorough preparation on specific topic	Planning	meticulously planned
Assignments, Quiz	Extra Activities	Group Discussion, (Think pair share), Team work, Exposure to previous projects

4. Results

From the consistency data obtained, the various parameters for validation of the course is plotted in Table-4. From the table, we infer that the parameters -skill development in students, overall response of students, introducing the subject into the curriculum has shown a good performance. Hence the subject Introduction to Engineering, introduced for the freshmen has shown creativity, enthusiasm, and result oriented for the student community.

Table.4: Evaluation of Results



5. Conclusion

From the above result we conclude that the IE subject introduced has proven to be effective and innovative with collaborative learning between faculty / student.

According to Students perspective the subject made it to interact effectively with much of the time devoted for thinking and doing activity. The subject has shown improvements in soft skills, critical thinking, problem solving and creativity.

This zeal and enthusiasm created among the students will help to solve much of society problems by the time they become graduates.

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APPENDIX – I

COURSE ASSESSMENT

- **Program Educational Objectives (PEO's)**

I. Enhance the skill set of students by providing strong foundation in basic sciences, mathematics, engineering and use necessary tools to solve engineering problems.
II. Equip students with ethical, professional behavior and mould them to become successful qualified engineers.
III. Inculcate necessary aptitude and ability to equip students to use their knowledge as a foundation for lifelong learning.
IV. Build team work skills and develop abilities to communicate and deal with different professionals both nationally and globally.

- **Program Outcome(PO's)**

1. *Program Outcome (PO) 1: Engineering knowledge:* Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization for the solution of complex engineering problems.
2. *Program Outcome (PO) 2: Problem analysis:* Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. *Program Outcome (PO) 3: Design/Development of Solutions:* Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations.
4. *Program Outcome (PO) 4: Conduct investigations of complex problems:* Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. *Program Outcome (PO) 5: Modern tool usage:* Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
6. *Program Outcome (PO) 6: The engineer and society:* Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. *Program Outcome (PO) 7: Environment and sustainability:* Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. *Program Outcome (PO) 8: Ethics:* Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice
9. *Program Outcome (PO) 9: Individual and team work:* Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. *Program Outcome (PO) 10: Communication:* Communicate effectively on complex engineering activities with the engineering community and with t h e society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions
11. *Program Outcome (PO) 11: Project management and finance:* Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. *Program Outcome (PO) 12: Life-long learning:* Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

- **CO – PO Mapping**

Course Outcome	PO's											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

CO1	**M**	**H**	**M**	**M**		**M**						
CO2	**L**	**L**	**H**			**H**						
CO3	**L**	**L**			**M**	**H**						
CO4							**L**		**H**	**H**		
CO5									**H**	**H**		**M**
CO6			**M**			**H**	**H**					
CO7	**L**	**L**	**M**	**M**								
CO8									**H**		**M**	

H: High Contribution M: Medium Contribution L: Low Contribution : ☐ No Contribution

APPENDIX – II

NAME	External - Design Project - An open-ended design project executed from opportunity to a working prototype culminating with an investor pitch, customer product unveiling, and report					
	Rubric 1 - Opportunity Identification (20%)	**Rubric 2 - Idea Generation (20%)**	**Rubric 3 - Prototype (30%)**	**Rubric 4 - Presentation (10%)**	**Rubric 5 - Report & Skills (20%)**	**Total Score**
Exemplary - Demonstrates thorough and penetrating understanding of key concepts; exhibits copious evidence of attainment of skills (90 -100)	Generate a number of customer pain points, identify pain points that are of high value to individuals, users and society.	Clearly demonstrates generation of diverse ideas and advancement of concepts with high value proposition.	Demonstrates multiple prototypes - soft or computer model and paper/cardboard models and provide insights gained from each prototype	The presentationis well organized and delivered within the time limit. The props are useful with appropirate. Speaker maintains clear, audible voice and maintains eye contact.	The report is well organized, well written, and presents the design stages from opportunity to prototyping. Also, it demonstrates appropriate application of the skills learned in Unit 4.	
Proficient - Demonstrates general /adequate understanding of key concepts; exhibits adequate evidence of attainment of skills (70-89)	Generate a limited number of customer pain points, identify pain points that are of some value to individuals, users and society.	Demonstrates generation of a limited set of ideas and advancement of concepts with some value proposition	Demonstrates some prototypes - soft or computer models, paper/cardboard models and can not fully provide insights gained from each prototype	The presentation is organized and delivered not within the time limit. The props are have limited use Speaker most of the time maintains clear, audible voice and makes eye contact.	The report is some what organized and presents the design stages from opportunity to prototyping - but lacks details. Also, it demonstrates some of the skills learned in Unit 4.	
Novice - Demonstrates a lack of/little understanding of key concepts; exhibits minimal evidence of attainment of skills (0 - 69)	Generate very few customer pain points, identify pain points with no understanding of value to individuals, users and society.	Doesn't adequently demonstrate generation of ideas	Demonstrates no prototype development and can't provide insights gained from each prototype	The presentation is disorganized and are not delivered within the time limit. The props don't enhance the release or pitch Speaker is inaudible and doesn't makes eye contact.	The report is not organized and doesn't presents the design stages. Also, it doesn't demonstrate most of the skills learned in Unit 4.	