Paradigm shift in the Engineering Curriculum: Design Thinking

M.M.Irfan[1], A.Rajamallaiah[2], Syed Mushtak Ahmad[3]

[1]EEE Department, S R Engineering College, Warangal
[2]EEE Department, S R Engineering College, Warangal
[3]ECE Department, S R Engineering College, Warangal
[1]mmirfan.srec@gmail.com
[2]rajamallaih_a@srecwarangal.ac.in
[3]dean_acad@srecwarangal.ac.in

Abstract: This paper outlines the primary focus for the change required to improve the quality of education in Engineering Institute. The basic objective of education is to equip the student with employability skills and entrepreneur skills to sustain in the current environment. This paper presents paradigm shift observed at SR Engineering College in terms of teaching and learning pedagogies. The Transformations made in the curriculum from the traditional theoretical approach towards the project-based learning. A strong emphasis on "Hands on experience" made SR Engineering College unique among the other institutes of Telangana region. Finally, this paper describes the achievements and learning reflections of the student community.

Keywords: Introduction to Engineering (IE), Foundation for Product Design (FPD), Engineering Projects In Community Service (EPICS).

1. Introduction

Most of the engineers today are likely to recall their undergraduate period as a span of the mathematical and theoretical study. However, the engineering curriculum at most colleges was mostly practical rather than mathematical applications. As the engineering institutes hire the faculty to teach and conduct the research, the number of faculty with industry experience is declining. When institute decides to give so much value to the research than education, the innovative practices in teaching and learning becoming unsustainable and not preparing the students for industry-ready professional skills.

Most learning takes place on the job, in practical situations of a challenging project that required the freshers to step outside their comfort zone [1].

Corresponding Author
M.M.Irfan, EEE, S R Engineering College
mujahid_irfan_md@srecwarangal.ac.in

In engineer curriculum normally the capstone project will be done in the final semester of the fourth year. So the students will develop the employability skills like team skills, project management skills and communication skills in the final year, with less scope.

SR Engineering College felt that the persistent gaps between the Industry practices and the student interest should be filled through the dynamic shift in the curriculum. SR Engineering College got an autonomous status in the year 2015 and thereafter its journey started towards the vision 2020 [2]. In coordination with industry experts, successful entrepreneurs and research experts - paradigm shift was made in the curriculum by adding new courses like IE, PDS, FPD, EPICS. Training for faculty in design is in progress. Design thinking process will make us stay relevant with customers, create real innovations and gain changes [3].

Section-2 outlines about the Introduction to Engineering course and its impact on the students learning. Section-3 describes the FPD course and its significance towards the realization of product design. Section-4 explains in detail about the human-centered design course called EPICS and its significant impact on the career perspectives of the student community. Section-5 emphases on the overall paradigm shift in the curriculum and achievement obtained by the students and faculty due to change in the curriculum.

2. Introduction to Engineering

IE course basically deals with the difference between science, technology, and engineering with the help of activities.

A. The objectives of the course are as given below,

1. Summarize different engineering disciplines and identify engineering challenges.
2. Evaluating opportunities and design process applicable to the real world.

3. Mention the methods for generating ideas to improve the design of the existing product.
4. Build multi-disciplinary system perspective.
5. Design a physical model and recognizing the importance of technical report writing.

B. The outcomes of the course are as given below,

1. Define various disciplines technology and engineering challenges.
2. Judge the responsibilities as a 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 teamwork skills.

The basic structure of the course includes. Pain Storming (identifying the customer pain points), Brain Storming, concept match, concept maps and scamper are the tools used for generating the ideas. Finally, small open-ended design projects will be done at the prototype level.

Some of the activities like tower building challenge scamper and sketching sessions are shown with the help of below pictures.

Fig. 1 Tower building challenge

Fig. 2 Scamper activity

Fig. 3 Sketching practice

The observation made by the faculty during this course clearly indicates that passive learning is replaced by the active learning in the teaching-learning process, which helps the students to become more interactive. The Involvement of the students enhanced their level of interest towards learning of the engineering subjects. This course is mandatory for all first-year students with a provision of teaching this course in a multidisciplinary approach.

3. Foundations to Product Design

As a continuation of the Introduction to Engineering course, the students will learn the basics of product design in their second year.

A. The basic outcomes of the course are [4],

1. Describe and discriminate the design process and its stages.
2. Conduct an ethnographic study and frame a design need.
3. Decompose the need in terms of independent functions.
4. Formulate value proposition from the point of view of different stakeholders.
5. Conceive ideas, develop them into viable concepts through appropriate investigation, and select viable concept.
6. Plan a project and work towards implementation.
7. Produce a working prototype and create a design report.
8. Demonstrate the project/product and prepare cost estimates.

To make this course very practical one lab session is also included called Product Design Studio (PDS) where the students will get complete exposure to the modern tools essential for the design of any product.

B. The outcomes of the Product Design Studio lab are given in the following points,

1. Produce new products by using carpentry tools.
2. Create new products by using tin smithy tools.
3. Perform soldering with different circuit elements.
4. Evaluate the characteristics of components related to electrical and electronic systems.
5. Design circuit using various electronic components and sensors.
6. Compute various electrical parameters of various circuits using DMM.
7. Assess the characteristics of various signals using CRO.
8. Create a product using rapid prototyping technique.

FPD course outlines the complete engineering process which includes problem identification, needs assessment, concept development, cost estimation, prototyping and effective report writing.

The shown below pictures are the activities followed under this course and lab sessions

Fig. 4 Carpentry

Fig. 5 Carpentry Items

Fig. 6 Tinsmith activity

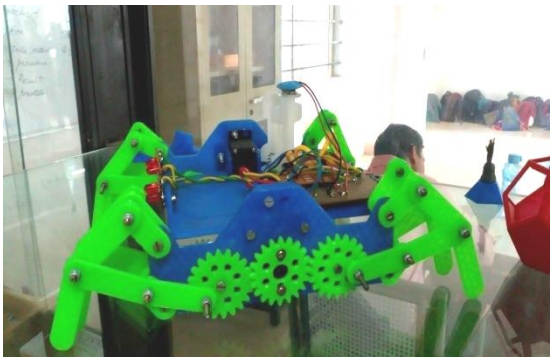

Fig. 7 Colour code detecting robot

Finally, students will be given one open-ended design product to be executed from working prototype level to the customer product level. Figure 7 presents the product developed by one of the student teams.

The reflection of the faculty teaching this course presents that the excitement of the student's involvement and their retention in the other engineering subjects drastically improved compared to the previous batch students. The learning outcomes of the students show that how significantly they have learned the design thinking and applied in the product design.

4. EPICS

Epics stand for Engineering Products In Community Service, It is a design course for the 3rd year students, where students form multidisciplinary teams to solve the social problems through their engineering knowledge.

As the extension of FPD, EPICS will enhance the design skills among the students to the fullest extent. EPICS is a combination of design thinking and service learning, students learn from the communities and thereby serve the communities by solving their problems.

In EPICS student interact with real people and identify the unmet needs of them. Students will design real products which will address the needs of the communities. Here community partner engagement will help the students to understand the wide nature of the customers and how to handle them in a professional way.

The curriculum of the EPICS outlines the different five phases of design that includes problem identification, specification development, conceptual design, detailed design and product delivery.

A. The following are the course objectives [5],

- Discipline Knowledge: ability to apply material from their discipline to the design of community-based projects
- Design Process: an understanding of design as a start-to-finish process
- Customer Awareness: an awareness of the customer
- Teamwork**:** an ability to function on multidisciplinary teams and an appreciation for the contributions from individuals from multiple disciplines
- Communication: an ability to communicate effectively both orally and written with widely-varying backgrounds
- Social Context: an appreciation of the role that their discipline can play in social contexts

The following table will describe some of the projects done by the students of S R Engineering College under EPICS course [6].

Table. 1 EPICS Projects

S No	Name of the Project	Community Partners
1	Multi Agri machine	Farmers
2	She Bracelet	Balavikasa , Widow woman
3	Cap Massager	Mallikamba Manovikasa Mentally handicapped school
4	Self-supporting Handstick	Sahrudaya Old age home
5	Artificial Limb	CHAI society
6	Antishock hiking walking stick	Physically handicapped person
7	School children bus safety App	Greenwood School
8	Fuel level indicator	Sai Seva Old age home
9	Low-cost Gas leakage detector	Bharat Gas agency
10	IoT based Agri motor control	Farmers

B. The following are the course outcomes,

- Apply disciplinary knowledge to real and possibly ill-defined problems.
- Collaborate with people from other disciplines and develop an appreciation for cross-disciplinary contributions in design.
- Develop the broad set of skills needed to be successful in the changing global workplace and world.
- Identify the customer requirements and community demands.
- Design the products used for the community service.
- Communicate effectively with widely varying backgrounds.
- Provide significant service to the community while learning; gain an understanding of the role that engineering (and their discipline) can play in society.

C. Case Study

One of the projects is explained here to understand the concept of EPICS. SHE BRACELET is the product used for woman protection.

1) Opportunity: Women are being attacked or harassed mainly when they are alone or in workplaces or abandoned areas. This project is a weapon against the crimes.

2) Market survey: As per market survey Titan Company has released a GPS tracking watch using a Smartphone, which can send message alerts to 5 contacts but it is not used by most of the women as it is expensive. It is a watch cum tracker. It costs Rs. 3000-5000

3) Partner: Bala Vikasa (Women protection based NGO) Widow Woman.

- This project can be useful in finding missing persons or children also.
- Funding: Accepted for 1000$ funding by EPICS in IEEE
- Using Nanotechnology, this circuit can be minimized and placed in the bracelet.

The experiences recorded by the EPICS students clearly showcases the excitement and the passion towards "Real design for real people" [7]. Management of SR Engineering College believes the philosophy of IDEO that is, ‘they believe that change is mandatory for every organization to survive in the current market and “change through design for the benefit of the people’’ is their slogan’ [8].

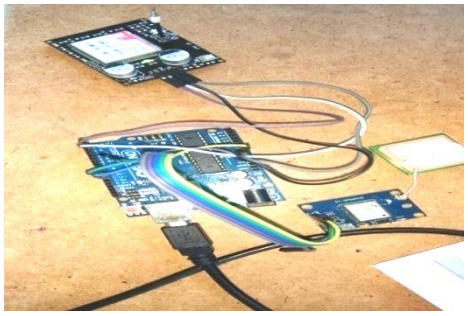

Fig. 8 She Bracelet Circuit

5. Conclusion

The best practices at SR Engineering College were outlined in this paper. Observations made by the teaching faculty and the students towards the paradigm shift in the curriculum were discussed in this paper. After the change in the curriculum, the dynamic shift is observed in the campus culture towards the teaching and learning patterns. Project-based learning is the key concept included in the curriculum through the new subjects like IE, FPD, EPICS. Students developed the skills of design, communication, team building, creativity, customer awareness and budget analysis. This broad skill set will surely make the students ready for industry and entrepreneurship. This kind of outcome-based curriculum is the best model for implementing in any institute to make their student's industry ready.

Acknowledgement

We are grateful to the Secretary and Principal of SR Engineering College for their motivation towards training us in these new subjects. We are also thankful to Prof. William Oakes, Director EPICS – Purdue University for the guidance and also thankful for the funding provided by EPICS in IEEE for the student team.

References

1. Evans, D.L., McNeill, B.W., and Beakley, G.C., "Design in Engineering Education: Past Views of Future Directions," Journal of Engineering Education, Vol. 79, No. 4, 1990, pp. 517–522.
2. https://www.srecwarangal.ac.in/vision- mission.php
3. Clive. Dym, Alicem. Agogino, Ozgureris, Danield. Frey, Larryj. Leifer. "Engineering Design Thinking, Teaching, and Learning," Journal of Engineering Education, Jan 2005, pp 103 – 120
4. https://www.srecwarangal.ac.in/eee- downloads/ SREC%20II-I%20EEE%20LP.pdf
5. https://www.srecwarangal.ac.in/epics.php
6. M.M.Irfan, P.Sammaiah, "Introducing the Service learning in the Engineering Curriculum", Journal of Engineering Education Transformation, JEET special issue 2017
7. Edward j. Coyle, Leah h. Jamieson and William c. Oakes, College of Engineering, Purdue University, 'EPICS: Engineering Projects in Community Service', Int. J. Eng Ed. Vol. 21, No. 1, pp. 139±150, 2005 0949-149X/91
8. Roberta Cruger, "Question Everything", www.howdesign.com, pp 54-59.