Journal of Engineering Education Transformations,
Volume No. 37, January 2024 Special Issue, eISSN 2394-1707

Empowering Student Publications: A Novel Approach through Student-Driven Research

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***Abstract*—To foster technological self-sufficiency in alignment with India's "Make in India" program, it is imperative to introduce initiatives that stimulate critical thinking among Engineering students. While theoretical and practical knowledge are pivotal in shaping the quality of future engineers. However, hands-on experience through lab courses and a project remains a conventional approach. Nevertheless, an increase in the number of projects enhances the problem-solving capability. This can be further taken to the next level by introducing student-driven research as part of the Engineering curriculum. Within this context, student-driven research emerges as a dynamic avenue, presenting students with a distinctive chance to cultivate vital skills, expand their knowledge, and nurture their professional advancement. This paper introduces the concept of Research-focused teaching and student publication as interconnected elements that can cultivate a culture of inquiry, innovation, and scholarly development among engineers. By merging these elements, educational institutions can nurture a generation of engineers proficient in research capabilities, contributing to technological advancement. The authors propose a comprehensive strategy for amplifying student-driven research through projects ensuring quality work leading to paper publication in standard conferences. The proposed approach introduces a novel team formation strategy, discusses evaluation rubrics, and explores potential graduate attributes attainment.**

***Index Terms*—Critical thinking, Student-driven research, Research-focused teaching, Student publication, Novel team formation strategy, Graduate attributes attainment.**

JEET Category - **Pedagogy Teaching and Learning. Sub Category - Research focused Teaching**.

I. INTRODUCTION

To transform India into a developed country, overall development in all sectors is essential, which demands critical thinking, polished skill sets etc as the major requirements. To achieve this, the role of the new generation is prominent. Thus, it is important to train and guide the new generation from the early days of education to imbibe these desired qualities. Raising the standard of the students as per the requirements of industries is a major issue that needs attention.

Lot of literature is available which highlights the effort of course instructors to create an effective teaching-learning environment. Authors in [1] introduces innovative frameworks and concepts for incorporating projects into the Engineering curriculum, emphasizing their role in fostering social, academic, and industrial partnerships. Teaching through simulation software, particularly focusing on SEQUEL is presented in [2].The authors share their approach to using SEQUEL to teach Digital Electronics, highlighting its benefits in enhancing students' comprehension of digital circuit analysis. Computer simulation, specifically PSpice Schematics Evaluation Version 9.1, to the teaching and laboratory environment for second-year Undergraduate students [3]. Significance of including Value Added Courses in the Electrical and Electronics Engineering curriculum is presented in [4]. It emphasizes team-based practical skill refinement and industry-readiness. The suggested approach involves a pragmatic integration of product design with fundamental courses, fostering hands-on experience and enhancing Graduate Attributes attainment. Authors in [5] addresses the growing demand for engineering students to engage in team projects, emphasizing active and cooperative learning. An effective teaching approach using the PSpice simulation tool for courses such as Circuit Analysis, Analog Electronic Circuits, and Digital Electronics Circuits is discussed in [6]. A reflective approach aimed at improving the effectiveness of undergraduate courses is discussed in [7]. The goal is to enhance the learning experience beyond traditional teaching methods. Authors in [8] present computerized adaptive assessment system which effectively measure course learning outcomes through summative assessments.

This paper was submitted for review on September 06, 2023. It was accepted on November, 15, 2023.
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However, there is a need to support the theoretical knowledge with sufficient practical knowledge. Practical knowledge can be delivered to the students through laboratory courses and projects. Unlike in conventional methodology, if students are encouraged to carry out more projects, their skill set can be improved. The authors in this paper present a methodology through which students' capability of carrying out projects can be taken to the next higher level. The authors propose a methodically organized strategy for gradually introducing the necessary foundational requirements, starting from the initial semesters for successfully undertaking projects.

The organization of the paper is as follows: Methodology is presented in Section II. Section III deals with Team formation strategy. Role of mentor is included in section IV. Quality assessment of the work for publication is discussed in section V. The conclusion of the work is presented in section VI.

II. METHODOLOGY

Traditionally, in numerous Engineering colleges, students engage in one or two projects in their journey of Engineering. However, in the Department of Electrical and Electronics Engineering (EEE), the curriculum structure mandates the completion of four distinct projects starting from V semester till VIII semester. Additionally, students are encouraged to undertake course projects. Based on the authors' previous experience in supervising department projects following a conventional approach, several observations are outlined below.

- Lack of exposure to the process resulted in improper or no planning during the execution of the project.
- In their first project, students encountered difficulties in applying acquired knowledge to achieve objectives effectively. It typically serves as a learning experience, guiding them through the do's and don'ts.
- Due to a lack of prior knowledge and exposure to such endeavors, students often struggle to produce work of good quality.
- No discussion regarding the work with the outside world in the form of publications. Hence, lack of knowledge sharing.
- Students exhibited lack of proficiency in skill sets demanded by industries.
- The skill imbalances among teams potentially resulted in reduced contributions towards the project.

Thus the involvement of the faculties in the early stage is essential to ensure good quality work. This is in the form of training and providing guidance, particularly starting from the second year of engineering studies. This training aims to familiarize students with the varied requirements for producing projects of exceptional quality. To ensure a holistic learning journey, the training is thoughtfully scheduled during vacations before the onset of the semester. This strategic timing empowers students to refine their skill sets, equipping them to proficiently undertake tasks aligned with their respective domains [4].

A. Formulated strategy

The identified prerequisites encompass a range of elements, including the necessary theoretical foundation, familiarity with computational and EDA tools, proficiency in presentation tools and report preparation. Further, knowledge about usage of various hardware components, and hardware prototyping are also included in the list. To guide students effectively, a meticulously crafted strategy is introduced in distinct stages. This approach is detailed in Table 1, ensuring that the process remains manageable for students and doesn't become over- whelming.

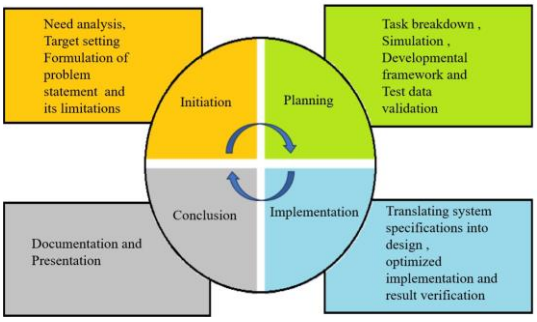

Fig. 1. Expected attributes for Individual reviews

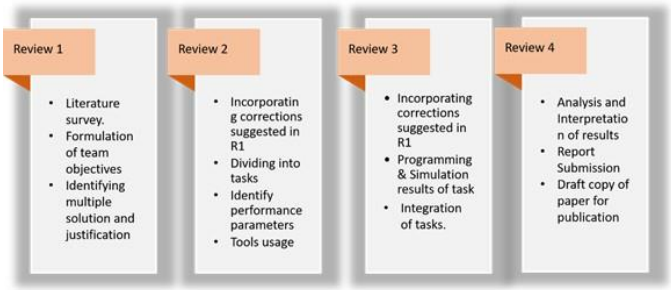

Fig. 2. Review Process

B. Objectives of the proposed methodology

The objectives of the proposed methodology are outlined below.

- Enhancing the fundamental knowledge of various courses essential for project execution.
- Refining students' coding and hardware skills.
- Introducing standard approaches for composing academic papers.
- Aiming to publish the research paper at a recognized standard National or International conference.

III. TEAM FORMATION

The conventional approach of team formation in academics is based on the final grade of the students usually by their CGPA (Cumulative Grade Point Average) or percentage score. However, final grades are primarily based on academic performance and do not necessarily capture a student's broader skill set. Effective teamwork often requires a diverse range of skills such as communication, problem-solving, leadership, and collaboration. Focusing solely on grades may result in teams lacking the necessary skill diversity for optimal performance. Commonly used conventional student team formation methods are listed below.

- Self-selected team: This allows team members to choose who they want to work with, which can lead to more cohesive and productive teams. However, it is important to make sure that the teams are balanced in terms of skills.
- Randomized approach: Using a randomizer is a straight- forward approach to form diverse teams for projects, considering a mix of skills. This allows for unbiased team formation, promoting equal opportunities for all students and fostering collaboration among individuals with varied strengths and backgrounds.
- Hierarchical approach: It involves creating teams based on the roll numbers of the students.

A. Proposed Team formation methodology

As discussed in the methodology section, there exist specific limitations in conventional methods that, once surpassed, can elevate the quality of student projects. Therefore, a new methodology "Skill-based approach" is proposed to create teams for project work with a balanced distribution of high performing, average, and lower performing students. It can be adapted to diverse categories of project work like simulation based or combination of simulation and hardware. The attributes listed in Table 2 are applicable for all categories of projects.

The authors recommend conducting a Technical Competency Assessment (TCA) to evaluate students' proficiency in various aspects, such as analytical and problem-solving skills, communication abilities, creativity, design, coding, and time management. Good teamwork requires a blend of these qualities, promoting cross-functional collaboration. A screening test is to be conducted to evaluate their knowledge, practical experience, and problem solving abilities related to hardware and software. After the assessment, students are divided into two groups based on their respective strengths in either hardware or software. By carefully categorizing students according to their knowledge base, teams can be formed

with a balance of hardware and software skills. Students can also be categorized specifically for software based projects, and the TCA questions will center on the skill sets essential for these projects. Thus, enabling effective collaboration and successful completion of projects. This approach encourages interdisciplinary collaboration and brings a fresh perspective to problem solving. Merging students' passion and skill set guarantees that teams are not only driven by students' interest but also equipped with the required expertise for effective project execution.

IV. Role of Mentor

The mentor plays a crucial role in project guidance, offering essential support and expertise to ensure project success. They assess the distinct requirements of the project and aim to create teams that synergize each other's abilities and expertise. The mentor has to design the problem statement for conducting a TCA based on the project requirements. Assessment questions are based on aptitude, logical reasoning, circuit design and coding concepts. The result obtained is used to categorize students based on their different skill sets like analytical and problem solving skills, communication and time management, creativity, circuit design, coding and elevator pitch. Students' area of interest can be an additional input for team formation. The overview of TCA is shown in Table 2.

A committee of faculty experts collaboratively has to define the project's problem statement. The students are guided in setting clear project goals and objectives along with a timeline. Training on prerequisites mentioned in Table 1 help students to prepare a plan for the execution of the project. Regular fortnightly reviews are to be conducted to assess the project's progress and provide guidance for necessary changes and improvements. Mentors also assist in selecting appropriate National/International conferences for showcasing the project outcomes.

V. Quality assessment of paper for publication

Quality assessment of paper for publication is a critical process to be carried out by the faculty experts. A transparent assessment strategy is to be established, accompanied by detailed rubrics that offer students a comprehensive understanding of project expectations. Rubrics are designed to describe the qualities and accomplishments associated with different tiers of performance. This is to ensure comprehensive and objective evaluation compared to a single, purely subjective rating. The course Articulation Matrix is shown in Table 3. The expected attributes for individual reviews are shown in Figure 1 and the corresponding Project Assessment Rubrics are listed in Table 4.

A series of regular reviews, guided by predefined rubrics, are conducted to evaluate and to provide continuous feedback. These reviews play a pivotal role in maintaining the project's trajectory, allowing the students to modify and improve the work based on the comments and feedback from reviewers. Thus, the uniqueness of ideas and methodologies of the work can be identified. The details of various stages of review are given in Figure 2.

TABLE I
ACTIVITIES PLANNED FOR TRAINING STUDENTS

Sl.No	Semester	Course	Tools	Outcome
1	III	Analog Electronics, Digital Electronics	Circuit simulation tools	Exposure to Industry standard EDA [2,3,6].
		Microcontroller	Embedded Development tool and related EDA software	Programming controller for various applications and its hardware implementation.
		Modes for effective documentation	Latex	Prepare standard reports/ drafting paper and power point presentations.
2	IV	Electrical machines, Power Electronics, Linear Control System.	Computational tools	Mathematical modelling of Electrical machines, power converters and controllers.
3	V	Machine Learning(ML)	Machine Learning tools	Application of various algorithms for complex problem solving.
		Power Systems	Power system software	Creating standard IEEE bus and performing various analysis.

TABLE II
COURSE ARTICULATION MATRIX

S.No	Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	Develop the ability to identify and formulate problems by applying diverse technical knowledge and skills for real world application	H	H	-	-	-	-	-	-	-	-	-	-	-	-
2	Apply the fundamental knowledge acquired in the curriculum to design, plan, and execute the system. Also build a prototype by choosing an appropriate simulation tool/ desired hardware components to meet the identified requirements.	-	M	H	M	H	-	-	-	H	M	-	-	H	-
3	Develop technical writing skills, communication skills and team work.	-	-	-	-	H	-	-	-	H	H	-	-	-	-

TABLE III
PROJECT ASSESSMENT RUBRICS

Stages Of Project	Attributes	Marks	CO
Initiation	Need analysis and Target Setting	03	1
	Formulation of Problem Statement and its Limitations	04	1
	Identifying multiple solutions and selecting the best suited solution and justifications with support of technical literature.	03	1
Planning	Project Planning and Task breakdown	03	2
	Formulating specifications and identification of performance parameters.	03	2
	Selection of appropriate modern tools.	02	2
Implementation	Design and functionality verification of individual sub blocks through simulation using appropriate modern tools.	05	2
	Integrating the various blocks and carrying out performance analysis.	09	2
	Analysis and interpretation of the results.	08	3
Conclusion	Report submission using standard engineering tools.	02	3
	Formulating specifications and identification of performance parameters	08	3

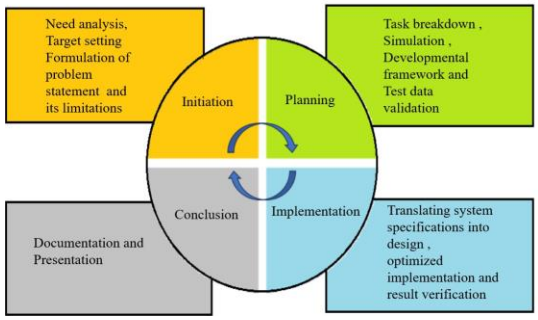

Fig. 3. Expected attributes for Individual reviews

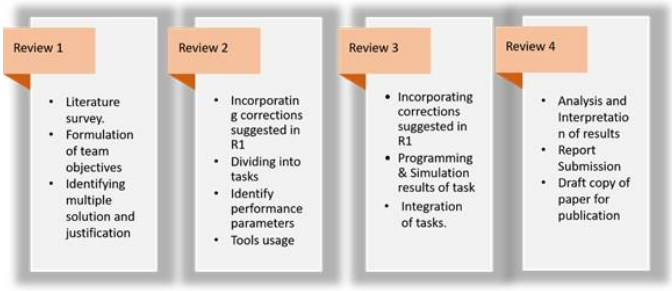

Fig. 4. Review Process

The frequency of reviews can be adjusted based on the specific project requirements. The proposed framework can be suitably modified and applied to projects carried out by students in their engineering curriculum. This systematic approach aids in maintaining consistency and thoroughness in the project development and thus achieving good quality work. Precise supervision of this work drafted in the form of paper by students is to be carried out to match the scope and focus of the target conference.

TABLE IV
OVERVIEW OF TCA

Skill set	Aptitude	Logical reason-ing	Circuit design concepts	Coding concepts	Elevator pitch
Analytical	✓	✓	✓	✓	
Problem-solving	✓				
Innovative design and coding			✓		
Communication					✓
Time management	✓	✓	✓	✓	✓

VI. CONCLUSION

The authors present an innovative approach aimed at cultivating critical thinking among Electrical and Electronics Engineering students to promote student-driven research. A comprehensive plan is outlined to equip students with the skills necessary to effectively carry out project work. It encompasses polishing fundamentals, familiarize students with modern tool usage, and expose them to recent technological trends relevant to their respective domains. The methodology involves carrying out project work at various semester levels. A novel team formation approach is proposed which addresses key shortcomings associated with traditional methods. Continuous monitoring and assessment of project work guided by rubrics helps in ensuring its quality, and worth publishing the paper in standard conferences. Rubrics and Attainment of possible

Graduate Attributes are discussed. This proposed framework demonstrates adaptability to project work across various engineering disciplines

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