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# Improving the Instructional Strategies of Traditional Electrical Engineering Course during the Pandemic

**Dr. Yasser Mahgoub, Department of Electrical Engineering, The University of Texas at Tyler**

Dr. Yasser Mahgoub is a Senior Lecturer in the Department of Electrical Engineering at UT Tyler. He received his Ph.D. in Electrical Engineering from Carleton University, Ottawa, Canada in 2009. His Ph.D. research topic focused on Co-channel Speech Separation Using State-space Reconstruction and Sinusoidal Modelling. This research was partially funded by the National Capital Institute of Telecommunications (NCIT) in Canada. He received his B.Sc. and M.Sc. degrees in Electrical Engineering from Al-Azhar University, Cairo, Egypt in 1992 and 1999, respectively.

Prior to joining UT Tyler, Dr. Mahgoub spent eight years as a faculty member in the Royal Commission Yanbu Colleges and Institutes, Yanbu, KSA, and the Higher Colleges of Technology, Ras Al Khaimah, UAE. He also served as the head of the Curriculum Development Department at the Royal Commission Yanbu Colleges and Institutes for three years.

**Dr. Prabha Sundaravadivel, The University of Texas at Tyler**

Dr. Sundaravadivel is an Assistant Professor in the Department of Electrical Engineering, at the University of Texas at Tyler. She received her Ph.D. in Computer Science and Engineering from the University of North Texas, Denton in 2018. She earned her Masters of Technology (M.Tech) in VLSI design from VIT University, India, in 2015 and Bachelors of Technology (B. Tech) in Electronics and Communication from SRM University, Chennai, India, in 2011.

Currently, she is working with a diverse multi-disciplinary research group of Graduates, Undergraduates, and High Schoolers as the Director of the Intelligent Systems Laboratory (ISL) at UT Tyler. As a Faculty at the University of Texas at Tyler, she has been involved in outreach activities in East Texas to broaden participation in STEM.

# Improving the Instructional Strategies of Traditional Electrical Engineering Course During the Pandemic

**Yasser Mahgoub**
Senior Lecturer
Department of Electrical Engineering
The University of Texas at Tyler, Houston Campus.

**Prabha Sundaravadivel**
Assistant Professor
Department of Electrical Engineering
The University of Texas at Tyler, Tyler Campus.

## Abstract

Engaging students throughout the semester has been particularly challenging through online and hybrid learning during the times of COVID-19. Each traditional course in the sophomore and junior level in the Electrical Engineering curriculum lays as a foundation or prerequisite for other courses, as the student advances in their Bachelors of Science (BS) degree. Failing to retain the student for the entire semester can cost them a year in their BS degree. Retaining the students in the online/hybrid courses means that the curriculum needs to be presented using more relatable and case-based methods, where students feel the significance of each learning objective and assessment. One solution is the integration of active learning techniques that can take advantage of the flexible timing that is not prevalent in the traditional classroom setting. In this paper, integrating problem-based learning (PBL) as an assessment tool in the EENG 3306 Electronics Circuit Analysis I course is discussed as a strategy to promote student engagement. This course was taught as an online and hybrid course at the University of Texas at Tyler, in both the Tyler and Houston campuses. The analysis of the data collected in the assessment reflect increased student engagement and enthusiasm in the curriculum.

## Introduction

Recruiting, retaining, and engaging students in STEM disciplines have always been a major concern. As per the reports of the President's Council of Advisors on Science and Technology (PCAST) [1], with the help of targeted funding programs for "STEM Retaining Boards," the National Science Foundation (NSF) will bring millions of Americans from non-technical backgrounds into Industries of the Future (IOTF) and other jobs [2]. The report also states that NSF will aim to have sufficient funding to permit its graduate fellows to spend time in industry as part of their training. These initiatives emphasize that enabling hands-on experience through skills-based licenses and certifications can help recruit and retain individuals in STEM at all STEM pipeline stages. Studies have shown that academic course engagement and degree attainment are directly correlated, implying that engagement is a crucial factor impacting retention [3].

Several conceptualizations have been discussed as different teaching methodologies to improve student engagement in a classroom setting [4]. These teaching methodologies focus on engaging the students in all three dimensions: behavioral, cognitive, and affective/emotional. The traditional lecture-based teaching pedagogy cannot be effective at all times, as each learner has a different learning speed. In a traditional classroom setting, it is difficult for the teacher to engage the students for the entire lecture time by merely going over all the instructional materials. In a post-COVID era, where the courses are being taught online or as hybrid courses, such a passive learning environment is a big challenge due to many reasons. It is difficult for the teachers to (a) track each student's progress and struggles, (b) monitor if the student is paying attention to the class during the lecture time, and (c) explain all the concepts via PowerPoint presentations as the complexity of the materials increase during the semester.

Active learning is a broad range of student-centered teaching methodologies that engage students as active participants in their learning during class time [5]. Active learning methods encourage learners to approach a problem through inquiries, collaborate with their peers, and develop realistic solutions [6]. Studies have shown that active learning increases the enthusiasm for both learners and facilitators, making it easier for them to evaluate. Active learning methodologies are centered around engaging students in the course material through discussions, projects, problem-solving, role plays, case studies, etc. [7]. Widely used teaching pedagogies that promote active learning include project-based learning [8], problem-based learning [9], game-based learning [10], flipped classroom [11], team-based learning [12], experiential learning [13]. With the help of technology, instructors can use effective methodologies to translate the theoretical concepts into engaging learning materials.

## Background and Literature Review

Located in Central-East Texas, the University of Texas at Tyler established its College of Engineering in 1996, and the first classes were taught in summer 1997. The Department of Electrical Engineering at UT Tyler is one of the oldest departments in the College of Engineering, which offers Bachelor of Science in Electrical Engineering (BSEE) and Master of Electrical Engineering (MSEE) at both the Tyler and Houston campuses. Though the College of Engineering was primarily an upper-division school, offering the continuing education curriculum for transfer students from community colleges, the freshmen and sophomore enrollment had started in Fall 1998 [14]. As an ABET-accredited BSEE program, the curriculum focuses on providing more hands-on experience for undergraduates at all levels. In both the Tyler and Houston campuses, the transfer students represent over 70% of the entire enrollment. There are certain challenges in engaging the transfer students in the curriculum. First, most of them would have already taken similar courses in their community college, that serve as feeders for the current university-level courses. Therefore, students tends to develop "student resistance" while basic topics are covered again for the traditional students. This makes them less engaged in the class. Second, when a teacher develops instructional material, it must be designed for both traditional and transfer students. This might lead students with previous knowledge of the material to feel disconnected from the class as the pace might curb their enthusiasm. Third, not all transfer students come from well-established community colleges, which can create a difference in the depth of each student's knowledge.

The EENG-3306 Electronic Circuit Analysis I course is offered as a required course in the junior year of the BSEE curriculum. This three-credit-hour course has a prerequisite of Linear Circuits I and General Chemistry and a co-requisite of Electronics I Lab. The topics discussed in this course include generalized amplifier models, two-port applications of operational amplifiers, simulations, small-signal modeling, and applications of devices such as diodes, bipolar junction transistors, and field-effect transistors. As this is a required course in the curriculum, both traditional and transfer students are expected to enroll. Given the diversity of students and the online and hybrid course setup, the instructors designed a problem-based learning (PBL) assessment as an effective instructional strategy to improve student engagement. This paper discusses the pedagogy of implementing PBL in the online and hybrid models in the EENG 3306 Electronics course for teaching the concepts of diode circuit models, voltage regulation, and rectifier circuits.

Problem-based learning (PBL) is an educational method that is based on research in the cognitive sciences on how we learn [15]. It is an instructional approach that originated in the health sciences curriculum in the 1950s [16]. The intensive medical education was presented as real-world problems that promoted independent learning with reduced lecture time. Howard Barrows from McMaster University in Canada, who was involved in the early stages of PBL development, defines it as a student-centered learning approach where the teacher acts as a facilitator in organizing the problem statement [17]. In recent decades, PBL has been one of the major success stories in education. In PBL, the teacher supports the process and expects students to approach the given problem with critical thinking. PBL motivates its learners to explore various venues to get the relevant literature for solving the problem. There are several models or methodologies that help integrate PBL as required in the curriculum. The objectives in designing a PBL assessment are based on the perception of knowledge, learning, problems, students, teacher roles, and assessment. The seven-step method of PBL is given in Figure 1.

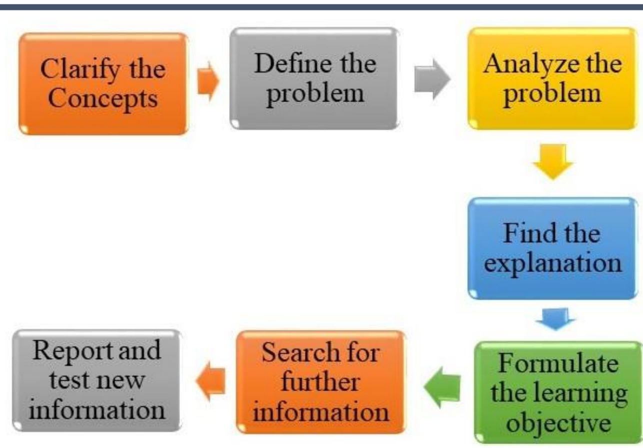


**Figure 1**: PBL seven-step method.

The main contribution of this article includes investigating the role of PBL in an online class to improve student engagement. This article presents the results of implementing PBL in a virtual environment for teaching Electronic Circuits Analysis I. Through this investigation, it was analyzed that the quality of the project outcomes, students interaction with the team, and the facilitator, significantly improved through the online PBL activity which was reflected through the assessments. The results of this online PBL activity is directly linked to the ABET student outcome 2. The steps involved in implementing online PBL activity for Electronics I is detailed in the following sections.

## Proposed Method of PBL in online class

PBL was integrated in the EENG 3306 Electronics I curriculum in the Fall of 2020 to teach the concepts of diode circuit models, voltage regulation, and rectifier circuits. The course was composed of three lecture hours and three contact hours of laboratory. The lectures were taught assuming that students enrolled in the class have prior knowledge of circuit analysis methods and general chemistry through the prerequisites. The proposed PBL method replaced the second midterm examination in the course. As the course was taught online, students were encouraged to design their proposed solutions as simulation files. The deliverables also included a comprehensive project report with a presentation followed by a short question and answer session. A detailed description of the PBL activity is presented below and summarized in Figure 2.

**Objective:** To design a Zener-regulated DC power supply.

**Expected Learning Outcomes:**

- **Transformer**: transformation ratio, step up or step down, rated ampere
- **Rectifier**: main types; half-wave and full-wave (center-tapped or bridge rectifiers), PIV
- **Filter**: ripple factor, determining C value
- **Regulator**: Zener diode, rated power, voltage regulation.

**Problem Statement:**

You are at a family gathering. People are impressed by you as a "skilled" Electrical and Electronic Engineer. Your uncle asks you to fix an old game console he used to play with ages ago. You check the game console and find out that the 10V regulated DC power supply is irrevocably doomed, and this part is no longer available in the market. Now you are the engineer! You need to save your engineering dignity by designing and building a new power supply. Your uncle urged you to finish this task in no longer than 10 days, as he is inviting a group of friends to enjoy old memories by playing this game. Are you up to the challenge?!

**Device Specifications:**

Input: 120V-AC, 60 Hz. Output: 10V-DC. Load power consumption: 1 Watt. Ripple factor: less than 1%. Voltage regulation: less than 1%.

**Deliverables:** Report, simulation of the designed circuit, and presentation.

**Rubric:**

1. Finished on time: 10%

2. Report: 40%
3. Presentation: 20%
4. Simulations: 30%

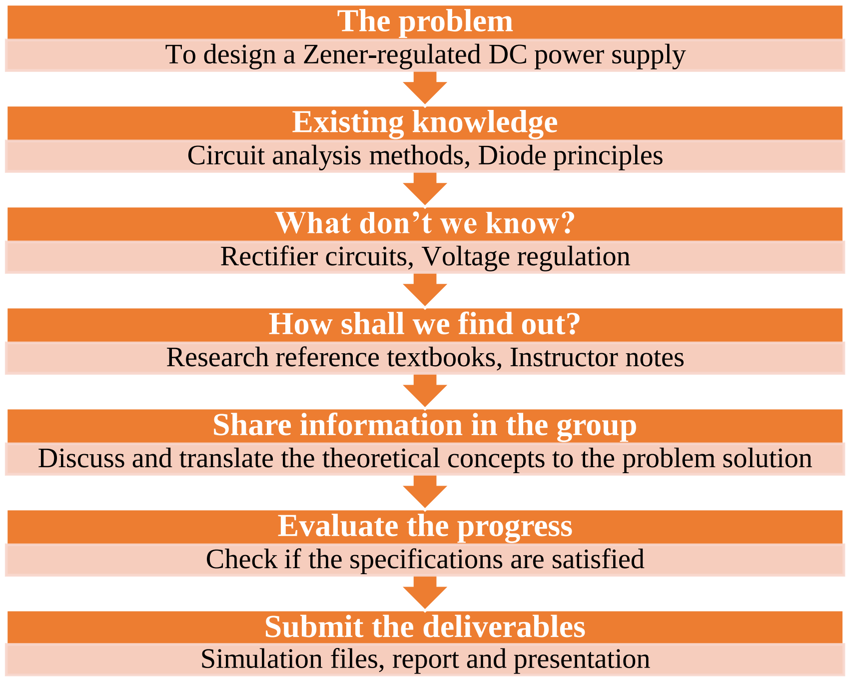


**Figure 2**: PBL Steps involved in solving the given problem.

## Results and Discussion

The PBL activity was implemented over three lecture hours, where the students were divided into small groups to work on the assignment. In addition to the textbook, students were encouraged to review the Instructor's notes and authentic online materials. Each group was assigned with a team leader to facilitate the discussion and a scribe to take notes, while other members acted as active participants during the discussion. The Instructor conducted the entire activity using the Zoom video-conferencing app. The results of this PBL activity were directly linked to the ABET student outcome 2, which included evaluating the student's capability to follow a design, define a problem, and produce a solution that meet specified needs. Figure 3 shows the mapping of the given deliverables to ABET student outcome 2. In the Tyler campus, there were a total of 19 students enrolled, who were formed into five different groups. By dedicating three lectures for the PBL activity, the instructor interacted with the teams with the help of Zoom rooms to facilitate the discussion on the given problem. At the beginning of the semester, students who were apprehensive about continuing the course as a hybrid class responded positively after the PBL activity. The overall class average significantly improved and kindled enthusiasm regarding electronic device topics later in the semester. A survey was conducted after the PBL activity to get student feedback on whether it can be incorporated as part of the instructional material in the upcoming semester. As shown in Figure 4, 15 out of the 17 students who took the survey responded positively to this question. The two students who had responded “no”, expressed a concern that the activity would have been more effective if conducted in-person.

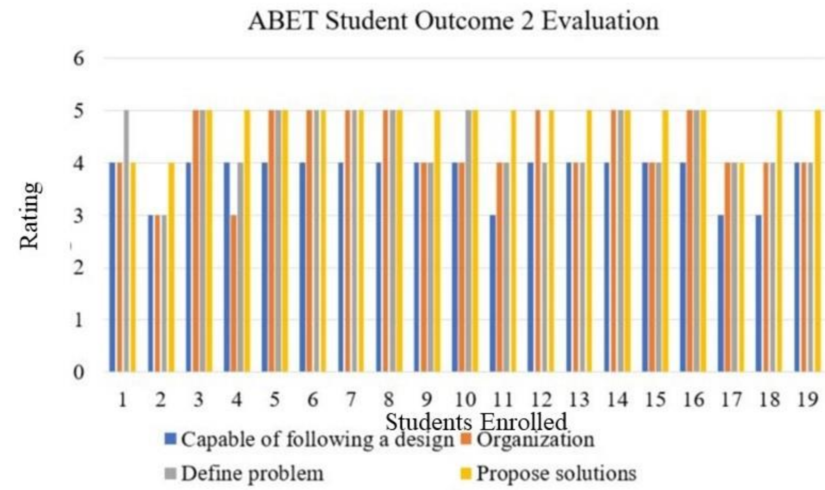


**Figure 3**: ABET Student Outcome 2 Evaluation with the proposed PBL activity in Tyler.

| | | | |
|---|---|---|---|
| True | 15 respondents | 88 % | ✓ |
| False | 2 respondents | 12 % | |

**Figure 4**: Student survey response to “ Can the PBL actvitiy be incorporated in upcoming semesters”

The PBL activity was conducted at the Houston campus using the same outline and procedure. The 37 students enrolled in the class were randomly assigned to six groups. The course instructor utilized Zoom breakout rooms to interact with the groups as a facilitator. At the end of the semester, the assessment results of the PBL activity were mapped to the four indicators of ABET student outcome 2. Figure 5 shows the average performance of students in each of the four indicators for the Houston campus. A survey consisting of four questions was voluntarily and anonymously answered by 25 students at the end of the activity. In the survey, students were asked to rate their overall satisfaction with the PBL activity. About 68% of students responded “very satisfied” or “somewhat satisfied”. In addition, 80% of the students agreed to incorporate the PBL activity in the following semester. Finally, students were asked to share what they liked most and what they liked least about the activity. Most students enjoyed the opportunity to work in teams while solving a real problem. The majority of students indicated what they least liked about the activity was the conflict it created with other course work and exams. Figure 6 shows the results of the first two survey questions.

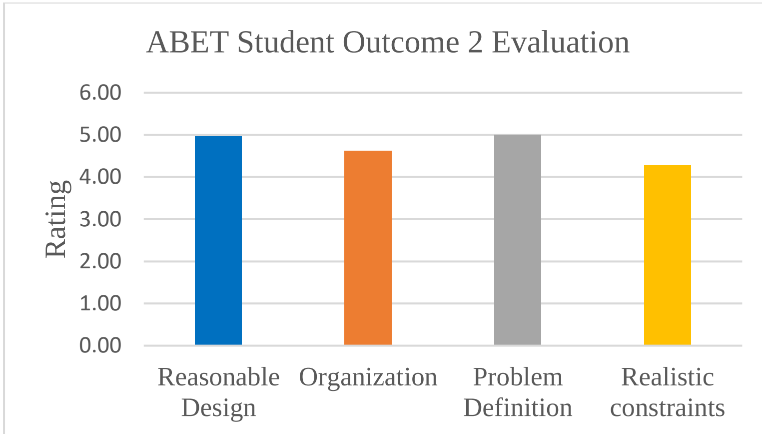


**Figure 5**: ABET Student Outcome 2 Evaluation with the proposed PBL activity in Houston (averaged for the 37 students).

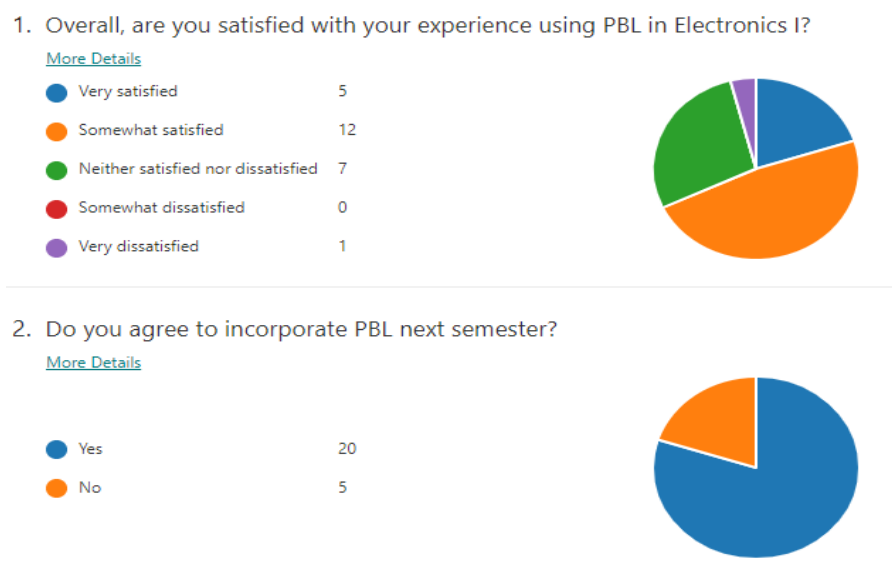


**Figure 6**: Student survey results at Houston campus.

## Summary and Conclusions

The main goal of integrating the PBL activity in the EENG 3306 curriculum was to increase the students' enthusiasm and engagement in acquiring engineering skills by solving a real-world problem that could translate the theoretical concepts. From the beginning of the semester, students were informed of this activity. In the lectures leading to it, they were well prepared to solve the given problem through realistic solutions that met the given specifications. As the proposed activity was well received by students both at Tyler and Houston campuses, the instructors will plan on replacing the traditional quizzes with more such activities that promote active learning. Future steps involve integrating the "hardware prototype" as one of the deliverables in the given problem statement.

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YASSER MAHGOUB
Dr. Mahgoub currently serves as Senior Lecturer in the Electrical Engineering Department at the University of Texas at Tyler, Houston Campus. He has several years of experience in implementing active learning strategies in the Electrical Engineering curriculum. He is experienced in integrating problem- and project-based learning techniques in course activities, supervising students in senior design projects, and mentoring students during work-placement.
PRABHA SUNDARAVADIVEL
Dr. Sundaravadivel currently serves as Assistant Professor in the Electrical Engineering Department at the University of Texas at Tyler. She is is a certified team-based learning practitioner. Her research interests include developing consumer electronic systems for smart cities and smart healthcare, affective computing for healthcare, and reconfigurable systems for IoT applications.