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Examining Imposter Syndrome and Self-Efficacy Among Electrical Engineering Students and Changes Resulting After Engagement in Department's Revolutionary Interventions

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WIP: Role of an Electrical Engineering Department's Revolutionary Programs through the Lens of Impostor Syndrome and Self-Efficacy: An Undergraduate Researcher's Investigation in a Participatory Action Research Project

Abstract

Purpose: In this work-in-progress paper, we discuss the student-led research efforts investigating the role of new programmatic activities within the University of South Florida's (USF) Department of Electrical Engineering (D-EE) and its effect on student's feelings of impostor syndrome and perceived self-efficacy. Impostor syndrome has been found to occur more frequently in scientific communities and found more prevalently in marginalized communities.

Context: In 2020, USF's D-EE was awarded the Revolutionizing Engineering Departments (RED) grant by the National Science Foundation (NSF). The ongoing grant supports organizational and cultural revolutions to improve the current Research-Teaching-Service model to a Research-Students-Practice model. Research efforts within the grant include sections on Participatory Action Research (PAR) in which students within the department could launch their own research projects into the effectiveness of the changes within the department, such as this one.

Approach: Three students within the Electrical Engineering department, who had completed at least one of the new RED revolutionary activities (e.g., classes, project, evaluation), participated in a semi-structured interview format, in order to complete a qualitative analysis of the effects of these classes on students' feelings of impostor syndrome and perceived self-efficacy. Thematic analysis was employed to analyze the qualitative data and identified broader themes demonstrating students' perception and changes in impostor syndrome and self-efficacy.

Preliminary Outcomes: Preliminary interviews confirmed that impostor syndrome is partially felt within the electrical engineering community under investigation. However, some of the RED program activities have played an important role in increasing student's perceived self-efficacy and thereby combating impostor syndrome. Students specifically mentioned how the distinct focus on design and project-based learning have supported, rather than traditional undergraduate theory courses.

Conclusions: This paper addresses the results obtained from the qualitative study mentioned above on the effect of the new RED program activities, specifically the Professional Formation of Engineers (PFE) classes, on student's feelings of impostor syndrome and perceived self-efficacy. These results will additionally be submitted to the university to help affect positive change in the RED program and the set-up of these classes moving forward.

Introduction

The Department of Electrical Engineering at University of South Florida's Revolutionizing Engineering Departments grant support radical change in the training of undergraduate

engineering students and help them establish identities as professional engineers with the necessary technical and professional skills needed to solve the complex problems facing society today. At the department, the RED program consists of many changes to the department including new Professional Formation of Engineers (PFE) classes, the Take Responsibility to Understand Engineering (TRUE) Lecture series, Track-Focused advisory boards for different electrical engineering tracks, and the industry-focused, TRUE-Outreach Capstone Projects. The PFE classes focus on preparation for engineering practices, primarily focusing on team-based activities to promote professional engineering communication, along with helping students create a qualification plan to develop their undergraduate and professional goals in engineering. The TRUE Capstone projects focus on preparing students for professional engineering problems by incorporating industry partners into the project decision process in order to identify real-world problems and solutions for the Capstone teams.

In accordance with the RED ideology, a group of students, mentored by an engineering education researcher, decided to apply Participatory Action Research (PAR) to study the role of new changes in the department. In this paper, we present the investigation led by one of the undergraduate researchers (first author) on undergraduate electrical engineering students' perceived self-efficacy and Impostor Syndrome during their participation in RED program activities.

Self-efficacy refers to the "students' beliefs in their ability to achieve tasks," [1] while Impostor Syndrome is defined as a "psychological term that refers to a pattern of behavior wherein people (even those with adequate external evidence of success) doubt their abilities and have a persistent fear of being exposed as a fraud," [2]. Impostor Syndrome is known to occur more frequently in scientific communities, along with marginalized communities and communities frequently facing mental health issues, such as anxiety and depression [3]. For this project, the goal is to study how the new classes, specifically the Professional Formation of Engineers classes, are affecting EE student's self-efficacy and symptoms of Impostor Syndrome.

Positionality

First author's positionality

In my own life, I, Jeffrey Morrison, have always felt a sense of Impostor Syndrome. Regardless of how well I do in school or how much I accomplish; I have always had doubts in my own abilities. Existing in the engineering world, I find this problem to be the most prevalent, particularly in industry. Even when I have succeeded in all my classes, I have felt a constant fear that when I get into the professional world, I won't be competent to be a successful engineer. Personally, I felt this fear was most prevalent during the initial foundational engineering course I took. In this course, students were put into groups and had to complete an engineering task (in my case, build a simple robot); however, the class's primary learning outcomes focused on non-technical concepts like engineering ethics, which made this course like a mini capstone where students had to find the information themselves to complete their projects. Reflecting on this project, I realized that researching and building circuitry for robots was the primary reason for selecting Electrical Engineering. Therefore, when I look at the department's RED program, I see a similar ideology: an attempt to teach students more about the professional side of engineering and empower students to take responsibility for learning. I still have not fully gotten over my

fear of failure in the engineering world. Still, as I venture further into the PFE curriculum, I hope it will help me further validate my abilities. In that way, I believe it is essential for the RED program to give students that sense of belonging in the engineering industry and improve their self-efficacy. This research is needed to determine how the RED program improves those metrics for other students. While performing my analysis of this data and collection of interviews, I was nonetheless determined to stay as unbiased as possible. Although biases surely affected the question set and analysis to some degree, I attempted to build the question set and analysis with the other authors on my paper, along with referencing other literature, to avoid personal biases.

Second and Third authors

The second author (Dhinesh Radhakrishnan) is a researcher in engineering education with extensive training and expertise in participatory approaches. The author values care, justice, equity, and democracy and, therefore, develops and conducts research collaboratively by centering diverse epistemologies and axiologies. In this paper, Dhinesh mentored the first author on research design, data collection, analysis, and dissemination. For the overall project, Dhinesh is the lead researcher investigating varied aspects of the department's RED programmatic activities. The third author (Chris Ferekides), the principal investigator of the department's RED program, is the department head. Chris believes in transformative change through research and evaluation and prioritizes student agency in research and teaching. In this paper, Chris provided broader mentorship on the overall needs of the program and provided administrative support. Dhinesh and Chris, true to student-led research, remained in purely mentoring roles post-research training for all the PAR undergraduate researchers. During the research process, guidance was provided based on the needs of the first author.

Context

Under the new RED program, six transformation activities were planned: a.) applying the Theory of Rugged Landscape in planning for overall transformations; b.) applying the Theory of Action State to study student transformations; c.) including the Taking Responsibility to Understand Engineering (TRUE) initiative as part of the capstone design; d.) designing and implementing the Professional Formation of Engineering (PFE) courses; e.) establishing Track-Focused Advisory Boards with industry-faculty-student members; and f.) Stakeholder (Student) Empowerment in the Faculty Evaluation process [4].

In this study, the main focus will fall on the PFE layer (which consists of a series of classes taken throughout an undergraduate's engineering schooling to prepare students for the professional engineering world) and the TRUE-Capstone projects (which are the culmination of the new EE degree, in which undergraduate student teams will be formed to provide an engineering solution to an industry-sponsored or community-sponsored project). A recent qualitative study on the effectiveness of the new industry-sponsored TRUE Capstone project on EE students' self-efficacy demonstrated increased perceptions of engineering self-efficacy after engaging with the TRUE projects. All three of the participants had positive opinions on the capstone project and mentioned many self-efficacy beliefs, specifically a belief in personal success for General (Academic-Learning) Engineering and Project Engineering [5].

Literature Review

Impostor Syndrome in STEM

Impostor syndrome, often stemming from burnout and gender-related stereotypes, leads one to question their competence and attribute their accomplishments to luck rather than merit. This phenomenon is prevalent in STEM majors, highlighting the importance of investigating perceptions of impostor syndrome and its counterpart, self-efficacy, particularly in initiatives such as the RED program [5].

In a Nature article titled "The Blight of Burnout and Impostor Syndrome," author Woolston [3] discussed the rising expectations and stress levels experienced by STEM researchers and graduates, where comparisons with highly qualified peers contribute to feelings of inadequacy. Declining job satisfaction rates among STEM graduates underscore the urgency to address burnout and Impostor Syndrome [3] comprehensively.

Studies have shown that impostor feelings are prevalent among ethnic minority college students and can impact their mental health [6], [7]. Furthermore, imposter syndrome has been identified among various professional and academic disciplines, such as nursing, chiropractic, and computer science [8], [9], [10]. In the context of undergraduate engineering students, the prevalence of impostor syndrome has not been extensively studied. Still, it is reasonable to infer that the unique academic and professional demands of engineering programs may contribute to the experience of impostor feelings among these students. Impostor feelings have been linked to educational outcomes, such as disengagement and grade point average, particularly among women [11]. The experience of impostor syndrome has also been connected to factors such as gender stigma consciousness, perceived discrimination, and minority status stress [6]. These findings suggest that impostor syndrome is a complex psychological phenomenon influenced by various social, cultural, and individual factors.

While the existing literature provides valuable insights into the impostor syndrome among diverse student and professional populations, there is a need for further research explicitly targeting engineering students. Investigating the prevalence, impact, and potential mitigating factors of impostor syndrome among engineering students would contribute to a deeper understanding of this phenomenon within the context of technical and STEM-focused disciplines.

Impostor Syndrome, Self-Efficacy, and Sense of Belonging

The relationship between impostor syndrome and self-efficacy among STEM students has been a subject of interest in academic research. Self-efficacy, defined as an individual's belief in their ability to succeed in specific situations or accomplish a task, has been found to be interconnected with impostor syndrome among students in STEM fields [12], [13], [14]. Studies have shown that self-efficacy and imposter syndrome play a significant role in shaping students' intent and career aspirations in STEM disciplines [15], [16], along with their engagement and continuation in STEM fields [17]. Sense of belonging has also been noted as a factor for minority students' engagement in STEM fields [18]. Furthermore, STEM self-efficacy has been linked to students' knowledge acquisition and problem-solving skills, which are essential components of success in STEM fields [12].

Impostor syndrome, characterized by feelings of intellectual fraudulence, has been found to impact self-efficacy among STEM students. Research has indicated an inverse relationship between impostor beliefs and self-efficacy, particularly among women in STEM [19]. Self-efficacy has also been identified as a strong predictor of intention to pursue STEM education among high school female students [20]. Additionally, impostor syndrome has been associated with low self-esteem among students, further highlighting its potential impact on self-efficacy [21]. Moreover, self-efficacy has been recognized as an essential component for positive outcomes, especially in combatting impostor syndrome among underrepresented STEM students [13].

In summary, the literature suggests a complex interplay between impostor syndrome, self-efficacy, and a sense of belonging among STEM students. Impostor syndrome has been found to impact self-efficacy, career aspirations, and persistence in STEM fields. Understanding and addressing the relationship between impostor syndrome and self-efficacy is crucial for supporting the success and well-being of students in STEM disciplines.

Project Summary

For this project, we look into EE students' perceived notions of self-efficacy and impostor syndrome while undergoing the RED programmatic activities. Specifically, the project looks at these constructs as they relate to industry, seeing how the PFE courses and the TRUE-Capstone project shape EE student's perceptions of confidence in school and the workplace. Due to the University's multicultural and diverse demographic, it is the ideal place to research Impostor Syndrome and address students' perceived sense of belonging in the engineering discipline and industry.

Research Methodology

The primary research methodology employed in this study is a qualitative interview study. While a quantitative approach may hold value for future studies, the focus here lies on a qualitative investigation akin to the recent studies conducted in the RED program. Given the emphasis on students' perceptions, a qualitative interview approach was deemed more suitable for effectively communicating the study's objectives and obtaining nuanced results. Nonetheless, some questions from previous studies will be adapted for a new interview format, specifically regarding self-efficacy. Unlike prior studies in the RED program that concentrated solely on alums, this research examined current students undergoing one or more RED interventions.

During the interviews, questions varied, encompassing inquiries about students' perceived skills for success in engineering studies or the industry (addressing self-efficacy), their sense of accomplishment in engineering, classes influencing their confidence, reasons for choosing engineering, and experiences of impostor syndrome. Additionally, some of the questions were chosen to align with cognitive motivation theories [1]:

- Goal theory queries students' career readiness goals.
- Expectancy-value theory prompts reflections on envisioned achievements with an engineering degree.
- Attribution theory explores students' interpretations of successes and failures.

Student participants were selected from different stages of their PFE and TRUE capstone curriculum. Of the three students interviewed thus far, one was in early university semesters,

another midway through the program, having completed the first PFE course, and the last nearing degree completion, finishing PFE coursework and entering the TRUE Capstone project phase. Future endeavors aim to interview more students across these undergraduate engineering career stages. Ideally, more research should be done explicitly on students in the TRUE Capstone project phase of their undergraduate career, along with adding more students in the PFE stages to increase the population's sample size. Additional interviews could also be conducted for recent engineering alums, implementing an identical question set.

Data Analysis

The transcribed data underwent analysis using the qualitative analysis tool NVivo, facilitating deductive coding. The coding framework encompassed five principal codes: Impostor Syndrome, Sense of Belonging, Perceived Self-Efficacy, RED Implementations, and Goal Setting. The data was further categorized into positive and negative subsets within these overarching categories to capture students' varying sentiments (Table 1). This systematic approach enabled the nuanced exploration of students' perspectives and experiences within the context of the study's focus areas.

Total Codes Analysis			
	Frequency (Negative)	**Frequency (Positive)**	**Frequency (Total)**
Perceived Self-Efficacy	4	9	13
Sense of Belonging	3	6	9
RED Implementations	2	5	7
Impostor Syndrome	4	2	6
Goal Setting	0	4	4
Grand Total	**13**	**26**	**39**

Table 1: Coding Framework

Findings

While the analysis is ongoing in this Work-In-Progress article, we present below some of the key preliminary findings.

Perceived Self-Efficacy

A substantial portion of the data coded for self-efficacy leaned toward positivity, reflecting interviewees' strong belief in their ability to excel in engineering coursework and industry endeavors. Despite all participants having completed at least one PFE course, none attributed their confidence solely to PFE. One prevalent theme revolved around students' positive attitudes

toward design, inspired by impactful bioelectrical Capstone projects, which bolstered their confidence in engineering success. When asked about confidence, one student specifically said,

> *"The biggest thing for my confidence so far has been the practicality of the tracks, specifically with bioelectricity"*.

Students expressed positive sentiments toward the electrical engineering track design, citing its specialization benefits, detail-oriented approach, and hands-on lab experiences as catalysts for confidence growth. Transitioning from foundational math and physics coursework to specialized courses further boosted self-efficacy among students.

Sense of Belonging

Responses regarding the sense of belonging exhibited a diverse range, with a notable split between positive and negative sentiments. Negative responses primarily centered on concerns within the electrical engineering discipline, particularly related to coding coursework. Some students questioned opportunities in fields like computer science or expressed dissatisfaction with coding, favoring electronics instead. Conversely, positive responses highlighted a strong sense of belonging within engineering, largely attributed to connections forged with classmates, especially through collaborative PFE projects. Students formed study groups, fostering camaraderie and confidence while mitigating feelings of impostor syndrome. One of the students had even recommended someone else to the program:

> *"…. was struggling to pick which school and engineering program to go into"* and *"I suggested electrical because of the specialization we get to go into and the USF's EE program since it's been easy for me to make friends and form study groups here."*

RED Program

The RED program category reflected positive feedback, although negative responses primarily stemmed from perceptions of PFE course content. While some students felt the PFE courses could be improved and questioned their professional relevance, others recognized benefits such as resume-building opportunities and exposure to successful engineers, with one student stating,

> *"PFE helped me build my resume and meet with successful engineers to show me what engineering can be."*

Variability in student perceptions suggests the differential impact of PFE courses.

Impostor Syndrome

In contrast to other categories, the impostor syndrome code exhibited mostly negative responses, albeit skewed by students' overall confidence in their chosen path. One participant initially experienced impostor syndrome, feeling dismissed by peers and questioning her aptitude for engineering coursework, specifically stating,

> *"After my first semester I felt like an imposter,"*. However, involvement in PFE projects helped alleviate these doubts, stating, *"over time and after more of these (PFE) classes, I began to feel more confident in my abilities and [felt] capable to complete the program"*.

Goal Setting

All participants expressed specific engineering goals, attributing some to PFE experiences, electrical course tracks, and past Capstone projects. PFE classes provided exposure to diverse career paths, influencing students' career trajectories. One student mentioned:

> *"I saw a few years back they created new COVID test kits in their Capstone project after the pandemic started,"* and ever since then, *"I've wanted to develop something small like that that can help people."*

The emphasis on designing meaningful contributions to society or industry emerged as a central goal among participants, inspired by past industry-sponsored capstone projects and specialization tracks.

In summary, while students demonstrated high perceived self-efficacy and strong goal-setting behaviors, challenges related to impostor syndrome and disciplinary concerns underscore the complexity of their engineering educational experiences. The positive impact of collaborative initiatives like the PFE courses and Capstone projects highlights the importance of hands-on, experiential learning in fostering student engagement and confidence within the engineering discipline.

Discussion

The findings presented in this study provide valuable insights into various facets of undergraduate engineering education, particularly concerning students' perceptions of self-efficacy, sense of belonging, the efficacy of USF's RED program, experiences of impostor syndrome, and goal-setting behaviors. These findings are contextualized within existing literature on engineering education research and shed light on the multifaceted nature of students' experiences within the discipline.

Perceived Self-Efficacy

Consistent with existing literature, our study underscores the significance of perceived self-efficacy in shaping students' confidence and attitudes toward engineering coursework and industry endeavors. The predominance of positive perceptions among participants aligns with previous research emphasizing the pivotal role of self-efficacy beliefs in predicting academic and career success in STEM fields [22]. Notably, the positive impact of specialized course tracks and hands-on design experiences highlights the importance of tailored curricular initiatives in nurturing students' confidence and skill development [23].

Sense of Belonging

Our findings reflect a nuanced understanding of students' sense of belonging within the engineering discipline. While concerns regarding disciplinary aspects, such as coding coursework, surfaced among participants, the positive influence of collaborative learning environments, particularly within PFE courses, underscores the importance of fostering inclusive and supportive educational climates [24]. The formation of study groups and peer support networks within PFE further accentuates the role of interpersonal connections in enhancing students' sense of belonging and academic confidence [25].

RED Program

The varied responses regarding the RED program highlight the complex interplay between curricular initiatives and students' perceptions of program efficacy. While participants recognized the potential benefits of PFE courses, concerns regarding course content relevance and professional growth opportunities underscore the need for ongoing program evaluation and refinement. The differential impact of PFE courses on students' experiences suggests the importance of personalized and adaptive pedagogical approaches to meet diverse student needs [26].

Impostor Syndrome

Our study illuminates the pervasive nature of impostor syndrome within the engineering discipline, despite the predominance of positive self-perceptions among participants. The experiences shared by one participant resonate with existing literature on impostor syndrome among STEM students, highlighting the potential impact of collaborative project-based learning experiences in mitigating feelings of inadequacy and self-doubt [11].

Goal Setting

The robust goal-setting behaviors exhibited by participants underscore the importance of purpose-driven learning experiences in facilitating students' career exploration and professional development [27]. The influence of PFE courses and specialized tracks in shaping students' career aspirations and skill acquisition underscores the value of experiential learning opportunities in engineering education [28].

Conclusion

In conclusion, our study contributes to the growing body of literature on undergraduate engineering education by elucidating the complex interplay between students' perceptions, curricular initiatives, and educational experiences within the discipline. By examining key themes such as self-efficacy, sense of belonging, program efficacy, impostor syndrome, and goal setting, our findings provide valuable insights for educators, curriculum designers, and policymakers seeking to enhance the quality and effectiveness of engineering education programs. Moving forward, future research endeavors should continue to explore innovative pedagogical approaches and interventions aimed at fostering inclusive learning environments and empowering students to thrive in their engineering careers. For the university, efforts should be continued to focus on hands-on, project-based learning in the curriculum. Additionally, efforts can be made to remodel some of the PFE coursework to focus more on project-based learning, with potential student input on the curriculum.

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