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Breaking Boundaries: An Organized Revolution for the Professional Formation of Electrical Engineers

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Breaking Boundaries:

An Organized Revolution for the Professional Formation of Electrical Engineers

The Department of Electrical Engineering at the University of South Florida is at the second year of its RED program. The main goal of the project is to change the department culture by transforming the existing traditional unidirectional Research-Teaching-Service model to a completely connected Research-Student-Practice one. There are several major tasks undertaken under the *Organized Revolution:* (1) The creation of Track Focused Advisory Boards (TFABs) for direct and impactful engagement of industry with the Electrical Engineering program; (2) the development of a novel faculty teaching evaluation process with direct engagement of student and industry review teams; (3) the launch of a new course series, *Professional Formation of Engineers 1, 2, and 3* to provide electrical engineering students with professional skills and career development guidance to broaden their education experience and support them in better understanding their discipline and potential future careers; (4) Study of the impact of action-state orientation on student success. An overarching theme for the project is that the new *completely connected department model* will engage all stakeholders in sharing the *responsibility* to empower students to *Take Responsibility to Understand Engineering* (TRUE).

INTRODUCTION

The department of Electrical Engineering at the University of South Florida (USF) has been committed to reform and implementation of innovative ideas for the continuous improvement of the professional formation of our students. This is evident in the ambitious RED program undertaken in the fall of 2020. Preceding the start of the RED program was a multiyear review and benchmarking of the BSEE degree requirements, that led to a new curriculum launched in 2017. The new curriculum organized the technical content (EE courses) in three categories: (1) *required core:* courses required of all EE students; (2) *elective core:* students must choose 4 out of 6 courses that provide additional breadth to the elective core; (3) *technical electives:* organized in 6 technical tracks (bioelectrical systems; communication systems; energy, power, and sustainability; mechatronics, robotics, and embedded systems; micro- and nano-scale systems; wireless systems); the 6 courses under the elective core serve as gateway courses for the technical tracks. Students must choose a minimum of two technical tracks and complete a minimum of two (3-credit) courses and one (1-credit) lab under each; all remaining electives can be taken under any track; students can also select courses engineering and science courses (beyond EE) as well as receive internship credit. The new requirements allow students to fully personalize their program by choosing depth or breadth depending on their own career goals and academic strengths. During the program's most recent ABET accreditation visit, the students identified the flexibility to design their own curriculum as one of the top two strengths of the

program. The breadth of choices offered by the new curriculum also created the need for improved career advising to assist students in navigating the technical elective structure, and opportunities for the department to seek transformative and innovative approaches to improve our students' *professional formation*.

The RED program seeks to build upon the recent curriculum reform by seeking ways to transform the department to better address our students' professional formation. The proposed *organized revolution* is based on the concept of *organized innovation* which also relies on the need to remove boundaries and eliminate silos in order enable innovation[1]. Under RED, the USF effort inspires to transform the traditional siloed Research-Teaching-Service model to a completely connected Research-Students-Service model (see Fig. 1). This paper reviews several of the main activities undertaken under the RED program with emphasis on the new required course series *Professional Formation of Engineers 1, 2, and 3* (PFE).

OVERVIEW AND PRESENT STATUS OF MAIN TASKS

In this section we review key tasks, define the goals, and describe the present status for each. A RED team member has taken the responsibility to lead each task, and the project is being evaluated by an external evaluator.

Track Focused Advisory Boards (TFABs): The creation of TFAB's represents the most significant and challenging activity under RED, and the key goal in transforming the department culture and creating a fully connected model. The ultimate goal is to create a TFAB for each technical track in the curriculum (i.e. bioelectrical systems, communication systems etc.); this approach will provide industry and students with an opportunity to have direct input in continuous curriculum improvement process, form networks, define capstone projects, seek out internships and more. The TFAB concept is not new in the department, as the wireless systems group have for over 20 years been engaging industry through their own industry advisory board. These interactions were initially focused on curriculum development and the integration of industry relevant tools in EE courses; the group developed and offers an industry certificate in wireless systems in close collaboration with Keysight. More recently the group begun hosting student-led workshops (see student organized forums below), which provide an excellent forum for students to serve in leadership positions, learn about the various subdisciplines within EE, and connect with industry and government experts. The intent is for the wireless systems TFAB to serve as a model for the other tracks as they launch their own TFABs and begin their direct interactions with industry. During the first year of RED two additional TFABs were created (Micro and Nano-systems and Mechatronic, Robotics and Embedded Systems). The two TFABs have held a several virtual meetings during which discussions took place on the potential directions and the nature of the interactions among faculty, industry, and students. The participating industry members of the newly formed TFABs have already contributed several capstone projects for our students.

During the first year of the RED program, the wireless systems TFAB has continued its activities and held its annual student led and student organized forum, which had to be organized in a virtual mode due to COVID. The key highlights of the one-day forum are:

- Organized by graduate and undergraduate students taking leadership roles
- Nearly 200 attendees participated in the meeting
- Microsoft TEAMS was the hosting platform; an interactive pdf agenda was created to emulate the natural setting of a conference
- A Panel on "RF/Microwave/Wireless Engineering, Hiring and Internships in the Age of Covid-19" was organized with panelists from industry, national labs, and academia
- Ten Industry Members and Event Sponsors held virtual booths for interacting with students on career opportunities.
- Ten virtual poster presentations took place and were judged by judges from industry and faculty to identify the top 3 for best poster awards
- Three guest speakers were invited to present technical talks with topics:
    - "Making It All Work: Evolving Challenges of RF System Design".
    - "Adaptive Electromagnetics – from Fields to Bits".
    - "Advances in Power Amplifiers for the RF Energy Market".
- A Young Professionals and Women in Engineering session held a panel of young professionals

In the comments section of the first year-end RED survey, the faculty expressed concerns with regards to the time investment required to launch and maintain the TFABs, while they also praised the existing wireless systems TFAB for having demonstrated *"very organic and enthusiastic"* and *"consistent engagement"* of all stakeholders including industry and students. The survey results were quite encouraging as 85% of the faculty agreed or strongly agreed with the proposed creation of additional TFAB's in the department.

A Novel Faculty Teaching Evaluation Process: The goal under this RED task is to create a novel teaching evaluation process that engages all stakeholders (including industry & students). The new process will be based on developing training materials to prepare students on how to effectively evaluate teaching and teaching portfolios, and it is intended to become an integral part of the faculty promotion process. The training will include the fundamental elements of designing a course and delivering content; the initial plans call for the students to observe instructors in the classroom, review the course syllabus, and other course materials, and prepare a report. A similar approach will be developed for TFAB industry members who will also be invited to evaluate faculty teaching portfolios. At present the faculty teaching activities and effectiveness are based on several factors including: (1) the creation of new courses, (2) faculty participation in curricular and pedagogical activities, and (3) student end-of-semester evaluations, the usefulness of which has been called into question [2]; teaching portfolios are reviewed and evaluated only by faculty, and the department chair. The only feedback faculty receive is based on the department chair's annual evaluation.

During year one, a student training module, *Preparing to Evaluate Teaching* (PET), was developed within the university's learning management system (CANVAS), and a team of 5

students were invited/selected to participate. The students were selected based on certain criteria that include academic performance and prior completion of the courses they are inivted to evaluate/review. The selection criteria list is evolving, and the intent is to also review the students' overall engagement through extracurricular activities. No results are available currently as the first student reports are under preparation/review.

Results from the first year-end RED faculty survey were in general in favor of the new process: 40% of the EE faculty agreed or strongly agreed with the proposed teaching evaluation process, while 25% disagreed or strongly disagreed; 35% were neutral or did not know enough to provide a response. Faculty comments included *"I strongly agree that the evaluation system has to change"*; *"I do not believe that students and industry partners can fairly evaluate the faculty performance without being affected by their biases…",* and "*neither students, nor industry understand well the expectations from faculty…".* It is noteworthy that this RED activity was the top vote getter, when faculty were asked to indicate which aspects of the RED program they would like to learn more about. The to-date activities and overall faculty responses on the new teaching evaluation process appear encouraging, but it is also clear that additional effort is needed to better inform and engage the faculty on the specifics of the process and its overall intent to assist faculty in identifying areas where they can improve their teaching effectiveness.

Action-State Orientation: This activity focuses on investigating the impact of action-state orientation on student study habits and performance and will also investigate whether students can become more action-oriented through interventions and guidance from faculty/department. Action-state orientation is a personality attribute that reflects how well people can develop effective strategies to achieve their goals.[3] Becoming more action-oriented is part of the Taking Responsibility to Understand Engineering (TRUE) concept that aims at improving the students' engagement with their academic program. During the 1st year of RED, *action-state* orientation surveys were completed in various university courses, including EE, engineering, and non-engineering courses. Over 2600 students were surveyed, with >1300 engineering majors, >1000 psychology majors and >260 electrical engineering majors completing the voluntary surveys. The initial results did show a link between action-state orientation and study behaviors; action-oriented students exhibited improved study habits. Additional information on this study will be presented at the same conference [4].

Next steps under this task will seek to identify whether action-state orientation can also be linked to academic success, and whether students can become more action-oriented through interventions (guidance and training) by the faculty/department. Such interventions were implemented at the start of the 2nd year of the RED program, and the analysis of their impact on student study habits and performance is underway and will be reported in a future publication.

PROFESSIONAL FORMATION OF ENGINEERS COURSE SERIES

Course Description and Background

The Professional Formation of Engineers (PFE) course series was initially intended to be based on career readiness competencies as defined by the National Association of Colleges and Employers [5]. Following the creation of new general education (Gen Ed) requirements at the university, the PFE series was modified to also serve as one of the new Gen Ed requirements for *ethical reasoning and civic engagement (ERCE);* this meant that the PFE credit hours would not impact the total credit hours of the program. The capacity of PFE courses is capped at 25 students to promote student engagement and participation in in-class activities; the intent is for these courses to be taught by a *Professor of Practice.* The PFE courses, which are taken in the middle sophomore and junior years, also serve as a *bridge* linking the freshman engineering design experience (all USF engineering students are required to complete the freshman Engineering Foundations course), with the senior capstone design courses required of electrical engineering students. Table I lists the course objectives for each of the 1-credit PFE courses.

Table I. Course Objectives for the Professional Formation of Engineers Course Series

PFE 1 *will provide students a foundation in:*	PFE 2 *will provide students a foundation in:*	PFE 3 *will provide students a foundation in:*
engineering ethical codes and creeds	identifying academic and research career opportunities and assessing the benefits of pursuing graduate degrees	processes of engineering design, innovation, invention, and entrepreneurship
exploring ideas of engineering career opportunities and factors that will influence individual preferences	identifying current engineering research activities at USF and best practices	methods to determine customer needs and obtaining continuous feedback
formulating short and long-term college and career goals	enhancing technical skills by selecting a technology area for further study and completing an external learning course activity	using stakeholder analysis to create market strategies and value propositions
creating plans to develop personal and professional competencies	promoting and proposing innovative solutions for research and technology development that address a local community need	elements of good design, project roadmaps and project management plans

Embedded within the PFE series are two additional components of the RED program: (1) TRUE Lecture series (TLS), and (2) Personalized Qualification Plans (QP).

The TRUE lecture series was launched in year 2 of the RED program. The goal of TLS is to create a direct link between students and practicing engineers in an interactive setting during the middle years of their academic program to better inform them on the importance of curricular content and extracurricular activities on their future careers within the EE discipline.

The Qualification Plans were introduced since the initial implementation of the PFE series [6]. The QPs are intended to instill self-learning and continuous education among EE students, and are part of the TRUE concept, with students taking responsibility to pursue self-learning beyond their regularly scheduled coursework. PFE students developed their own QP to address certain skills and competencies they identify as critical to their future careers, and in which they see the need for self-improvement. Initially the QP's were self-defined and self-monitored (by the students). Students provided progress reports on the % completion of the various skills/competencies they included in their QP plan; it was not required that all skills and activities are 100% completed. The goal under RED is to provide additional structure for improved monitoring of student progress and recognition. During the first year of RED a module has been created within CANVAS that will enable faculty to monitor QP activities and assign grades as these are completed. Next steps include the development of an award/recognition process that will recognize students who have developed exceptional QPs and achieved high level of completion.

Having undergone a review through the university's approval process the PFE courses series is currently a *required sequence* for the BSEE program. During the first year of RED the program's external evaluator developed and run surveys to evaluate the impact of the new courses. The students were asked to rate their abilities prior to and at the end of the respective PFE course, as captured in the course objectives and student outcomes. A 5-point scale (1-novice to 5-expert) was used, and the surveys were voluntary. Response rates were 40-50% for the three courses, and total enrollments were 35, 26, and 27 for PFE 1, 2, and 3 respectively; enrollments are still low since the courses became a required recently. The surveys were designed to track student progress as they progress through the 3 PFE courses, however they are not identical since objectives, activities, and student outcomes vary from course to course.

Figure 2 shows the before and after survey results for students in PFE 1; the survey focused on the course objectives. Clearly the responses suggest that the students believe they improve in all areas being addressed by PFE 1, with the largest improvement being in how to *utilize the Technology Development Process;* this topic is most likely a concept the students had never been exposed to prior to taking this course, which may explain why they feel they improve the most. Applying ethical perspectives and recognizing ethical and professional responsibilities is the second most improved area; ethics is also addressed in the freshman engineering course, however, student exposure and engagement (participation in case studies, in-class discussions etc.,) is more significant and impactful in PFE 1.

Figure 3 shows the responses from PFE 1(top) and PFE 3 (bottom) related to a question on the QP plan, where students were asked to select four skills they included in their QP. Clearly the top choice is Career Management under which the top activity was seeking and completing an internship prior to graduation; it should be noted that the department has been emphasizing the value of internships through other means including several annual information sessions, one-on-one advising, and other activities through the academic year. Although the sample size is small, it is interesting to note, that there were two significant changes in the selection rate (or ranking) of the various skills between PFE 1 and PFE 3 students.

(1) Teamwork: the interest in teamwork for PFE 1 students is in the top 3 (@ 53%), while for PFE 3 students it drops to the bottom 3 (@ 22%); the trend is supported by the results of PFE 2 (not shown here) where teamwork was in the middle (@ 46%). Although it is not clear at this time what caused this change/trend, and additional information will be needed to understand it, it is possible that students believe that their teamwork skills improve considerably as they progress through the EE program, and therefore they do not fell they should include it as part of the skills they must improve upon.
(2) Technology: *technology* includes engaging in activities where the students can gain experience and learn a new technical skill, such as using a new software/hardware tool. Technology moved up for students in PFE 3, having been selected with a frequency 29%, 39% and 44% for PFE 1, 2 and 3 respectively (the complete results for PFE 2 are not shown here). The preliminary conclusion on this trend is that it is probably too early for students in PFE 1 to be familiar with relevant technical skills, but as they progress through their program and gain more insights and understanding of their future careers they begin to select technical skills (that include tools like AUTOCAD, ADS, PYTHON etc.)

Figure 4 summarizes student responses from PFE 1, 2 and 3 on a question where the students were asked to indicate the *extent to which the course supported* their understanding and abilities on various professional characteristics. Noting again that the sample sizes are small and that additional results will be needed to fully evaluate the impact of the PFE courses, in nearly all instances the scores have decreased. A review of the open-ended student feedback and comments did not provide additional insights to explain the lower scores from PFE 1 to PFE 3. At this time we can only speculate that PFE 1 is more impactful being the first course in the sequence, and that students view the activities and knowledge in PFE 2 and 3 as incremental. The surveys will continue in subsequent years of PFE in order to improve the effectiveness of the PFE series.

PROGRAM CHALLENGES

A significant challenge for the program was the fact that it was launched while the university was operating fully online under COVID protocols. The RED program is led by the department's curriculum committee which comprises of faculty representing all undergraduate tracks; the RED activities and overall program was a topic of discussion in nearly all monthly

faculty meetings, and faculty (not members of the curriculum committee) were invited to participate in RED related activities (for example as members of the new faculty evaluation of teaching committee). Nevertheless, the results of the year-end survey point to the need for improved communication and engagement, as captured by a RED team member comment "*Many faculty members are fatigued with online meetings, and it is often difficult to have the deep conversations that an in-person retreat fosters. The team members acknowledged the need for more communication and dialogue with faculty members outside of the project team to ensure the project's success.*" The faculty survey results indicated that 65% of the faculty expressed interest *to learn more* about the new faculty evaluation process, the top choice among all RED activities. TFABs and the PFE course were at the bottom of the list as it appears that all faculty are well informed of these two tasks.

Additional challenges include the departure of the university president (currently on leave) who was a mentor on the project and an expert in *Organized Innovation.* The participation of the former university president in the RED team, provided direct access to university leadership and institutional support at the highest level.

SUMMARY

The department of Electrical Engineering at USF has successfully launched its RED program at the start of the academic year 2020. Every major task is led by a RED team member which contributed to the successful launch. As the program moves into the second year, the RED team has identified several key issues for continuing the successful execution of the program: (1) improved communication and faculty engagement; (2) maintaining the high level of activity achieved in year one; (3) implement effective evaluation tools to assess the impact of the various activities on the professional formation of our students.

Figure 1. A depiction of today's siloed traditional engineering department (left) that is based on a Teaching-Research-Service approach, and the vision of the USF RED program to transform the department to a fully connected Research-Students-Practice unit.

Figure 2. Survey results in PFE 1 on the question: *Rate your ability in each of the following course objective prior to starting PFE 1 and at the end of the course.*

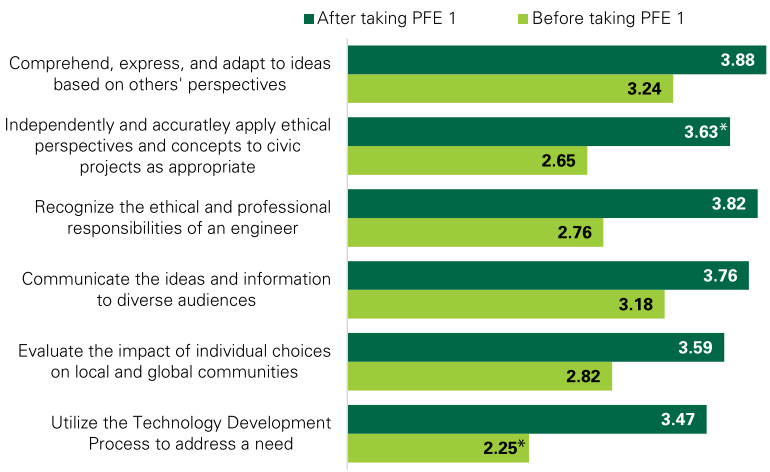


Figure 3. Survey results in PFE 1 (top) and PFE 3 (bottom) on the question: *Select the four skills you are choosing to focus on for your professional Qualification Plan.*

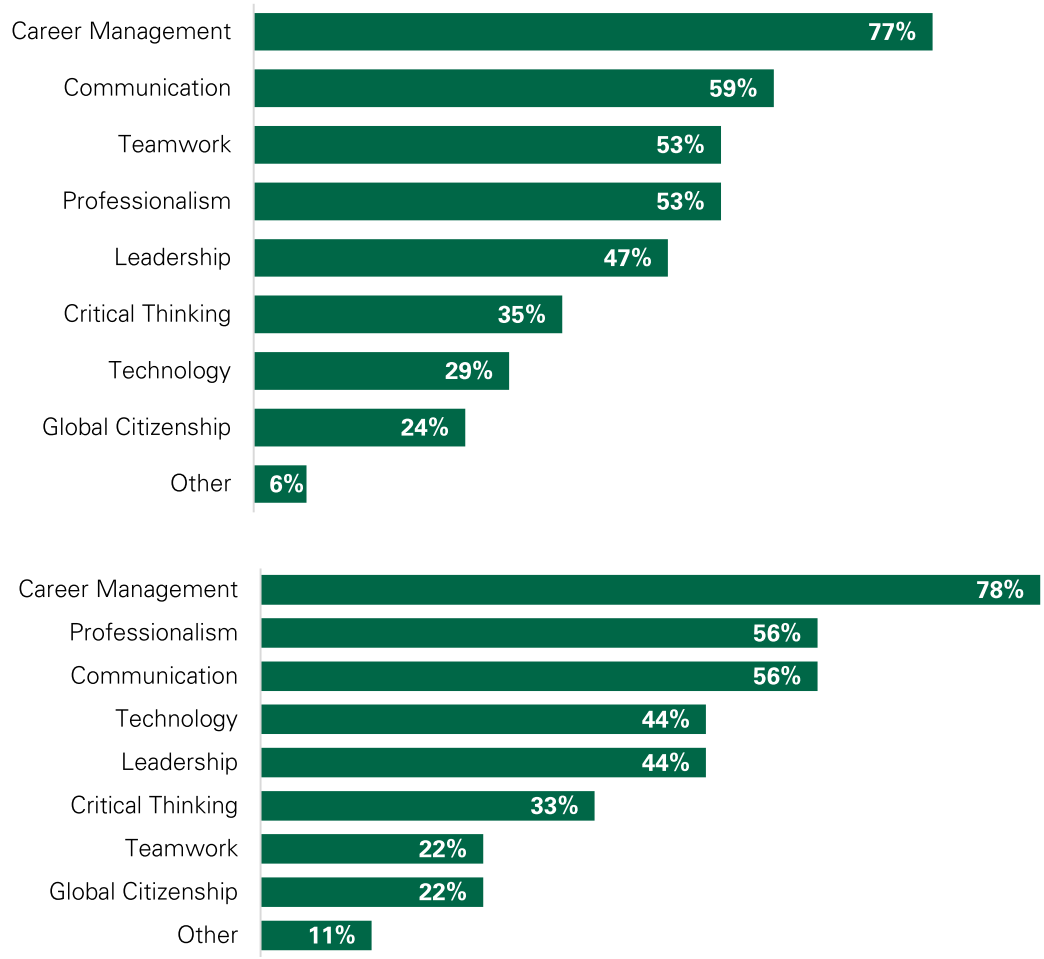
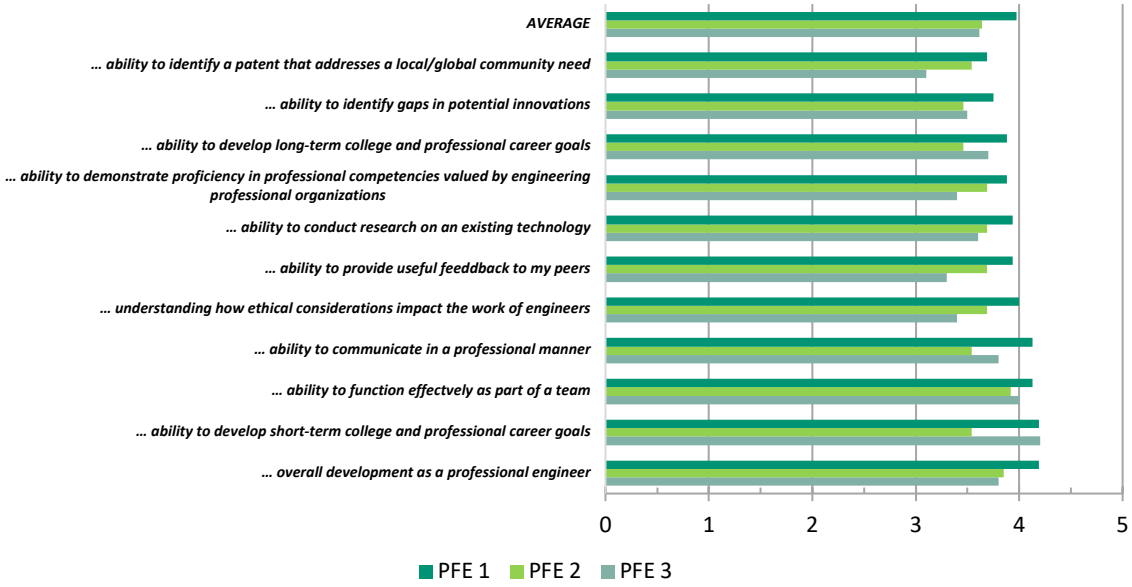


Figure 4. Survey results in PFE 1, 2 and 3, where students were asked to: *rate the extent to which the course supported you in the following ways.*



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