



## **Integrating Research into the Undergraduate Engineering Experience**

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## Integrating Research into the Undergraduate Engineering Experience

### Abstract

At the University of Central Oklahoma we have successfully embedded undergraduate students in research projects; these projects often result in conference papers and other products with these students as lead and co-authors. Here we discuss our overall environment of embedding students early in their engineering curriculum through their senior design course. Our focus has been on exposing students to core research skills, open-ended problem-solving and design, and every possible venue for student practice of communication skills. The end result over seven years has been a strong string of senior design projects, research productivity, and employment and/or graduate school acceptance.

### Introduction

At the University of Central Oklahoma (UCO) we actively integrate undergraduate students in research projects across all levels from Freshmen to Seniors. The integration occurs deliberately through a combination of undergraduate research (UGR) support opportunities from external funding and institutional funding. Engineering students at UCO are one of the most active majors across campus in UGR activities and programs. Here we discuss the suite of programs in place to support UGR and the authors' specific experience with UGR over several years.

UCO has served a model institution in the area of Transformative Learning and has helped define this area especially in engaging students inside and outside of the classroom. This is very evident when one considers that UGR has been part of the Central Six in the transformative practice of Problem Solving (Research, Scholarly and Creative Activities).

One primary driver that initially embedded UGR in the UCO culture was a National Science Foundation (NSF) STEP (STEM Talent Expansion Program) grant. We have had this funding for over ten years. This program places incoming freshmen (and a smaller number of transfer) students into research projects the summer before they become UCO students. This is a residential experience for four weeks in which the incoming students work with peer mentors and faculty in STEM disciplines. Following this summer bridge experience, these students are eligible to continue participation in UGR and receive stipends in their first year at UCO. These students who also demonstrate financial aid needs have received scholarships from the NSF S-STEM program. Another support mechanism has been Department of Education (DOE) funding for some of the STEP students to work as peer mentors with early STEP students. Additional DOE funding has recently been received that is further enhancing the STEP students experiences and assisting in continuing the funding of the summer portion of this program. Although engineering majors are not the only majors taking part in the STEP program, they make up a large fraction of the STEP students spanning across biomedical engineering, electrical engineering, engineering physics, and mechanical engineering.

In UCO's College of Mathematics and Science the Center for Undergraduate Research and Education in STEM (CURE-STEM) was formed eight years ago. Faculty CURE-STEM scholars are supported to engage students in UGR and seek external federal funding. This support includes reassignment time, UGR student funding, travel funding, and supply funding. The end result has been of significant increases in federal funding and success of UGR students.

The suite of programs is rounded out by a university-wide program that supports student grants - the RCSA (Research, Creative, and Scholarly Activities) grant proposal are written by students and support UGR students to work 5 hours per week, receive a partial tuition waiver, and buy \$500 in supplies for the proposed project.

Across the UCO campus, engineering students are taking part in the suite of programs and activities mentioned above as much as any majors on campus. The primary author is doing research in fluids engineering. He has had students participating in these programs for eight years. Some examples of student projects are: Experimental Validation of a Porous Media Simulations, Experimental and Computational Investigation of Energy Losses in Microfluidic Channels and Junctions, Simulations of Flow in the Human Renal Artery with an Aneurysm, Experiments Using Particle Image Velocimetry to Measure Entropy Generation Rates in Laminar Flow in Junctions, as well as others.

The common track for the pipeline of students and projects works as follows:

#### Freshmen Year

NSF STEP students begin working with existing students on a project. This is sometimes the current year's senior engineering design project for other students that have been involved in the author's lab for one to four years.

#### Sophomore and Junior Years

Students (some continuing as NSF STEP students and some new students) have applied for and received RCSA funding and have their own projects. These projects often are related to a current year's senior design project, but they sometimes are a new research direction that the group is interested in. This works very well if we have a new manufacturing or measurement technique we want to try, but do not know how well it will work.

#### Senior Year

A subset of the current years senior engineering design team is supported by an RCSA grant. These students have specified a design project related to their research interests. This interest usually goes very closely with the faculty mentor's ongoing projects. Often the design is related to an experiment we want to carry out. As part of senior design deliverables we now include the demonstration of the ability of a flow and measurement system to be capable of producing publication-quality data. The ability to confidently include this high bar as a deliverable took several years to be able to consistently achieve.

The students that have gone through multiple years of this training have significant lab, manufacturing, prototyping, and measurement skills. Also as part of RCSA and senior design requirements must at a minimum produce a research poster for a statewide research day. Many students also give oral presentations about their work at statewide and regional conferences. Some of these students also attend national and international conferences: serving as first author and presenter on conference papers. The combination of technical skills, team skills, and communication skills gained by these students enables them to obtain better positions in the workplace and in graduate school.