Preparing PhD Students for Jobs in Industry

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Abstract

More than 70% of engineering PhDs now plan to pursue business or industrial careers as opposed to careers in academia. In an effort to better support these students, the University of Arkansas College of Engineering developed a one-hour course devoted to career preparation and success. The focus of the class was on finding the right job and then succeeding at the right job. The course was taught in Spring 2023 and 2024 by two distinguished alumni who have significant experience in the course content from their many years of industrial experience. In the Spring 2024 semester, the course attracted 21 PhD students from 13 majors across three colleges and two post-docs that audited the class. The class was well received, with 100% of the students saying they would highly recommend the class to their peers.

Keywords

Career preparation, career success, industry jobs for PhD students

Introduction

According to the National Center for Science and Engineering Statistics (NCSES), there were 9,733 earned doctorates in all fields from U.S. colleges and universities in 1960 and 31,019 in 1980. By the year 2000, the number of doctorates had grown to 41,369 and, in 2022, the number had grown to 57,596 [1]. As is shown in Table 1, the number of engineering doctorates also increased steadily from 8,469 in 2012 to 11,530 in 2022. Doctorates in engineering now represent 20% of the total doctorates earned in the U.S. and are second only to the life sciences among the STEM fields.

Table 1. Earned Doctorates in STEM Fields and Overall, 2012-2022 [1]

Field	2012	2014	2016	2018	2020	2022
Engineering	8,469	9,626	9,459	10,165	10,476	11,530
Life Sciences	11,964	12,484	12,539	12,755	12,561	13,211
Math/Computer Science	3,496	3,862	3,954	4,022	4,392	4,854
Physical/Earth Sciences	5,419	5,910	6,251	6,331	6,247	6,649
All doctorates	50,943	53,986	54,809	55,085	55,283	57,596

In further examining the earned engineering doctorates in 2022, 27% of the doctorates were earned by females and 54% were earned by temporary visa holders (see Table 2). This latter statistic is very important to students searching for postgraduate jobs because many companies only hire U.S. citizens or permanent residents. Electrical/computer engineering and mechanical

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doctorates are the most plentiful, a trend that is also observed with undergraduate engineering degrees.

Table 2. Earned Engineering Doctorates in 2022 by Gender and Citizenship Status [1]

Engineering Field	Total	Male	Female	Temporary Visa Holder
All engineering	10,763	7,832	2,931	5,820
Biological, biomedical, biosystems	1,236	676	560	350
Chemical, petroleum	1,255	840	415	635
Civil, environmental, transportation	1,315	897	418	823
Electrical, computer	2,132	1,735	397	1,471
Engineering technologies	361	286	75	252
Industrial, operations research	655	469	186	396
Materials, mining	925	637	288	434
Mechanical	1,545	1,248	297	842
Engineering, other[a]	1,339	1,044	295	617

[a]Includes aerospace, engineering mechanics, nanotechnology, nuclear and other types of engineering

Table 3 shows the post-graduate plans of recent engineering PhD graduates by sector (academia, government, industry or business, nonprofits or other) from 2000-2020 [2]. Only 10% of the PhD graduates planned to enter academia in 2020, a percentage that was at its lowest level since the year 2000. Conversely, 77% of the graduates pursued a job in industry or business, showing the highest percentage level since 2000.

Table 3. Post-graduate Plans of Engineering PhD Graduates, 2000-2020 [2]

Employment Sector	% Employed in Each Employment Sector				
	2000	2005	2010	2015	2020
Academia	14.8	18.5	16.9	14.5	10.3
Government	9.0	9.3	12.9	9.8	8.5
Industry or business	72.9	68.7	64.3	72.0	77.0
Nonprofits	1.8	2.3	3.1	3.2	3.2
Other or unknown	1.5	1.2	2.8	0.6	1.1

With this trend toward industrial employment, are universities doing a good job in preparing their PhD students for future jobs in industry? The answer is no and, according to the National Academies [3], has been no for several years. Why? Choe and Borrego [4] note that engineering faculty have a greater familiarity with academia over industry and even tend to push their students toward coveted positions at research universities. Holloway *et al.* [5] recognize that PhD graduates are technical experts but often suffer from a lack of preparation and have difficulty in translating their knowledge into impact in practice. Furthermore, campus recruiting events such as resume workshops, the sharing of tips for successful interviewing and career fairs

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are more often directed toward undergraduates (and perhaps MS students) rather than PhD students.

PhD advisers and career service personnel need to realize that many PhD students are interested in jobs in business and industry and also need help in securing employment. In addition to technical expertise, this help includes broader preparation in professional areas including oral and written communication skills, selling their capabilities, networking and mentoring, and working in teams. It includes the development of interviewing skills, expertise in the proper use of LinkedIn and other professional networks, and skillful resume preparation.

This paper describes a PhD course in the College of Engineering at the University of Arkansas (U of A) which emphasizes career development for PhD students and career success once the job is secured. The class is co-taught by two distinguished alumni and Chemical Engineering Academy members, Jose Vega and Mike Mourot, who have significant experience in the course content from their many years of industrial experience. Dr. Vega has an MS and PhD in chemical engineering from the U of A and is retired from Procter & Gamble in Brussels, Belgium and Cincinnati, Ohio. He is now working as a consultant out of Brussels. Mr. Mourot has a BS and MS in chemical engineering from the U of A and works for the Sinclair Group in Houston, Texas. He retired from Dow Chemical, where he served as Head Recruiter for the U of A and other schools.

Class Development/History

"Careers in Engineering" began in the Spring 2020 semester as a one credit hour Chemical Engineering senior/graduate level course. The course was taught by Jose Vega, who annually visits the U of A from his home in Brussels. The purpose of the course was to introduce senior undergraduate and graduate chemical engineering students to a broad outline of concepts and practices that they will encounter when landing a job in industry and prepare them to be strong contributors from the start of their employment. As is shown in the course topics in Table 4, the course explored many of the key areas that will lead to a successful career as an engineer and presented skills that new engineers will need to develop on the job. The class was taught with an enrollment of 13 students (six chemical engineering seniors, three MS students and four PhDs) in Spring 2020 and again with an enrollment of ten students (nine chemical engineering seniors and one PhD) in Spring 2021. The course was very well received by the students, who felt that the course provided very good information for undergraduates and graduate students that were about to enter the workforce. The course was again offered in Spring 2022 but only attracted three students.

Table 4. Careers in Engineering Course Topics (Spring 2020, 2021)

1. Understanding yourself: your talents and strengths • Personality and career orientation profiles • Performance reviews • Performance vs. potential
2. Your relationships • The importance of emotional intelligence • Working with a manager and in your teams

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• Crucial conversations • Personal and professional networks
3. The company you work for • Company culture, business models and organizational structure • Company economics • Innovation models in industry
4. Working as an engineer in industry • Scale-up and launch of initiatives • Intellectual property • New influences in industry

Leading Innovation in Industry—Unlock Your Potential

After the last offering of "Careers in Engineering" in Spring 2022, it was decided to open the course to all engineering majors in order to attract more students, but it was also decided to restrict the course to PhD students only. The course retained the one-hour of course credit but was now taught as a College of Engineering graduate course. The feeling was that the course could be most beneficial to PhD students because of their lack of employment resources but that the course also needed a career development focus to provide the most benefit to the PhD students.

Enrollment

The first offering of this PhD-level course occurred in Spring 2023 and retained the title "Careers in Engineering." The class met on Tuesdays and Thursdays from 3:30-4:45, beginning in early March and ending in early May with the close of the semester. Mike Mourot joined the team (commuting from Houston) to provide a career development focus and jointly taught the course with Jose Vega in Spring 2023 to 15 engineering PhD students from five engineering majors (see Table 5). One of the major problems encountered in recruiting students to the class was the reluctance of the students' academic advisors to see value in the class. It was observed that students would pre-enroll in the class and then drop the course 1-2 weeks later after speaking with their advisors. The course was renamed "Leading Innovation in Industry—Unlock Your Potential" in Spring 2024 and was made available to PhD students from any STEM major. In 2024, the course attracted 21 PhD students from 13 majors across three colleges and two post-docs that audited the class. Figure 1 shows the students and guest speaker Yang Luo-Branch from Tyson Foods as she addresses the class in Spring 2024.

Table 5. PhD Student Enrollment in Careers in Engineering and Leading Innovation in Industry

Semester	Engineering	Arts and Sciences	Agriculture
Spring 2023	Chemical Engineering—6 Civil Engineering—1 Computer Science—2 Electrical Engineering—3 Industrial Engineering—1 Mechanical Engineering—2		
Spring 2024	Biological Engineering—2	Biology—1	Food Science—1

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	Biomedical Engineering—1 Chemical Engineering—3 and 1 post-doc Civil Engineering—4 Computer Science—1 post-doc Materials Science—2 Mechanical Engineering—2	Chemistry—3 Geosciences—1 Mathematics—1 Physics—1	

Figure 1. Guest Speaker Yang Luo-Branch from Tyson Foods, Spring 2024

Course Coverage

Table 6 shows the topics covered in the class in Spring 2024. The first five class periods covered topics on finding the right job, led by Mike Mourot. Students were asked to introduce themselves to the class using the STAR (Strengths, Weakness, Opportunities and Threats) technique, were required to assemble a personal persona and think about and answer behavior-based questions that are often used in job interviews. They learned about the importance of career matching (what is important to you?) and the many aspects of the job search and interviewing, including written and on-line resumes, participation in in-class mock interviews and the use of profiles on social media with LinkedIn as a target. Verbal and written communication skills and social styles were highly emphasized, as well as the critical organizational behaviors that are necessary for success. Dr. Jenn Campbell, an Assistant Professor of Mechanical Engineering at the U of A, spoke to the class on March 26 about how engineers think, how they work on teams, and how this impacts social and environmental sustainability.

Table 6. Leading Innovation in Industry Course Topics, Spring 2024

Date	Instructor	Topic
March 7	Mourot	Introductions, class expectations
March 12	Mourot	Self-introductions
March 14	Mourot	Behavior-based interviews
March 26	Mourot	Job search and interviewing; guest speaker

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March 28	Mourot	Soft skills, social styles
April 2	Vega	Essence of leadership
April 4	Vega	Learning about you and your results
April 9	Vega	Leading others
April 11	Vega	Organizing for innovation
April 16	Boyd	Starting and leading your own company
April 18	Industry panel	Examples of leadership in industry
April 23	Vega	Protecting innovation
April 25	Vega	Key strategies to be most successful at work
April 30	Mourot	Deployment of concepts; guest speaker
May 2	Mourot	Deployment of concepts

The next eight class periods, April 2-25, covered success at the right job, led by Jose Vega. The first class covered the essence of leadership—being at your best, talent diversity, leading at various stages of a career, motivation and the contribution cycle, and leading through questions. The students then learned about themselves. What are your talents? What are your weaknesses? How can you acquire new skills? What is performance? How is your manager impacting your performance? What career traits are you attracted to? They learned about leading others including emotional intelligence, crucial conversations, the potential for advancement, the performance, image and exposure (PIE) model, mentors, sponsors and networks. They learned about the importance of leadership in innovation, different leadership styles, the company culture, the stages of the innovation cycle, managing complexity and understanding your job.

Hop Boyd, another alumnus who is the Chief Manager at Process Engineering Associates in Oak Ridge, Tennessee, spoke about starting and leading your own company on April 16. What is the main purpose of a company? Why would someone start their own company? What is your key role as leader of your own company? On April 18, using a panel of four alumni (Bob Poag, RK Poag, PA, Osceola, Arkansas; Jerry Gollinger, an Independent Quality Consultant, Flippin, Arkansas; Hop Boyd and Mike Mourot), the discussion addressed development as a technical leader, becoming a manager, when to change jobs or companies, and how to find your own path.

Discussions then turned to protecting innovation—why IP is important, how to protect your inventions and how to safely collaborate with other companies. Finally, this section of the course ended with the key strategies to be most successful at work. What makes a great performer? What are the practical tips to succeed in industry?

The final two class periods attempted to put everything all together and were led by Mike Mourot. The class reviewed the students' updated profiles, resume, job search plans and revisited the personal persona information. Dr. Yang Luo-Branch, Community Transformation Leader at Tyson Foods, spoke to the class on April 30 about the "confidence to lead" and how meaningful innovation starts with self-innovation. The students then filled out a class evaluation to help guide future offerings of the class.

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Grading

In determining the grades for the semester, the class was treated as a seminar class with attendance as the only factor used in determining the grade. While this is not the usual procedure in academic classes, it does set the tone for typical industrial courses where the participant individually determines the value of a class through participation.

Evaluation

In evaluating the quality of the class, the instructors noted that they preferred a class with an enrollment of 20-30 students in order to have a better discussion of the topics that were presented. They noted that the Spring 2024 class with 21 students was just about perfect in number and also noted that the class with 13 different disciplines presented a real opportunity for students to consider topics from different perspectives. The instructors said that discussions were lively and that the students were able to see that all PhDs are not alike.

Table 7 shows selected results from an end-of-semester class and instructor survey for both the Spring 2023 and Spring 2024 offering of the class. The class and instructors scored very high on all of the survey points and, most importantly, 100% of the students said they would recommend the class to their peers. Here are a few of the additional student comments from the class:

- *This course is important in the development of students professionally and gives insight into how life in industry will look. The class should be mandatory for students in the future.*
- *All sessions that were taught were informative and engaging.*
- *Excellent class. I really liked the inclusion of young women speakers in the class.*
- *Mr. Mourot was an excellent instructor. I appreciated his ability to connect topics across sessions, enhancing my understanding. His wealth of experience and nuanced grasp of innovation provided me with a fresh perspective.*
- *Dr. Vega was great. He had very interesting points of view and provided us with a ton of resources to use at our discretion. Listening to and interacting with him has made me feel more confident in myself and more prepared to face the future.*

Table 7. Results from End of Semester Class Survey, selected questions

Survey Question	Score (5.0 max)	
	2023	2024
This course material is pertinent to my professional training	4.27	4.69
This course gives me skills and techniques directly applicable to my career	4.64	4.56
The team teachers in this class are compatible	4.55	4.75
This course made me more aware of my interests and talents	4.27	4.56
Overall, I would rate this course as:	4.55	4.75
My instructor is effective in teaching the subject matter of this course	4.64	4.81
Overall, I would rate this instructor as:	4.64	4.75
Would you recommend this course to your peers?	100% yes	100% yes

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Future Work

Obviously, a single one-hour graduate course in career development and success is not going to change the employment culture for PhD students at the U of A, but the course is a good start. In addition to the course, the Career Development Center in the College of Engineering has begun to reach out to PhD students with help on resume preparation and the use of LinkedIn. They have also hosted workshops for graduate students with industry representatives and are hoping to add networking opportunities for PhD students. Each department in the College of Engineering has agreed to host representatives from industry in their seminar series who will include opportunities for PhDs with their companies. The Chemical Engineering and Industrial Engineering departments have developed alumni career mentoring opportunities for their students and several other engineering departments have recently expressed interest in student mentoring as well.

Discussions have also started between the College of Engineering and the Graduate School to perhaps open the class to all PhD students at the U of A instead of just STEM majors. The Graduate School could definitely do a better job of advertising the class to all PhD students but there are concerns that the course content may or may not be appropriate for all majors. In the next offering of the course in Spring 2025, a few PhD students from any major that are currently participating in the Graduate School's Razorgrad Institute for Success and Engagement (RISE) program at the U of A will be invited to participate in the class.

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