

UW Academic Challenge and Engagement Study (UW ACES): Industrial and Systems Engineering

Angela Davis-Unger, Office of Educational Assessment

Jennifer Tsai, Academic Adviser

November 2015

INTRODUCTION

Research on learning in college shows that learning is profoundly shaped by the goals, practices, cultures, and values of the academic disciplines¹, particularly the disciplinary practices in students' majors. Therefore, if we are to understand the kinds of experiences that students find intellectually rigorous (and, thus, engaging), we need to examine challenge in the major. Understanding challenge in the major is important because at every stage of their college experience, students report that they want to be challenged, that they perform better in courses that are challenging, and that they value classes that stretch their thinking and ask them to demonstrate learning more than they value classes that ask little of them.² Although learning about where students experience challenge is important, asking students to describe challenging learning experiences in their majors requires some prior understanding of how those majors operate. The Office of Educational Assessment (OEA) designed the UW Academic Challenge and Engagement Study (UW ACES) to accommodate these needs.

METHOD

Qualitative methods are recommended when researchers are seeking to understand the complex learning experiences of students, as well as the meaning they ascribe to those experiences³; therefore, we designed the UW ACES to be primarily an interview study.⁴ Using a "citizen science" model, OEA asked departmental advisers if they would be willing to volunteer to interview seniors in their departments who came in to advising to apply for graduation. Advisers are knowledgeable about their academic programs, understand disciplinary practice in their departments, and are trusted by students in the major, so they have the best chance of gathering good information from seniors about their experiences in the major.

Sixty-six advisers from 33 undergraduate programs volunteered to participate. During the 2012-13 academic year, the volunteer advisers asked students if they would participate in brief (5-10 minute) interviews about challenge in the major. If the students agreed, advisers asked them to respond to four open-ended questions, entering students' responses directly into a Catalyst survey form that OEA researchers had designed for that purpose. The questions were as follows:

¹ Beecher & Trowler, 2001; Bransford et al., 2000; Beyer et al., 2007; Donald, 2002; Pace and Middendorf, 2004; Wineburg, 2001, 1991; Neumann et al., 2002; Shulman, 1988; Biglan, 1973.

² Beyer, et al., 2007.

³ Merriam, 2001.

⁴ One participating department asked students to respond to the open-ended questions in writing.

1. What do you consider to be the most challenging work that you had to complete in this major? And by "challenging" I mean doing the work that stretched your thinking the most. This can be anything—a project, a paper, an exam question, homework, something else you did related to the major.
2. What made the project/class/activity challenging?
3. What did you do or learn that enabled you to meet those challenges?
4. What do you think you learned by completing this project/class/activity?

In addition, advisers asked students in what course the challenging work took place and how many quarters they had until they graduated.

Researchers in OEA conducted training workshops in interviewing skills with all participating advisers, provided individual departments with survey customization if required, and monitored all resulting interviews, reporting back to advisers about the interviews they had conducted. By the end of the academic year, departmental advisers had interviewed 1,237 students, about 17% of the total 2012-13 graduating class. Students' responses were analyzed using a constant comparison method⁵, an inductive process designed to let themes emerge, rather than imposing assumed categories on students' comments.

STUDY LIMITATIONS

If we interviewed students post-graduation, they would be likely to identify their capstone courses or their advanced senior-level courses as the ones asking for their most challenging work. However, because we wanted to attach the interview to a time when students would normally see their academic advisers, we interviewed students when they came into the advising office to apply for graduation, which often meant that they were two or three quarters away from graduation. Senior-level courses, particularly capstone or capstone-like classes, are those which students often say are their most challenging and satisfying. Although interviewing students as they applied for graduation meant that we might not gather information about late-senior year courses, we felt that it would be interesting to departments to learn the kinds of challenges that lead to and prepare students for those more advanced experiences.

INDUSTRIAL AND SYSTEMS ENGINEERING RESULTS

Industrial and Systems Engineering was one of the UW ACES' 33 participating departments. Jennifer Tsai, the department's academic adviser, asked 19 students if they were willing to be interviewed for the study and all of them agreed. This number represents about 38% of the 50 seniors in Industrial and Systems Engineering who graduated during the 2012-2013 school year.⁶

Quarters to Graduation and Where Students Experienced Challenge

Sixteen of the students interviewed reported having two quarters until graduation. Two were in their final quarter and one student indicated having three quarters to go before graduation.

⁵ Merriam, 2001.

⁶ The number of undergraduate degree completions is based on the 2012-13 UW Profiles reports published by the UW Office of Planning and Budgeting (https://bitools.uw.edu/views/13-SummaryandTrendsDegreeAttributes_0/13-Dashboard#1)

Overall, the 19 interviewees listed 17 courses as presenting them with significant challenges. All of those courses, except for one, were requirements for the major. Six interviewees listed more than one course as the source of their greatest challenge.

Students identified five 100-level courses, two 200-level courses, two 300-level courses, and eight 400-level courses as the sites of their most challenging academic experiences. The list of courses in the major as well as the number of students who identified them (only one if not otherwise noted) were as follows:

- CSE 142: Computer Programming I
- CSE 143: Computer Programming II
- PHYS 121: Mechanics
- PHYS 122: Electromagnetism
- PHYS 123: Waves

- EE 215: Fundamentals of Electrical Engineering
- ME 230: Kinematics & Dynamics

- IND E 316: Design of Experiments and Regression Analysis

- IND E 410: Linear and Network Programming (3)
- IND E 411: Stochastic Models and Decision Analysis (3)
- IND E 412: Integer and Dynamic Programming (2)
- IND E 424: Simulation
- IND E 455: User Interface Design (2)
- IND E 494: Design in the Manufacturing Firm (4)
- IND E 495: Industrial Engineering Design (3)
- IND E 499: Special Projects

One student identified the following course outside of the Industrial and Systems Engineering major as the source of her/his greatest challenge:

- AMATH 301: Beginning Scientific Computing

1. Students' Greatest Challenges

Students were asked: "What do you consider to be the most challenging work that you had to complete in this major? And by "challenging" I mean doing the work that stretched your thinking the most. This can be anything—a project, a paper, an exam question, homework, something else you did related to the major."

One major theme and two minor themes emerged from students' responses.

A class. Eight (42%) of the 19 Industrial and Systems Engineering majors mentioned a specific course when asked to explain their greatest challenge in the major. Six of the eight participants mentioned aspects of the course including homework, mid-terms, and final projects⁷. As three of these eight participants explained:

⁷ These responses were coded according to multiple categories

- *Course material in the engineering fundamental class was the most challenging. Moving coordinates were difficult. It was kind of hard to wrap my head around it.*
- *Electrical engineering 215 was the most challenging. It was both the structure of the class and the teacher.*
- *Homework assignments in computer science class were the hardest homework in my life! I got a 90 on the mid-term but got a 1.2 in the class due to bad homework!*

A project. Six (32%) students cited projects as their greatest challenge with four of the six specifying the senior design project. As four of them noted:

- *In my last year in the program I completed a project with Seattle Children's Hospital. That was the most challenging engineering experience. Working with others and sharing your ideas among other engineers proves to be more difficult than it sounds. Working through that experience was the most memorable and greatest learning experience in my college career.*
- *The capstone senior design project was the most challenging.*
- *The big final project in the design of experiments class.*
- *The user interface project was challenging but also fun. I learned a lot from it.*

Homework. Four (21%) students explained that homework, particularly coding assignments in computer science classes, provided the biggest challenge in the major. In the words of two students:

- *Math homework or individual assignments with math problems were the most challenging.*
- *Homework in computer programming class was most challenging.*

Other. One or two students gave the following responses:

- **Exams (2).** *Exams in physics class were challenging. There was no clear outline of what would be on the test, conceptual or computational items, so it was hard to prepare. Also, the curves were so low! I never felt confident with the material.*
- **TAs.** *Sometimes in labs for science courses, the TAs are not native English speakers and it's difficult to understand their pronunciation.*

2. What Made Those Activities/Classes Challenging?

Next, students were asked to note what it was about the activity or the class they had described that made it especially challenging. About 37% of the interviewees identified more than one reason the course or project they had described was challenging. Several themes emerged from students' responses.

Working with others/teamwork. Five (26%) of the interviewees reported that the class or project was particularly challenging because it required them to work well with others to achieve a shared goal. Moreover, students explained that teamwork required them to interact with others with different personalities and cultural backgrounds, respect others' opinions and ideas, and be confident of their own. The following quotations illustrate this category of response:

- *It was challenging to bring courage to the table and share your ideas with a group with the possible chance of rejection. In the real world, you will interact with other intelligent people, whom you must learn to accept and consider their ideas in pursuing a solution because that is the common goal of an organization.*
- *The teamwork aspect, dealing with other people on teams and different personality types. It was a multi-cultural team with students from SE Asia, Europe, India, and the US.*
- *Technical difficulty of the problem to be solved and the intense teamwork made it challenging. That included getting along with the team members and the logistics of managing a team.*

The open-ended nature of projects. Four (21%) interviewees commented that the work was particularly challenging because they had to come up with their own ideas for what to research as opposed to being handed a topic and research plan. For example:

- *It was challenging because you had to figure out what to research, collect the data, analyze the data, and work with a group.*
- *There was no syllabus and no clear plan. We had to develop a project plan ourselves, follow it, do the research, and write the paper.*

Problem solving. Three (16%) interviewees reported that the most challenging aspect of the classes and activities in the major was learning how to set up and solve complex problems. In the words of two students:

- *Solutions to problems in operations research classes were not obvious so I had to spend a lot of time just thinking. However, those were among favorite courses in department*
- *Setting up the problem and analyzing the results was most challenging.*

Other: Two or three students each spoke of the following as aspects of the class or project that made it particularly challenging:

- **Time management (3).** *It was challenging to juggle schoolwork and other people's schedules.*
- **Difficult subject matter (2).** *The subject matter was challenging because it was hard to visualize the concepts.*
- **Learning a programming language (2).** *I had to change my thinking process; it was outside of anything I'd ever done. I was used to equations, doing math, but now you have to learn a language as you go, learn how to think about a problem and it's all new.*

Three students gave the following individual responses for why the course/project was challenging:

- *You have to combine everything that you learned and apply all the concepts learned in class to a real setting.*
- *TA's who were hard to understand made it difficult to figure out what is expected of you.*
- *Professor would waste first 15-minutes, then cram stuff in at the end. Lab write-ups were onerous and needed to be too long and detailed than in comparable classes.*

3. What enabled students to meet those challenges?

All interviewees discussed a single, specific source of assistance that helped to meet the challenges they summarized. Overall, students' responses produced two major themes.

My own efforts. Sixty-one percent of the students interviewed explained that their own efforts helped them to meet the challenges that they described. More specifically, students explained that they completed the necessary work, attended lectures, worked with others, and sought out help when needed among other things. For example:

- *I went to class, TA office hours, and had discussions with professors as needed. I generally kept trying, I was persistent.*
- *I went to every lecture, took notes, and paid attention intently in class.*
- *I went to the computer lab for computer science and engineering classes and met with the TA during office hours. I went every week to get help on the code and especially liked when the TA answered questions by asking us new questions because that teaches you to think critically.*
- *I was good at attending lectures in this class so I was comfortable with the material and prepared for the exam.*
- *I learned to meet with instructors ahead of time. I didn't realize this freshman year but it's amazing how much professors will tell you when you meet with them. I always go to professors' office hours now.*

Working with peers. Eight (35%) of the interviewees noted that working with peers—including team-building activities both in class and out—served to help them meet the challenges in the major. In the words of three of these students:

- *I treated it like a full time job and worked on the project eight hours per day. I did team-building activities outside the scope of the project like going out to eat, etc.*
- *I worked with a bunch of people, not just one group or particular students, but multiple parties throughout the quarter.*
- *Accepting others ideas and incorporating them into your model to truly make a robust model that will help their process helped me meet the challenges.*
- *Finally, one student noted the following as helpful:*
- *The internship done at Children's Hospital fall quarter helped a lot. Having to solve problems, apply what was learned in class.*

4. What did students learn by completing this project/class/activity?

When asked what they felt they had learned by meeting the challenges they had described, two major themes emerged, while the remainder of responses were largely unique.

How to work effectively with others. Seven (37%) of the participants said that they learned how to work with others from different backgrounds and/or varying personalities in pursuit of a common goal. The following quotations illustrate this category of response:

- *I learned how to work on a team. That was the best experience I had. I learned how to acknowledge other ideas to help build a robust model!*
- *Putting thoughts into writing before meeting helped. Some students in Asian cultures communicated differently. Generally, American students are more direct and Asian students are more roundabout.*
- *I learned a lot about group dynamics and leading a group.*

Problem solving/critical thinking. Five (26%) of the participants explained that they gained valuable problem solving and critical thinking skills as a result of meeting the challenges described. In the words of two of them:

- *I learned critical thinking skills, problem solving, and the analytical approach.*
- *Before you jump into a problem you need to make sure you have it set up right and have all the constraints and inputs set up. You need to know what the objective of the model is.*

Other. In addition to these themes, two or three students identified the following as things they had learned by completing activity they had described as their most challenging.:

- **Content knowledge (3).** *I learned the bigger picture of what industrial engineering is.*
- **Perseverance (2).** *I learned that perseverance is key and that I can do programming. It may be hard but I can do it.*
- **Real-world application of knowledge (2).** *I learned real world applications and how to apply equations to real life.*
- **Importance of asking for help (2).** *I learned the power of talking to people and voicing concerns when you don't understand something. Professors know you are trying to learn at least.*

Finally, individual students said that they learned the following in the process of meeting the challenges in the major:

- *Time management*
- *I learned the difference between being a good teacher and a researcher. The professor was primarily a researcher and didn't like teaching and it showed.*
- *I was able to learn more by meeting with the TA in person.*
- *I learned not to be so hard on myself to be perfect. It is hard at first to not get an A but that doesn't mean I'm an idiot and worthless. Know that doing your best is all you can do.*

SUMMARY

Learning to operate as members of problem-solving teams, including integrating ideas different from one's own and managing group logistics, was a recurring theme in students' responses to questions about challenge in the major.

Students in the Industrial and Systems Engineering major were mostly likely to identify a specific course as the site of their most challenging work, as well as noting specific features of courses including homework, exams, and projects.

Students mentioned that aspects of courses were challenging because they were often required to work with other classmates in pursuit of a shared goal. More specifically, students noted that it was a challenge to get along with others with different personalities and/or cultural backgrounds, share ideas, and, more generally, to manage a team. In the words of one student:

It was challenging to bring courage to the table and share your ideas with a group with the possible chance of rejection. In the real world, you will interact with other intelligent people, whom you must learn to accept and consider their ideas in pursuing a solution, because that is the common goal of an organization.

Students also said that projects were particularly difficult given the fact that they were required to come up with their own ideas for what to research, as opposed to being given a topic. In addition, some students explained that the most challenging aspect was learning to set up and solve complex problems.

When asked what helped them meet the challenges discussed above students were most likely to cite their own efforts, which broadly included attending class, taking notes, completing homework, working with others, and meeting with TA's and professors when they struggled to understand the material.

One participant explained:

I went to class, TA office hours, and discussions with professors as needed. I generally kept trying, I was persistent.

Students also commonly noted the value of working with peers both in-class and out (e.g., study groups, informal meet-ups) to meet the challenges posed by the major.

When asked what they learned by completing the project/class, students were most likely to mention that they learned how to work effectively with others. In the words of one student:

I learned how to work on a team. That was the best experience I had. I learned how to acknowledge other ideas to help build a robust model.

In addition, students talked about learning how to problem solve more effectively and being able to think more critically. Students also reported learning general content knowledge (e.g., greater understanding of industrial engineering), real-world application of knowledge, and the importance of asking for help when needed and persevering in the face of challenge.

In sum, although the number of students interviewed was fairly small, their responses are reflective of the broad goals of the Industrial and Systems Engineering major which aims to provide students with the skills needed—particularly problem solving and team participation—to serve as organizational change agents.

In closing, students' responses to the UW ACES interview questions suggest that Industrial and Systems Engineering majors felt that the challenges they described were inherently rewarding. As one participant said:

Solutions to problems in operations research classes were not obvious, so I had to spend a lot of time just thinking. However, those were among favorite courses in the department.

These responses to challenge are consistent with research on student learning, which shows that when an assignment is challenging for students and when instructors help students meet those challenges, students are engaged in their courses and, therefore, learn more than when coursework is easy.

Two Student's Responses to All Four Questions

Course where greatest challenges occurred: IND E 424

Q1. What was the most challenging work you did? *Simulation models--how to set up the problem, get the right inputs and check the outputs.*

Q2. Why was it challenging? *Setting up the problem and analyzing the results.*

Q3. What helped you meet that challenge? *I played around with the software program before we had our first assignments. I also did the examples used in class, and went to office hours.*

Q4. What did you learn by meeting that challenge? *Before you jump into a problem, make sure you have it set up right, have all the constraints, and inputs set up. Know what the objective of the model is.*

Course where greatest challenges occurred: IND E 494 and 495

Q1. What was the most challenging work you did? *Capstone senior design project*

Q2. Why was it challenging? *Technical difficulty of the problem to be solved, and the intense team work made it challenging including getting along with the team members and the logistics of managing a team.*

Q3. What helped you meet that challenge? *I treated it like a full time job and worked on the project eight hours per day. I did team-building activities outside the scope of the project like going out to eat, etc.*

Q4. What did you learn by meeting that challenge? *I learned how to solve problems in an operating room (the project was managing turnover time and resource allocation in surgical suite). I learned how to work better in a team and how to respect everyone's point of view while coming up with one solution.*

SOURCES

- Beecher, T. & Trowler, P.R. (2001). *Academic tribes and territories: Intellectual enquiry and the culture of disciplines*. Suffolk, UK: St. Edmundsbury Press.
- Beyer, C. H., Gillmore, G. M., and Fisher, A. T. (2007). *Inside the undergraduate experience: The University of Washington's Study of Undergraduate Learning*. San Francisco: Jossey-Bass.
- Biglan, A. (1973). The characteristics of subject matter in different academic areas. *Journal of Applied Psychology*, 57(3), 195-203.
- Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.) For the National Research Council. (2000). *How people learn: Brain, mind, experience, and school*. Washington, D. C.: National Academy Press.
- Donald, J. G. (2002). *Learning to think: Disciplinary perspectives*. San Francisco: Jossey-Bass.
- Merriam, S. B. (2001). *Qualitative research and case study applications in education*. San Francisco: Jossey-Bass.
- Neumann, R., Parry S., & Becher, T. (2002). Teaching and learning in their disciplinary contexts: A conceptual analysis. *Studies in Higher Education*, 27, 405-417.
- Pace, D. & Middendorf, J. (Eds.) (2004). *Decoding the disciplines: Helping students learn disciplinary ways of thinking*. San Francisco: Jossey-Bass.
- Shulman, Lee S. (1988). A union of insufficiencies: strategies for teacher assessment in a period of educational reform. *Educational Leadership*, 46(3), 36-42.
- Wineburg, S. (2001). Interview with Randy Bass. *Visible Knowledge Project*, Georgetown University, from <http://crossroads.georgetown.edu/vkp/conversations/participants/html>. Accessed 10/12/06.
- Wineburg, S. (1991). On the reading of historical texts: Notes on the breach between school and academy. *American Educational Research Journal*, 28(3), 495-519.