

## **UW Academic Challenge and Engagement Study (UW ACES): Materials Science and Engineering**

*Angela Davis-Unger, Office of Educational Assessment*

*Stanley Choi, Academic Adviser*

*December 2015*

### **INTRODUCTION**

Research on learning in college shows that learning is profoundly shaped by the goals, practices, cultures, and values of the academic disciplines<sup>1</sup>, 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.<sup>2</sup> 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 experiences<sup>3</sup>; therefore, we designed the UW ACES to be primarily an interview study.<sup>4</sup> 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:

---

<sup>1</sup> 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.

<sup>2</sup> Beyer, et al., 2007.

<sup>3</sup> Merriam, 2001.

<sup>4</sup> 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 method<sup>5</sup>, 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.

## MATERIALS SCIENCE AND ENGINEERING RESULTS

Materials Science and Engineering (MSE) was one of the UW ACES' 33 participating departments. Stanley Choi asked 20 students if they were willing to be interviewed for the study and all agreed. The 20 students who were interviewed represented about 38% of the 52 seniors in Materials Science and Engineering who graduated during the 2012-2013 school year.<sup>6</sup>

### *Quarters to Graduation and Where Students Experienced Challenge*

Eighteen (90%) of the students interviewed reported having two quarters until graduation and two (10%) said that they were in their final quarter.

---

<sup>5</sup> Merriam, 2001.

<sup>6</sup> 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://uwprofiles.uw.edu/Viz/View/13-SummaryandTrendsDegreeAttributes>)

Overall, the 20 interviewees listed 12 courses in the Materials Science and Engineering major as presenting them with significant challenges. Students identified nine 300-level courses and three 400-level courses as the sites of their most challenging academic experiences. The courses mentioned most frequently were MSE 312: Integrated Junior Laboratory II and MSE 313: Integrated Junior Laboratory III, noted by four participants each.

The list of courses in the major and the number of students who identified them (only one if not otherwise noted) were as follows:

MSE 310: Introduction to Materials Science Engineering  
MSE 311: Integrated Junior Laboratory I (2)  
MSE 312: Integrated Junior Laboratory II (4)  
MSE 313: Integrated Junior Laboratory III (4)  
MSE 333: Materials Characterization (3)  
MSE 342: Materials Processing I  
MSE 351: Electronic Properties of Materials (3)  
MSE 352: Functional Properties of Materials I  
MSE 362: Mechanical Behavior of Materials I  
  
MSE 491: Design in Materials Engineering I  
MSE 492: Design in Materials Engineering II  
MSE 499: Special Project

### **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." About 65% of the interviewees gave more than one response to this question.

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

**A course.** Thirteen (65%) interviewees stated that a course or courses had presented them with their most challenging work in the major. Of those students who cited a course or courses, the majority explained that the subject matter was new and challenging. In the words of five students:

- *The first and second quarters of Materials Science and Engineering were the most difficult (AUTUMN 2011 and WINTER 2012). I didn't know much about the discipline and MSE kinetics was very difficult.*
- *MSE 362 was the most challenging. The class provides foundational knowledge of the major and the homework problems made the class challenging.*
- *MSE 499 was the most challenging because it required the most creativity. I had to research non-destructive characterization properties using fillers and trial and error. I had to call other people to find information.*
- *Concepts that were covered in MSE 351 were out there and difficult to understand with no knowledge of the quantum world.*
- *MSE 351 was the most challenging. It included new topics and take-home final exams.*

**Group projects.** Eight (40%) of the interviewees stated that working on group projects presented them with their greatest challenges. In their own words:

- *MSE 491/492 was challenging. We had to do a group project that involved tweaking the process of how to make a stent including understanding the manufacturing process and inspection in the medical industry.*
- *The Boeing group project in MSE 310 was most challenging. I had no background in composites.*
- *MSE 333, the characterization class was the most challenging. More specifically, working as a team in Rolandi's class. You had to take a material (graphene) and look at the characterization method and properties. You had to find legitimate resources within all of the conflicting information.*
- *The characterization group project was most challenging. It had a biomaterials focus.*

**Labs.** Five (25%) of the interviewees explained that lab work was the most challenging aspect of the materials science and engineering major. As two participants said:

- *The electronic semiconductors alloys lab was the most challenging.*
- *The junior quarter lab report was particularly challenging because it was an integrated lab report combining three different labs: electronic, chemical, and kinesthetic labs.*

In addition, one or two students each mentioned the following as challenging features of the Materials Science and Engineering major:

- Planning your own project (2)
- Reading scientific papers
- Learning how to write scientific papers
- Using new equipment

## **2. What Made Those Activities/Classes Challenging?**

When asked what had made those activities challenging, 16 (80%) of the interviewees identified a single challenge. One major theme and two minor themes emerged from students' responses to this question in addition to numerous individual responses.

**New and challenging subject matter.** Nine (45%) interviewees explained that the activities were challenging because they presented them with subject matter that was both novel and intellectually challenging. In the words of four students:

- *The group project was biomaterials focus and students did not have background in that area.*
- *It was challenging because I had never been exposed to the topics before.*
- *I had no prior knowledge of homework question content.*
- *The exams were difficult. We had to understand currents and temperatures.*

**Using equipment.** Four (20%) of the interviewees noted that the activities were difficult because they required the use of unfamiliar technical equipment. Some examples of this category of responses include:

- *I had to try alternate methods including autoclaving pressure.*
- *I had never used a particle analyzer before.*

**Open-ended nature of projects.** Another three (15%) interviewees explained that the activities were difficult because they were unstructured, requiring students to make their own decisions regarding the steps needed to complete the project successfully. In the words of two students:

- *It was difficult because I had to figure out the process of an open-ended project.*
- *It was a challenge because I had to start from scratch with little direction.*

In addition, one student each mentioned that the following made those activities/classes particularly challenging:

- Different approach to learning
- Presenting in front of a group
- Challenging mentor
- Take-home exams
- Lengthy lab reports
- Manipulating data
- *“Finding relevant information (certain peaks in UV range) when there was so much conflicting information.”*
- *“Stuck on one idea but learning about different ideas.”*

### **3. What enabled students to meet those challenges?**

Seven interviewees (35%) identified more than one source of help in meeting the challenges they described. Overall, students' responses yielded two significant themes.

**My own efforts.** The great majority (80%) of participants explained that their ability to meet the challenges posed by the Materials Science and Engineering major were a result of their own efforts. Students noted that they put in extra time and effort, such as reviewing previous exams and homework as well as consulting online resources (e.g., Wikipedia, google). As seven of the interviewees explained:

- *I decided to do some background research.*
- *I conducted research on the literature.*
- *I went over previous exams and homework.*
- *I read organic chemistry online and consulted Wikipedia and google.*
- *It was a combination of cross-referencing and talking to an authority on the subject. I also used the UW Libraries database.*
- *In order to meet the challenges you had to pace yourself and learn how to take good notes.*

- *I dissected different parts of a journal article.*

**Help from professors/TAs/grad students.** Nine (45%) participants indicated that they received help from professors, TAs, and/or graduate students in meeting the challenges in the major. In their own words:

- *The teacher of the course made us think.*
- *I went to office hours with the professor and TA.*
- *I contacted graduate students to understand the best research methods and did informational interviews with graduate students to determine multiple ways to set up software/scanning.*
- *I asked a graduate student for help.*
- *I talked to my mentor.*

In addition, two students mentioned that the following was helpful in meeting the challenges posed by the major:

*Comradery. Everyone else was going through the same projects.*

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

We asked students what they felt they had learned by meeting the challenges they had described, and about one-half of the interviewees mentioned more than one lesson learned. Two strong themes emerged from their responses.

**Learned to work with others.** Eight (40%) interviewees explained that, as a result of their experience, they learned to work more effectively with others, particularly on teams in pursuit of shared academic goals. In the words of four students:

- *I learned to work and collaborate with others.*
- *I learned how to work with a team and enhanced my communication skills.*
- *I learned a lot about the topic and worked on compromising with group members.*
- *I gained team project skills.*

**Specific content knowledge.** A second theme in response to this question, noted by 30% of the interviewees, was that students had learned specific content knowledge in the process of meeting the challenges described. For example:

- *I learned about properties of carbon fibers and learned that weave direction of fibers mattered.*
- *I learned organic chemistry.*

**Other.** Two or three students reported that they had learned the following:

- **Better understanding of research (3).** *I gained a greater understanding of what real scientists do and what the research method is.*
- **Time-management skills (3).** *I learned to make a plan to get things done, to have better time-management skills.*

- **Examine things from multiple perspectives (2).** *I learned that there is more than one way to look at things.*
- **Presentation skills (2).**

In addition, individuals said that they had learned the following by completing the challenges they had described:

- Which databases to use
- The distinction between creating and duplicating
- Better reading skills
- How to implement in industry
- Instrumentation
- What she/he is interested in

## **SUMMARY**

Participants were most likely to cite a course in the major as the most challenging work with the great majority explaining that the subject matter was particularly difficult, as the example in the box that follows this summary shows. As one student explained:

*Concepts that were covered in MSE 351 were out there and difficult to understand with no knowledge of the quantum world.*

Moreover, students mentioned both group projects, including working as a team, and lab work as the most challenging aspects of the Materials Science and Engineering major.

Nearly one-half of students commented that the classes and other activities were challenging because of subject matter that was both novel and intellectually challenging. Participants also noted that the activities were challenging because they were required to learn how to use new equipment (e.g., particle analyzer) and the fact that projects were open-ended in nature. As one participant commented:

*It was a challenge because I had to start from scratch with little direction.*

Participants were in agreement that their own efforts enabled them to meet the challenges posed by the major. More specifically, interviewees explained that they put in a great deal of time and effort including additional research and reviewing past work. Moreover, nearly one-half of students commented that meeting with professors, TA's, and/or grad students was instrumental to their success. Two interviewees commented on the importance of a shared peer group in overcoming the challenges they faced.

When asked what they learned as they met the challenges discussed above, students were most likely to report that they had learned to work collaboratively with others, especially when taking part in group projects. Students also commonly explained that they gained a greater understanding of specific content knowledge presented in the major.

In sum, students' responses broadly reflect the learning goals put forth by the Materials Science and Engineering, an interdisciplinary field which designs scientific processes to manipulate materials and meet the technological needs of our modern society.

### ***One Student's Responses to All Four Questions***

**Course where greatest challenges occurred:** MSE 342

**Q1. What was the most challenging work you did?** *The first and second quarters of materials science engineering were the most difficult (AUT/11 and WIN/12). I didn't know much about the discipline and MSE kinetics was very difficult.*

**Q2. Why was it challenging?** *The exams were difficult, we had to understand currents and temperatures.*

**Q3. What helped you meet that challenge?** *We made study groups for exams and looked over sample questions and problems.*

**Q4. What did you learn by meeting that challenge?** *I learned to work and collaborate with others.*

### **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.