

UW Academic Challenge and Engagement Study (UW ACES):

Mathematics

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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, Chemical Engineering, 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.⁵

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 method⁶, 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.

MATHEMATICS RESULTS

Mathematics was one of the UW ACES' 33 participating departments. Brooke and Danyel asked five students if they were willing to be interviewed for the study and all agreed. Three of those students reported that they were completing a degree in Applied and Computational Mathematical Sciences; one reported completing a BA in Mathematics, and the fifth student reported completing a BS in Mathematics. Five students represents about 2% of the 288 students who graduated with degrees in Mathematics and Applied and Computational Mathematics in 2012-13, which is too small a number to allow us to draw conclusions about challenge in the Mathematics majors. Therefore, this report simply provides the department with the students' responses and summarizes those responses at the end.

⁶ Merriam, 2001.

Quarters to Graduation and Where Students Experienced Challenge

Four of the students reported having three quarters until graduation and one student had two quarters remaining.

The five students listed six courses as presenting them with significant challenges; three Mathematics, two Computer Science and Engineering, and one Applied Math course.

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

AMATH 383: Introduction to Continuous Mathematical Modeling (2)

CSE 374: Intermediate Programming Concepts and Tools

CSE 417: Algorithms and Computational Complexity

MATH 326: Advanced Multivariable Calculus II

MATH 327: Introductory Real Analysis I

MATH 402: Introduction to Modern Algebra

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." See below for all verbatim responses:

- *Both reading math texts and analyzing proofs in advanced math courses were challenging.*
- *A project, having to think up a math modeling project that used MatLab.*
- *Advanced computer programming and continuous modeling work and projects.*
- *Reading the whole text, which was very theoretical, not like reading a novel. It was difficult to understand it all and know how to use it.*
- *The writing in homework and papers was the most challenging. It brought up ideas and concepts from previous courses that I didn't put together before.*

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. In the words of all five students:

- *The reading went very slowly and was tough for me to 'get'. I had to drop this course the first time after trying for seven weeks.*
- *Thinking of something doable and somewhat novel that I could apply MatLab to solve. It was the most independent project that had ever been asked of me.*
- *The pace and [the projects] were more abstract. I had to remember and practice work and concepts from previous courses. It all seemed difficult.*

- *Not having English as my first language was challenging, but the concepts were difficult to relate to.*
- *I had thought of the Discrete Math option as being all about programming & computer science, but this was far more theoretical than coding. It was very proof-oriented and required us to apply mathematical techniques to a field unknown before this to me. It required thinking in a different way, applying concepts in math theory seen in contexts of computer sciences and algorithms.*

3. What enabled students to meet those challenges?

Students were asked to explain how they met the challenges posed by the major. In their own words:

- *I actually had to read the text! Also went online to look for resources, read other students' proofs, looked for videos, talked with other students. There was something about Prof. Sullivan's teaching that really helped clarify concepts.*
- *I learned to do teamwork, and looked for help from my classmates. Although we each had individual projects, we'd bounce ideas off each other and proofread each other's papers and learned extra possibilities.*
- *I had to bring up what I had learned before to try to apply theory into reality. Had to combine math, engineering and finance altogether.*
- *I had to spend hours and hours.*
- *Math 300 really helped (learning to do proofs) and getting more theoretical basis for why we do certain things. Some honors courses helped with writing.*

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

Finally, students were given the opportunity to discuss what they learned in the process of completing the project/class/activity. See below for all verbatim responses.

- *I learned a lot about myself, how to do different tasks and skills. I learned to overcome obstacles and how to persevere.*
- *I learned a lot about MatLab and how it could be used. It was the first time I had to think something up on my own. And it was VERY cool when the ideas and MatLab came together. It was a great feeling.*
- *This helps me realize how what I'm learning applies to financial modelling, mathematical biology and many other fields.*
- *Perseverance.*
- *Felt I learned to synthesize and pull ideas from other courses, and to write more clearly. Learned that techniques could be applied in many different ways. Felt more willing to seek out research and writing opportunities after that.*

SUMMARY

When asked about their greatest challenges in the major, two students mentioned reading dense, theoretical math textbooks. The remaining responses were largely distinctive and included a math modeling project using MatLab, advanced computer programming, analyzing proofs, and writing required for homework and papers.

Three of five students referenced the fact that the subject matter was abstract and often included mathematical theory in explaining why the activities were challenging. Other aspects of the activities that were challenging, mentioned by one student each, included the independent nature of the project, using concepts from previous courses, and the pace of the course.

When asked how they met the challenges in the major, students generally reported that they put in a great deal of work including reading the text, consulting online resources, and applying previously learned concepts. Two students commented on the importance of working with other students in meeting the challenges in the major. In the words of one student:

I learned to do teamwork, and looked for help from my classmates. Although we each had individual projects, we'd bounce ideas off each other and proofread each other's papers and learned extra possibilities.

One student mentioned that the professor's teaching was helpful and another explained that past honors courses helped them to meet the writing challenges in the major.

Finally, when asked what they learned as a result of meeting the challenges in the major, two of the five participants noted that they learned how to persevere in the face of difficult tasks. Moreover, individual students mentioned that they gained personal insight, a greater understanding of MatLab, and the ability to write more clearly.

SOURCES

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