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UW Academic Challenge and Engagement Study (UW ACES):

Environmental and Forest Sciences

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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 disciplines[1], 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 experiences[3]; 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 32 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:

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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. Students' responses were analyzed using a constant comparison method[5], 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.

ENVIRONMENTAL AND FOREST SCIENCES PROGRAM RESULTS

The Environmental and Forest Sciences Program (EFS) was one of the UW ACES' 32 participating departments. Michelle Trudeau, Director of Student Academic Services and Lisa Nordlund, Academic Adviser, asked 69 students if they were willing to be interviewed for the study and 64 students agreed. This number represents about 76% of the 84 seniors in the Environmental and Forest Sciences program who graduated during the 2012-2013 school year.[6]

[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)

Quarters to Graduation and Where Students Experienced Challenge

Forty (63%) of the students interviewed reported having three quarters until graduation. Eighteen (28%) said they had two quarters remaining; three were in their final quarter; and three students indicated still having four quarters to go before graduation.

Overall, the 64 interviewees listed 48 courses as presenting them with significant challenges. Students were not asked whether they were enrolled in the ESRM or the BSE tracks in the major, but based on the pattern of responses it appears that the majority were ESRM majors.

Students identified five (10%) 100-level courses, nine (19%) 200-level courses, 12 (25%) 300-level courses, and 22 (46%) 400-level courses as the sites of their most challenging academic experiences. Thirty (63%) of those courses were ESRM courses; four (8%) were BSE courses; and 14 (29%) were in disciplines other than EFS.

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:

ESRM 200: Society and Sustainable Environments
ESRM 201: Sustaining Pacific Northwest Ecosystems (4)
ESRM 235: Introduction to Environmental Economics
ESRM 250: Introduction to Geographic Information Systems in Forest Resources (5)
ESRM 300: Principles of Sustainability
ESRM 304: Environmental and Resource Assessment (2)
ESRM 311: Soils and Land Use
ESRM 321: Finance and Accounting from a Sustainability Perspective
ESRM 331: Landscape Plant Recognition
ESRM 351: Wildlife Research Techniques (2)
ESRM 368: Natural Resource Measurements
ESRM 381: Management of Wildland Recreation and Amenities
ESRM 400: Natural Resource Conflict Management
ESRM 403: Forest and Economic Development in the Developing World
ESRM 413: Soil Genesis and Classification
ESRM 415: Biology, Ecology, and Management of Plant Invasions
ESRM 425: Ecosystem Management (2)
ESRM 426: Wildland Hydrology (2)
ESRM 428: Principles of Silviculture and Their Application
ESRM 441: Landscape Ecology
ESRM 458: Management of Endangered, Threatened, and Sensitive Species
ESRM 462: Restoration Ecology Capstone: Introduction (2)
ESRM 463: Restoration Ecology Capstone: Proposal and Plan (2)
ESRM 464: Restoration Ecology Capstone: Field Site Restoration (2)
ESRM 470: Natural Resource Policy and Planning
ESRM 479: Restoration Design (3)
ESRM 490b: Special Topics
ESRM 491: Field Studies
ESRM 494: Senior Capstone Proposal
ESRM 495: Senior Project (2)

BSE 420: Bioresource Engineering I (2)
BSE 436: Pulp and Paper Laboratory II (2)
BSE 480: Bioresource Design I
BSE 481: Bioresource Design II

BIOL 161: Introductory Biology
BIOL 162: Introductory Biology
BIOL 180: Introductory Biology (3)
BIOL 200: Introductory Biology (5)
BIOL 220: Introductory Biology (3)

CHEM 142: General Chemistry (2)
CHEM 152: General Chemistry
CHEM 220: Principles of Chemistry II

CHEM E 325: Energy and Entropy
CHEM E 326: Chemical Engineering Thermodynamics
CHEM E 340: Transport Processes II

ECON 200: Introduction to Microeconomics

HCDE 231: Introduction to Technical Communication

QSCI 381: Introduction to Probability and Statistics

In addition to mentioning specific courses, three students noted that ESRM courses in general were most challenging and one student said that Biology courses posed the biggest challenge. Finally, one student stated that the biggest challenge in the major occurred in "the real world."

As shown in Table 1, students experienced challenges across the major. There were very few students in the group who had one or four quarters remaining, making comparisons challenging However, those students with two and three quarters remaining showed similar patterns of responses with 200- and 400-level courses being cited most often. Students with three quarters left were somewhat more likely to cite 400-level courses as the site of their greatest challenge in comparison with those who had two quarters left.

Table 1. Site of greatest challenge by quarters until graduation (n = 57[7])

	100-level course	200-level course	300-level course	400-level course
4 quarters left (n = 3)	0%	67%	0%	33%
3 quarters left (n = 34[8])	12%	32%	24%	50%
2 quarters left (n = 18)	6%	39%	22%	39%
1 quarter left (n = 2[9])	0%	50%	0%	50%

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 emerged from students' responses along with one minor theme.

A course. Fifty-two (81%) students cited a specific course or series of courses as their greatest challenge in the major. Students were most likely to note that the class that posed the greatest challenge was part of the Environmental Science and Resource Management major. The following quotations illustrate this category of response:

- *One challenging thing was learning all the general tree names and such in ESRM 201. In the end it was really worth it but at first it was really challenging.*
- *The specific class was soil genesis with Darlene Zabowski. It was really in-depth and stretched my thinking. It was all about soil formation and classification and understanding the natural processes, not just memorizing.*
- *ESRM classes in general were most challenging because you don't know the answers in general and have to come up with hypotheses.*
- *In ESRM 351 you had to memorize birds call sounds and appearances and this changed based on where in the state you were. It required you to be lot more observant in a short amount of time in order to differentiate sounds.*

Moreover, a sizeable proportion of the 52 students mentioned introductory Biology and Chemistry courses as posing the great challenge for them. For example:

- *BIOL 220 was the most challenging and much of it was not relevant. It would be more useful to spend more time on our courses in ESRM.*
- *The core sciences, chemistry and biology, were the most challenging.*
- *The BIOL 200 class was most challenging. The labs and course readings were in-depth in a different way for the major.*

[7] Given that some interviewees listed more than one class, percentages may exceed 100%.

[8] Three interviewees did not answer the question, two stated ESRM courses in general and one did not cite a course but instead, said "the real world"

[9] One interviewee said ESRM courses in general

Four students specifically mentioned the capstone series (462/463/464) but did not elaborate further and two students noted BSE 436, Pulp and Paper Laboratory II.

Fieldwork. Four (6%) students mentioned that fieldwork was a particularly challenging aspect of the major. As two participants said:

- *The two main Professor Ford field trips and Sharon Doty's lab. You were faced with real life situations, problems, or questions, and it is up to you to make a decision that will affect real life results.*
- *The field trips for wildlife research were challenging. You didn't have textbooks.*

Other. Two students said the following when asked about the most challenging work in the major:

- **Group work:** *Group work projects in field trip class and other classes were most challenging*.
- **Different way of thinking:** *Subject classes forced me to think beyond the topic that I learned. You have to bring in your own ideas and it really encourages you to use your own voice. I liked that a lot, but it was challenging*.

Finally, individual students gave the following six responses regarding the most challenging work in the major:

- *Not one assignment was the most challenging. It was more so the fact that the program is so broad in its focus. The greatest challenge is to understand my place and my interest within the major.*
- *Learning how economic sustainability is integrated with environmental sustainability*
- *Understanding the application of what we would be doing*
- *Knowing where to look for information and how to get experience working in a lab*
- *Internships*
- *Taking CHEM E and BSE at the same time*

2. What Made Those Activities/Classes Challenging?

When asked what had made those activities challenging, 53 (83%) of the interviewees identified a single challenge. There were two major themes from students' responses to this question, as well as several minor themes and numerous individual responses.

Weighing multiple perspectives/thinking critically. Eleven (17%) interviewees explained that the activities were challenging because they required them to think about more than one perspective on ecological issues, which led some students to realize that there is often not one clear-cut answer to a given problem. For example:

- *Sometimes it is a one-way street with other subjects that do not take into account a lot of things like viewpoints and facts. With ESRM 425 there is the human side and then the biology side. There is a lot of conflicting data, and you have to come out with a conclusion that suits both parties, and there is never a right answer.*
- *It makes me see both sides of an issue instead of looking at a problem and thinking there is one answer. It is why it's not that simple to fix something.*

- *[It was challenging] to look at issues from a social perspective and solve challenges from that perspective. The lectures make you think critically about an issue.*
- *To approach these kinds of problems in an objective way is like coming to a best case solution with people that don't agree about things. I always see environmental arguments in the paper, and it's interesting to try to rectify the situation.*

Application of knowledge/real-world problems. Eleven (17%) respondents explained that the work was particularly challenging because it required them to acquire new knowledge and/or apply existing knowledge to solve real-world problems that were open-ended in nature. As three students said:

- *You had to think about it. You were required to know stuff from past courses and apply them to new and relevant issues.*
- *You were required to integrate the knowledge of previous coursework into an undefined problem statement and work with economics and a variety of material throughout our four years.*
- *There are so many different ways the paper can be made and you have to rely on what you have learned in the past few years to come up with chemicals and process specific variables to run on the machine.*

New material. Eight (13%) respondents explained that the most challenging aspect of activities/classes was encountering material that they were unfamiliar with. In the words of three of those students:

- *It was not something I had any prior skills or experience with so it required a lot of additional time on the side, more than my other coursework. It was hard keeping up with that in addition to my other classes.*
- *The subject matter was not something I was used to studying and the people in the class were different in their mindsets.*
- *I had only had one biology class before so there was lots of information to learn.*

A lot of information/required memorization. Seven (11%) respondents spoke of the challenge involved in courses that required them to learn a lot of information and specifically courses that included a great deal of memorization. In the words of three students:

- *There was so much information. We had to memorize all the plant species.*
- *It was a challenge to understand the processes and memorize the classifications too.*
- *I realized a lot of cool things about our bodies but the course moved quickly and there was a lot of detail in a short amount of time. You were also learning about things you can't really see, whereas in ESRM you look at big things you can see.*

Group discussion/working with peers. Five (8%) interviewees explained that working with peers on various projects was a challenging aspect of the major. Some examples of this category of response:

- *The capstone series was challenging because it combined a lot of different components. The editor had to do a lot of the writing and there was group work and communication needed.*
- *It was challenging because you have to rely on other people's learning as well as your own.*

- *It was both physically challenging and built teamwork and it exercised the process of science involved in the data collection. Everyone involved was very invested and motivated to do well, more so than in a classroom environment.*

Rigors of fieldwork. Another five (8%) interviewees spoke of the challenge involved in going out into the field including the gear necessary, the amount of information one needed to learn in a short period of time, and, generally, the intensity of the experience. In the words of two students:

- *The expense of having the proper gear made it challenging. You need to go to the forest and be comfortable, and I'm not used to it yet.*
- *It was sort of an intense experience where you are immersed in it all day everyday, and there is so much information you are trying to take in. There is a steep learning curve.*

Other. In addition to the aforementioned themes, two or three students noted the following when asked what made those activities and/or classes challenging:

- **Learning GIS** (3): *The GIS program was hard to understand, but as you worked with it further, you became more familiarized with the tools and the program as a whole*.
- **Exams** (2): *The exam questions felt like they were out of left field. You would have to take all the definitions and the components of the course together to answer the exam questions*.
- **Homework** (2): *The questions were very specific, but the answers were so detailed. They would ask you a question and expect a certain answer. If you didn't say every detail then it was not considered correct*.
- **Math involved** (2): *I'm not a math oriented person. It was challenging to try to understand the system and how it affects forestry and wildlife*.
- **Working with clients/partners** (2): *We had to work around the client. We had to make the paper fit to the client and provide them with information they could use.*

Finally, individual students mentioned the following as things that made activities challenging:

- Balancing coursework
- Using logic to solve word problems
- The class as a whole
- Understanding what the major was about
- Taking courses and doing research at the same time
- How to convey information to different audiences

3. What enabled students to meet those challenges?

Most of the interviewees (76%) focused on a single source of assistance in meeting the challenges they discussed. Overall, students' responses yielded three major themes and several minor themes.

My own efforts. Nineteen (30%) of the interviewees said that their own efforts had enabled them to meet the challenges that they had outlined. The specific efforts described varied widely and included putting in the time needed to succeed, practicing new skills, adopting new approaches to learning, and gaining valuable negotiation skills. Two participants in particular mentioned that they put in extra effort

to memorize large amounts of novel information (e.g., memorizing the scientific names of trees). As six of the interviewees explained:

- *I poured in time and plugged away.*
- *I practiced more and learned a new learning style that I think I prefer, which was interesting.*
- *I met the challenges by not sleeping and persevering for long periods of time.*
- *I outlined the topics, then I would read articles and go back to lectures. That helped me to create an argument. Trying to stay on topic was a big challenge.*
- *I went to a lot of tutoring sessions and also read everything before and after the class.*
- *I sat in front of the computer for 12 hours, it was basically just putting in the time and learning the tools along with the help of the TA.*

Took the initiative to seek out/ask for help from faculty and TAs. Seventeen students (27%) explained that taking the initiative to seek out professors and TAs—including office hours and tutoring sessions—helped them to meet the challenges they faced in the major. Five students' comments serve as examples of this category of response:

- *I spent all week working on the homework and camped out in his office hours.*
- *I went to a lot of tutoring sessions and also read everything before the class and after the class*
- *When you have a question you ask. In a basic course you do not know everything so you outsource to an expert, ask a senior engineer. You can figure out a lot, but there is value in when to say you don't know and find a resource to help.*
- *I got more involved with the TA. This is the first time I have gone to a TA outside of class*
- *I was able to meet the challenges by taking the initiative to ask for help.*

Working with peers/group work. Another sixteen (25%) interviewees stated that having the opportunity to work with peers in groups or individually, both in class and out, helped them to meet the challenges discussed. In the words of four of these students:

- *Working in groups within the class and then coming together, each group would take a side.*
- *I made study groups, especially with my roommate, to go through practice midterms and anything the instructor gave for an exam review. We would bounce things off of each other.*
- *The group element was important, talking back and forth, doing research, and sharing group knowledge.*
- *There was lots of teamwork, pulling on previous notes and learning skills of how to find information and research.*

Looking at things from different perspectives/thinking critically. About 6% of the interviewees explained that they met the challenges by learning how to examine issues from multiple perspectives and, more generally, learning to think critically. For example:

- *It required looking at the data from a different perspective until I found one that made sense then pulling together different data and connecting it.*
- *Thinking outside the box. Many classes made you think about something in the pathway that you have not thought about before.*
- *There were lots of readings that were from sociologists and their perspectives. I had to familiarize myself with that way of thinking.*

Personal change. Four (6%) students noted that a personal change, including increased interest and investment in the material, going outside of their comfort zone, and recognizing their limitations helped them to meet the challenges in the major. For example:

- *There were a few classes that really caught my interest and shifted the way I looked at the goals and reasons for being in the school. One was ESRM 201/200 and the other was ESRM 425. These classes broadened my perspective of what you could gain from management and interaction from our forests.*
- *I could focus harder due to increased interest. I found the subject intriguing.*

Gained specific knowledge. Three (5%) students mentioned that learning a new body of knowledge helped them to meet the challenges they had described. In the words of two of these students:

- *I learned how restoration projects are carried out and implemented, included scheduling and finances.*
- *Learning about biorefining and the methods of collecting products and the chemistry behind it.*

Other. In addition to those themes already mentioned, two or three students noted the following when asked what enabled them to meet the challenges discussed:

- **Honing research skills** (3): *Learning skills of how to find information*.
- **Field trips** (3): *Field trips helped me because I got to see actual examples of the topography and environmental factors*.
- **Time management** (2): *The main thing was prioritizing different commitments, homework, projects, or things outside of school*.

One student each said that the following were helpful as they met the challenges they described:

- Honing research skills
- The core ESRM classes (200, 201, 300, 304)
- Friend who helped with GIS
- Lectures
- *Intuition of what happens on a molecular level.*
- *The diversity of teachers and classes is really good—it helps you understand all the aspects of the field.*

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, one major theme and a number of minor themes emerged from their collective responses.

Specific content knowledge. Fourteen (22%) interviewees described specific content knowledge that they had gained in the process of meeting the challenges described. For example:

- *Biology is really complicated and you ask why and how and always dig deeper.*
- *I learned forest health and plant identification and used that information for my senior project later.*
- *I learned a lot about native species. It was a great introduction to ESRM and I'm glad it was my first class.*
- *I learned about recreation management and the process of how to manage and use the land efficiently.*
- *I learned how soil is generated and also that I learn best by example or firsthand.*

General study skills/time management. Eight (13%) students indicated that their study skills had improved, including both their time and stress management as well as their general organization skills. In the words of three students:

- *My capacity to juggle those kinds of courses and my capacity to handle stress increased.*
- *My organization and time management skills got better. It was not just the time you put in but when you put in the time and it gives you more chance to have the information settle in.*
- *I learned better study habits by being challenged.*

Perseverance/increased confidence. Seven (11%) students explained that they persevered in the face of challenges and, as a result, gained confidence in their ability to complete difficult tasks. As three students remarked:

> *If you work really hard at something you can succeed, even if it is challenging.*
>
> *It taught me to be more hard working and to dig deep and do it.*
>
> *It taught me to work through one problem at a time. I broke them down into small elements. They were satisfying to complete.*

Complexity of the field. Six (9%) students said that the challenges they encountered served to reveal the complex nature of Environmental and Forest Sciences, including the various aspects involved as well and their interaction. As three of them noted:

- *I learned that ESRM is much more complicated and complex than someone can see from the outside. There are so many aspects to environmental science.*
- *How to better deal with issues by understanding the complexity.*
- *There is more to the project than I fathomed. Community and government partners, future maintenance, how will they maintain after you are gone and the project is over.*

How to effectively work in groups. Five (8%) students said that they learned both the importance of working in groups and how to effectively work with others to achieve goals, as the following examples show:

- *How to make group work work. As frustrating as it was it is a realistic skill that you will need in the real world.*
- *I learned that group dynamics are always hard.*
- *I learned how to keep up team morale.*

How to conduct scientific research. Five (8%) students commented that they now have a better idea of what it is like to conduct scientific research. In the words of two students:

- *I learned the actual process of doing science instead of the abstract idea.*
- *I am now capable of drawing conclusions from data on my own without any guidance.*

Being open to multiple perspectives. Four (6%) of the students we interviewed spoke about learning the value in being open to perspectives from people from a wide array of backgrounds. For example:

- *The best thing I learned was to look at things from different perspectives and to temper my idealistic student tendencies. Students want to make parks and sanctuaries but that doesn't solve the problems, and the real world aspects come into play.*
- *There is never a right answer, but the closest thing to a right answer would take into account the viewpoints, values, and science that lies behind every situation.*

Communicating with diverse groups. Closely related to the previous topic**,** four (6%) students mentioned that they learned the importance of tailoring one's communication to different groups based on their background knowledge. In the words of two students:

- *I learned that it is extremely complicated and we have to find a balance between using the correct language when communicating with the public. The terms used in forestry may not convey similar understanding to the public.*
- *Communication is really important whether it is your peers, professors, clients, or the public.*

Learned more about Geographic Information Systems (GIS). Another four (6%) students commented that they had learned a great deal about GIS and its usefulness in the field, as the following examples suggest:

- *I learned that there is a whole arena of work that can be done with GIS, and it is incredibly useful. It opened up my eyes to a whole new skill set.*
- *I now know what GIS is and what aspects go into it, and I'm very impressed with it the idea of it.*

One student each noted that he or she had learned the following:

- How to follow directions
- That economics is a complex subject
- How projects are both created and engineered

- Better observation skills
- *You might not learn a lot at once but over 12 weeks you learned more than you thought. The learning curve is gradual and steep.*
- *The main thing I learned was that I learn better in a hands-on environment, both in the field as well as the text. I can feel and touch things and see how it applies to the class.*
- *I learned that chemistry ties in well with biology and helped me understand concepts in biology classes as well as ESRM classes.*

SUMMARY

A strong, overarching theme that emerged from students' challenging work in the major was the realization that environmental issues are more complex and involve more perspectives than they had first imagined. Specifically, the overwhelming majority of students cited a particular course as the most challenging work in the major with most noting various Environmental Science and Resource Management courses and a handful mentioning introductory science courses including Chemistry and Biology. In particular, students mentioned that these classes were challenging because they required them to entertain multiple perspectives on ecological issues, which led some students to realize that there is not one "right" answer to a given problem. As one student aptly explained:

> *Sometimes it is a one-way street with other subjects that do not take into account a lot of things like viewpoints and facts. With ESRM 425 there is the human side and then the biology side. There is a lot of conflicting data and you have to come out with a conclusion that suits both parties and there is never a right answer.*

Students also stated that the work in these courses was particularly thought-provoking because it required them to apply both existing and new knowledge and think critically to solve real-world problems. As one student explained:

> *You had to think about it. You were required to know stuff from past courses and apply them to new and relevant issues.*

Moreover, students also commented that these courses required them to learn a significant body of new knowledge which sometimes required them to memorize copious amounts of information.

When asked what they did or learned that enabled them to meet the challenges discussed above, students most commonly cited their own efforts which included but were not limited to: putting in long hours, completing all of the required reading, and persevering when challenges seemed insurmountable. In addition, students often explained that they took the initiative to seek out help from professors and TA's when they were struggling. One student who cited ESRM 250: Introduction to Geographic Information Systems in Forest Resources as the site of her most challenging work explained:

> *I sat in front of the computer for 12 hours. It was basically just putting in the time and learning the tools along with the help of the TA.*

Approximately one-quarter of interviewees explained that working with peers and group work, both in the classroom and out, was important in helping them to meet the challenges they faced in the major. One student commented on the value of the group process as follows:

The group element was important, talking back and forth, doing research, and sharing group knowledge.

When asked what they learned as they worked through the challenges described above, students were most likely to indicate that they gained a great deal of specific content knowledge related to the major, enhanced their study skills including organization and time management, and felt more confident in the face of challenge.

Several students also mentioned that they came to realize the complexity of the field, including the number of groups involved in projects, multiple perspectives on issues, as well as the importance of working with others to solve problems. Finally, a handful of students commented that they had gained a greater understanding of scientific research more generally.

In sum, students' responses broadly reflect the objectives of the Environmental and Forest Sciences major including the acquisition of domain-specific knowledge, skill sets such as working on interdisciplinary teams and effectively communicating with various groups as well as developing comprehension, integration, and meaning as evidenced by their emerging understanding of the complexity of the field.

Finally, students' responses to the UW ACES interview questions suggest Environmental and Forest Sciences majors viewed the challenges they described as rewarding. 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: ESRM classes in general

Q1. What was the most challenging work you did? ESRM classes in general were the most challenging because you don't know the answers in general and have to come up with hypotheses.

Q2. Why was it challenging? It was challenging because you didn't know if your answer was going to be right or wrong.

Q3. What helped you meet that challenge? Thinking outside of the box. Many classes made you think about something in the pathway that you have not thought about before.

Q4. What did you learn by meeting that challenge? I learned that you shouldn't always expect an answer. You might not know the answer.

Course where greatest challenges occurred: BSE 420: Bioresource Engineering I, CHEM E 326: Chemical Engineering Thermodynamics, CHEM E 340: Transport Processes II

Q1. What was the most challenging work you did? My junior year load, taking challenging courses at the same time including CHEM E 340, CHEM E 326, and BSE 420.

Q2. Why was it challenging? Trying to juggle those courses and do research with a professor.

Q3. What helped you meet that challenge? The main thing was prioritizing different commitments, homework, projects, or things outside of school.

Q4. What did you learn by meeting that challenge? My capacity to juggle those kinds of courses and my capacity to handle stress increased.

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