...classes, projects, etc. [D]epartments . . . just need to get started. The big stuff always goes from nothing to something. To get started is really essential. So, while integrating real-world problems and industry problem solving into a course may feel daunting, the key is to just move forward. Internships

STUDENT CLUBS AND REAL-WORLD PROBLEM SOLVING

At BYU -Idaho, two student-run clubs—the Data Science Society (DSS) and the Mathematical Society (TMS)—work with real-world problems. Both clubs identify applied problems for their projects in a variety of ways. Sometimes students find them on their own through connections, vi cold calling leads, or by following up on leads from the university's business development center. Faculty advisors, especially those who come from industry, also identify projects. Faculty members who locate clients often give smaller, faster projects to the society and utilize the larger projects in their own classrooms.

The problems addressed by the clubs vary widely in both scope and substance. Often, once a company works with one of the clubs, they become repeat customers. Sometimes a single company will provide multiple projects for a club to work on during a single semester.

Whereas the DSS has only one faculty advisor, TMS has three. This difference in faculty presenc relates to the nature of the clubs' projects and the math skills needed to address them. It also reflects the fact that senior students in the DSS run an R bootcamp regularly to train new student to work on club problems. By giving seniors a chance to teach, this bootcamp also helps these students expand or improve their own skill sets.

In addition to learning how to apply math and data science skills to industry problems, participation in one of these clubs provides students with career readiness skills including leadership, communication, and teamwork. The fact that students are actually partnering with industry clients makes these clubs especially rich learning experiences that can sometimes lead directly to internships and jobs.

Internships are another way for math departments to prepare students for careers. Internships provide students with experience in the workplace, and were therefore perceived by many faculty as one of the most effective ways for students to acquire job readiness skills. In internships, students get exposed to working with and for others. They also can apply their growing skills in math to real-world situations. Many times, internships lead to job offers f r students. One faculty member stated that internships were the best way to cement student interest and focus on math. This faculty member commented that when students get some real-world experience *"under their belt,"* they no longer feel the need to double major. Their internships help them understand how math skills and a math major can open up a variety of work opportunities.

Institutions, however, are at very different stages in offering students internship experiences. Some responden described robust internship programs on their campuses, while others reported an interest in establishing an internship program for math students on their campus, where one did not yet exist.

The institutions that had internship programs described the people and systems that supported those programs. Two patterns emerged. In the first, internships were managed through the math depa tment. In the second, internships were managed through relationships with existing structures and services on campus, such as the college's career centers or business development centers.

In a few cases, internship programs were led by an individual, such as an internship coordinator or specialist or, in one instance, a dedicated faculty member. The University of Nebraska, Lincoln (UNL), has a full-time professional advisor who works with juniors and seniors in the math department to find internships

Internship coordinators have numerous responsibilities. These include identifying employer sites and establishing a partnership with them; creating departmental or campus awareness of internship opportunities; and preparing students for internships. The latter may involve helping students develop soft skills and write resumes, as well as matching students interests with the best available internship opportunity. One faculty member reported that their internship coordinator leads a pre-internship seminar—which includes helping students create their resumes—to better prepare students for their internship.

Schools fortunate enough to have a dedicated faculty or staff member in charge internships had an easier tim running internship programs than did those that had to cobble together faculty or staff time. But regardless o whether their department worked with a dedicated internship coordinator, respondents described success with offering internships

Colleges with internships reported the need to develop partnerships with the companies that host interns. (For more on this see the EERC brief: *Preparing Math Majors for Careers: Partnering with Industry*). A number of respondents spoke proudly about the many relationships they had developed with companies—most often, with local companies. For example, a respondent from St. Olaf College talked about the strong relationships they developed with companies in the Twin Cities area near the college, including the Mayo Clinic, Delta Airlines, and the Minnesota Orchestra. These companies offered internship oppo tunities in which students used applied math and statistics. Another respondent talked about successfully establishing internships with local companies and nonprofits instead of the large companies that more typically become internship sites

Respondents whose departments or schools had not yet developed internships expressed great curiosity and a keen interest in learning how to build connections with industry and employers. They saw it as a daunting task, however, and were uncertain where to start. They told the EERC interview team that they wanted help, including examples and tips about how to begin:

> *I would like to develop internship partnerships with industry or government. Advice on how to develop these relationships in a sustainable way would be helpful.*

Others wanted to know how to engage alumni in the creation of internships:

> *We need to learn how to set this up and how to build a network, possibly through our alumni, for these internships.*

Faculty indicated that a significant barrier in identifying internship sites for students was the general lack o awareness by employers as to how they might use the skills of math majors. Typically, employers request engineering or computer science students, which has resulted in a general lack of demand for math interns. The challenge is therefore how to educate employers about the way math interns could be helpful to them.

Another challenge faced by math-related internship programs is getting students interested in them and then helping them find the time to fit unpaid or sh t-term work into their college experience:

> *The main challenges are motivating students to apply for the internships and convincing employers that it is worth their time.*

Having discovered that one way to stoke students' interest in internships is to have them talk with students who have already participated in one, Villanova creates panels of senior students who visit core classes in fall early in the math sequence. The panelists share their internship experiences, and the students in the class can ask them questions. In EERC's interviews, several first- and second-year illanova students described these panels as *"eye opening."* Several students mentioned that they had been unaware that internships were open to freshmen prior to the panels. Students also said they learned about internships they previously did not know existed, and the panels helped them connect dots between their interests and an intern opportunity:

> *I think it mostly opened my eyes about things I never thought about before. You never hear about a math internship. But yet all those people are doing them.*

Another student was applying to a faculty-led research opportunity she had heard about in one of her math classes that focused on exploring the zombie virus and how it was portrayed in movies:

> *So, this intern will watch different zombie movies and read zombie literature and help him with research and math problems. I want to do that so bad. I had no idea you could even do anything like that with math. I hope I get it.*

Some colleges actually include internship experiences as a requirement for their majors. If students are to meet this requirement, the department or college must have a well-established and well-run internship program. For example, all BYU-I seniors must complete either an internship or a senior project. This requirement promotes internship participation. BYU-I's internships involve 300 hours over the course of a semester. The department has developed multiple strategies to identify internship opportunities, including faculty connections, use of the on-campus business development center, and encouraging students to use their own contacts or to do cold calling.

A challenge that has emerged with respect to internships involves the non-academic demands many students face when they leave campus. Thus, while internships have many benefits for students, some are unable to ive up paid work, even low-wage work, to take on an internship. Colleges are trying to balance their goals for students with students' short- and long-term needs. Solving these challenges were described as an important equity issue to address.

CAREER CLASSES

Short, typically one-credit courses are another way math for departments to prepare students for careers and job searches. In general, course content exposes students to a range of career options and pathways in which they can put their math skills and degrees to use, as well as guidance on how to prepare and engage in a job search.

One faculty member shared that they told her class about a local paint manufacturer looking for math majors with data science capabilities for internships and jobs. They observed,

> *Math students don't think about looking at a paint company for work. Who would ever think about car paint for a math major? But it is a career path. And for someone who has an interest in cars, it's a great fit. So, this course is designed to do that.*

Another respondent talked about partnering with other college departments to offer joint career courses. hey noted that math majors have many options in a variety of different fields, including healthcar

> *The more I do this work, the more I think about the professions that our students can do. Our thinking can be narrow. Like within healthcare, we think doctor, nurse, etc., but there are hundreds of professionals in the healthcare world. So, trying to deepen that knowledge and roles are what the one-credit courses are about. And getting across that an internship is allowing you to test-drive a certain career path. It can reinforce that "Yes this what I want to do," or "No, I don't see myself doing this long term."'*

Departments also use these short courses as opportunities to share information on internships, externships, campus clubs, and research experiences. Faculty have found that focused courses such as these can provide a helpful context for students to think about their career pathways and preparing for their careers, thereby increasing students' consumption of information. As one faculty member commented, *"Math majors are very busy. When is there time to be thinking about these concepts? It's hard."*

Some respondents from colleges that have not offered sho t, career-focused courses were interested in developing them.

> *I would like our department to develop and offer a one-credit-hour course on career readiness to our junior and senior students, similar to what many business colleges offer to their majors. Having such a course would make it easier to institute some quality control measures on the career readiness services we provide, and it would also signify to our students that we care about their career readiness.*

In lieu of a class, other respondents indicated interest in collecting career pathway materials they could use in their regular courses. One suggested that a set of videos about jobs for math majors might be helpful for a department to use in a variety of courses. The videos could include information about jobs in which employees use their math skills, and how these employees found their jobs. Respondents also spoke of websites (e.g., weusemath.org) and other tools they use to disseminate career information both to students as well as to other members of their department.

COMPETITIONS

A few faculty members talked about using contests as a way to promote career-specific learning. (or more on this see the EERC brief: *Preparing Math Majors for Careers: Revising Curriculum*). The Mathematical Contest in Modeling, hosted by the Consortium for Mathematics and its Applications (COMAP), was frequently mentioned, as were the Case Competitions put on by the Society of Actuaries. Departments with computer science concentrations talked about running and promoting participation in hackathons. Like some of the other examples above, contests give students an opportunity to solve difficult problems, think critical , and communicate their findings. Depa tments had different ways of promoting students' pa ticipation in campus, regional, and national competitions. For example, one math department pays all student registration fees and provides a quiet, secure space for students to work during the contest.

INFORMATIONAL ACTIVITIES ON CAREER PATHWAYS

Many colleges and universities inform their students about careers through lectures, panels, and newsletters. UNL received a gift from an alum to help undergraduates think about career options. The department used the donation to create the Career Perspectives lecture series. These lectures, which now occur once or twice a semester, feature people from non-academic math professions and, when possible, include individuals from career paths students usually do not think about. The goal is to demonstrate that math majors can do a variety of things. Recently, UNL hosted a speaker from a tech company who works in quality control using statistical techniques to figure out problems in manufacturing

The mathematics department at Southern Nazarene University invites its alumni to campus at least once a year to share with their current students what it is like to apply for jobs, how they found employment, and how students can prepare themselves for the working world right now. In at least one case, Southern Nazarene's series helped a student find employment after he graduated.

Some departments use their math clubs as a way to share information through talks and panels. A Texas A&M faculty member talked about this method:

> *In addition to the standard monthly math club, we have two more meetings aimed at career readiness. The AMUSE (Applied Mathematics Undergraduate Seminar) brings in speakers, many not from the math department, to present how math is used in a variety of other fields. Speakers from industry are included when possible. The other is the Actuarial Club at which an actuary speaks on what they do and answers questions about being an actuary.*

Departments use their networks to get speakers for talks and stories for department newsletters. Alumni often fil this role, but speakers can be from companies with whom faculty partner or others in industry whom faculty know. Some schools look to their career centers or business development centers to help them find speakers

RESEARCH OPPORTUNITIES

Some faculty members discussed undergraduate research opportunities as an important way for students to apply their math skills and develop additional analytic skills, as well as to develop soft skills including writing, organization, and teamwork. These experiences are often focused on typical academic research, but they still offe value in terms of helping students develop useful skills for work.

Students at the University of Washington have access to the Washington Experimental Mathematics project, which provides an opportunity for undergraduates to conduct research work with faculty. Other schools offer 10-wee summer research experiences, some of which meet departmental requirements for a senior project. A faculty member at Occidental College described that school's research opportunity:

> *Undergraduate research over the summer is a high-impact practice at Oxy. We have several students who participate, and during this activity, career readiness is a topic which is addressed during weekly meetings of the entire summer research cohort.*

Another faculty member talked about the value of independent studies:

> *We have a strong program of one-on-one research. Some students do research with faculty during the summers; others do independent studies. Our students tell us that employers are usually quite intrigued to hear what the students have managed to do on their own.*

At BYU-I, a student's senior project must be an experiential learning experience. Students either come up with their own project, or a faculty member helps them develop one. Over the course of a semester, students work 8 to 10 hours a week on their projects. They also have weekly meetings with a faculty advisor. While not all projects have a defined client to whom to present, all students must present their work at a depa tmental conference at the end of the learning experience. Students are also encouraged to post their work on a website of their creation. A further element of this learning experience is the requirement that students develop a resume in preparation for their job search.

CHALLENGES

Respondents and their departments face a variety of challenges in their effo ts to incorporate career readiness into their students' education. Probably the two challenges most frequently cited were faculty's lack of contact with potential employers and their limited knowledge about industry applications for the math concepts and skills they teach. Professional development is very much needed. (For more on this see the EERC brief: *Preparing Math Majors for Careers: Professional Development for Faculty and Staff*). There is also a need for departments to think differently about career readiness and its importance to their students' overall success—and to understand that doing so involves finding ways to value and reward faculty's activities in this area. In both the TPSE-M survey and in EERC's interviews, faculty respondents repeatedly expressed concerns about the challenges involved in addressing career readiness. One survey respondent wrote,

> *The biggest challenge is still that most of the faculty 1) don't see that undergraduates need to be encouraged towards what the students want to do, 2) have no idea what math people do other than teach and do research, 3) think their responsibility towards the undergraduates consists of teaching the course they are assigned, with as little personal contact as possible.*

Another wrote,

> *The greatest challenge is limited real-world experience on the part of most faculty members. It has been understood for a long time at St. Olaf (and elsewhere, surely) that most students of mathematics and statistics do not aspire to academic careers. Due diligence requires that we do our best to prepare students for this reality. An important challenge in this work derives from the fact that most faculty are academics by interest and training, and so [are] not necessarily intimately familiar with non-academic workplace requirements.*

In our study many respondents also spoke or wrote about the difficulty they have had making connections and keeping connections with both alumni and industry partners (For more on this see the EERC brief: Preparing Math Majors for Careers: Working with Alumni) One respondent said,

> *The challenge is always our lack of solid connections with industry partners. Also, very few faculty already have connections to or experience with industry.*

Finally, time and money were seen as challenges for departments, faculty, and students. Departments struggle to find the resources to offer many of the activities discussed in this bri , and faculty find it difficult to fit ca readiness into an already packed curriculum. For students, finding the time to pa ticipate in career readiness activities can be difficult, especially for those who must balance work and family obligations with their academic schedule

RECOMMENDATIONS

Get connected and stay connected with alumni. Create ways to get connected and stay connected with graduates of the program using listservs, surveys, newsletters, or by inviting them to speak or participate in campus events. Alumni can play an important role in career preparation events and activities.

Find ways to inform students about careers. Invite speakers to campus, offer informational classes, and get student groups involved.

Hire faculty with industry experience. Faculty can serve as connections to industry and help with career preparation activities. They can also play a role in educating one another on math in industry.

Teach students to advocate for themselves: Find ways to give students information to help them understand the applicability of their skills and how they can be used in the workplace. Help students learn to express this information verbally and in writing.

Use real-world problem solving. Students learn better and are more invested in learning when the work is connected to the real world.

Create a culture around career readiness. The key is department-wide support. Build a culture that values career preparation without compromising the academic mission. This includes recognizing this as valuable work.

Use campus resources. Work with the career center and alumni offices to enhance career readiness programming.

CONCLUSION

A misconception among some math department staff and faculty is that inte rating career readiness and career pathway content requires a tremendous amount of faculty time and departmental resources. The results of the TPSE-M survey and the data collected from EERC's interviews demonstrate the existence of multiple strategies that departments and faculty can employ to add or enhance career readiness content to their programming without using extensive resources. Rather than a major commitment of time and financial suppo t, these strategies require a shift of focus, some creativity, and a commitment to help students prepare for the future. While a systemic and integrated program is ideal, EERC's analysis suggests that minor changes can have a big impact.

Each of the six briefs in this series prepared by the EERC showcase different strat gies that have proven successful and that, with a minimum of resources, can be replicated and scaled to fit dive se institutions, e.g., offering ele tive career exploration/preparation courses, adding assignments that involve real-world problems, integrating course content on different career pathways, using online modules, inviting guest speakers, engaging with local employers, identifying research opportunities, offering internships, and engaging alumni in departmental activities. In addition, at colleges where there is an established career center, it important that the math department and individual faculty make use of its resources including center staff's connections with industry employers. Active department-center collaborations can also reduce duplication of efforts, especially around the development of industry partners, leverage expertise, and facilitate student referrals.

Some of the strategies identified in E RC's briefs are more resource dependent, including departmental curriculum reviews and restructuring or adding new degree programs (e.g., applied mathematics, data science). Given the dynamics of the Covid19 pandemic, including decreased college funding, shifts in student enrollment, and changes in how students perceive majors and career pathways, it is important for each college to fully assess which career readiness strategies are most relevant and feasible. However, regardless of how it is done, incorporating career knowledge and skills into higher education pathways is key to preparing students for careers in mathematics.

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TPSEMath

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