



TPSEMath

Transforming Post-Secondary Education in Mathematics

PREPARING MATH MAJORS FOR CAREERS: ADVISING STRATEGIES AND PRACTICES

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Transforming Post-Secondary Education in Mathematics (TPSE Math) aims to effect constructive change in math education at U.S. community colleges, 4-year colleges and research universities by working closely with faculty leaders, university administrations, membership associations, and disciplinary societies. TPSE Math identifies innovative practices where they exist, advocates for innovation where they do not, and works with and through partners to implement and scale effective practices in the pursuit of mathematically rich and relevant education for all students, whatever their chosen field of study. TPSE Math is funded by a grant from the Carnegie Corporation of New York.



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INTRODUCTION

Transforming Post-Secondary Education in Mathematics (TPSE Math), a project funded by the Carnegie Corporation, the Alfred P. Sloan Foundation and the National Science Foundation, is dedicated to enhancing math education in two- and four-year colleges to prepare students with the *“mathematical knowledge and skills necessary for productive engagement in society and in the workplace”* (<https://www.tpsemath.org/>). In 2019, TPSE contracted with the Rutgers' Education and Employment Research Center (EERC) to study career readiness programs for math students and to identify and study promising practices in math departments across the country.

EERC, housed within the School of Management and Labor Relations, engages in multi-site, multi-method qualitative and quantitative evaluation, and conducts research to inform curricula and programs at the intersection of education and workforce development. With input from members of TPSE's Mathematics Advisory Group (MAG), EERC developed and administered an online survey to faculty, department chairs and senior administrators at 143 public and private two- and four-year colleges across the nation as well as five non-profit organizations (survey respondents n=219). The survey asked questions about career preparation, career pathways, advising, research and internship/externship² opportunities, alumni networks, interdisciplinary collaborations, and partnerships with employers at the respondents' home institutions.

In addition, the EERC team conducted 26 in-depth phone interviews with faculty, staff, and students at seven colleges² identified through the survey as having innovative programs. We also viewed a TPSE webinar with a presentation from the Dana Center at the University of Texas – Austin.

This brief on recruitment and advising is one of six briefs prepared by EERC that discusses the findings and recommendations that emerged from this qualitative research study.³

¹EERC is mindful that there are differences between internships and externships, as well as many overlaps in respect to student learning. However, this study did not distinguish between them. We thus use the combined term “internship/externship” when discussing this career readiness activity.

²Babson College; Villanova University; Brigham Young University - Idaho; Harvey Mudd College; University of Nebraska – Lincoln; University of Arizona; and the University of Wisconsin.

³All the briefs in this series are available from the EERC website at:

<https://smlr.rutgers.edu/content/transforming-post-secondary-education-mathematics-research>

RECRUITMENT AND OUTREACH

Several interviewed faculty members spoke about the need to increase diversity among math majors and improve issues of equity of access, opportunity, and outcomes for historically unrepresented populations. To expand diversity more outreach is needed. Some colleges such as the University of Arizona have developed “on-ramping” activities including sending emails to all freshman students – not just those who have indicated an interest in math. The emails welcome the students to the college and describe the college’s math program; and how math courses can be beneficial to all students not just those who want to major in engineering, computer sciences and bench-lab sciences. They also describe how early involvement in math and math-related research can open up doors for undergraduate and graduate academic scholarships and well-paying jobs.

ADVISING

The remainder of this brief focuses on career readiness advising through the lens of the staff and faculty who were interviewed by the EERC team and/or responded to the TPSE-M survey. While faculty advising is central to this discussion, the brief also examines the advising provided by college career centers as well as career-oriented activities such as career panels and job fairs.

The type of advising generally offered to math students is often predicated on a combination of factors including the type of institution (e.g., community, two- or four-year college, university with graduate programs); its size; the size of the math faculty and their subfields; the number of enrolled math students; the existence of a dedicated career center; and the availability of other career-related resources. In addition, differences in the perceived goal or function of advising causes variations across colleges, departments, and even among faculty. It is not clear to what extent specific college characteristics, structural factors, and faculty resources (e.g., availability of departmental or faculty mentors, dedicated career center) create these variations or are the result of them. It is worthwhile to keep this caveat in mind in considering the advising goals survey respondents and interviewees identified in relation to their students. The discussion of advising goals will be followed by descriptions of three different types of advising: faculty advising, career center advising, and career panels/fairs. In each subsection, we will discuss how colleges are handling that task, and some of the challenges they face. At the end of the brief, we present all our recommendations on advising.

FACULTY ADVISERS

Goals of Advising

Overall, respondents stated that advising at their college was intended to help students successfully complete their studies, prepare for careers, and/or progress into graduate programs. Respondents frequently indicated that students are often *“unaware of career opportunities in math.”* Advising provides an opportunity to discuss with students the benefits and utility of math in multiple occupations, and the range of career pathways that exist for math majors. Advising enables the exploration of the ways an associate, bachelor’s, or graduate degree in a mathematics field can prepare them for a successful career. One faculty member shared that one of his former math students was admitted into a computational neuroscience program even though he had not taken a single biology or chemistry course. Instead, the student had a lot of math and computer courses. He summed it up *“...a math major with some supporting courses can go to school in anything.”*

Respondents from community colleges frequently stated that one of their goals was to help students plan their next step: whether to enter the workforce or move into a four-year degree program. A few respondents indicated that content about employment and academic options was routinely included in the course curriculum. (For more on this see the EERC brief: *Preparing Math Majors for Careers: Revising Curriculum*). Two respondents linked their departments’ advising activities to student recruitment.

Numerous respondents cited their desire to increase students’ marketability and strengthen their competitiveness in the labor market. One survey respondent wrote that advising practices on her campus had been developed in part to address disparities among students as they entered the job market:

Sometimes the best students were getting lousy jobs, and the worst students were getting great jobs. We asked ourself [sic] “What things could we do to help the students all get great jobs?”

Of note, only one respondent indicated that her goal for advising was to help students *“see the connection between coursework, degree completion, and good jobs in the area.”*

FACULTY ROLES IN ADVISING

General academic advising by faculty was common across colleges. In the TPSE-M survey fielded to mathematics faculty nationally (n=219), 20 percent of respondents indicated they provided “career readiness” advising to their mathematics undergraduate students. Many faculty members stated that advising was part of their service load, with a few indicating that they advise as many as 15 to 20 students. The frequency and intensity of advising, however, varied across the respondents, as did the focus of their work with students. Further, a number of respondents stated that in addition to faculty advisers, students at their college also had access to professional advisers either within their department or through a college academic or career services center.

ASSIGNING ADVISERS

Across respondents, it appears that the common practice is for students to begin their college career working with a non-departmental adviser. At the same time, some colleges also provide a math faculty adviser as students begin to explore a major or minor in math or indicate an interest in a math subfield such as actuarial sciences. In fact, some respondents indicated that their departments pair pre-majors with faculty mentors who meet with them several times before students formally declare a major or minor in math. One respondent put it this way:

ADVISING AT BYU-I

At Brigham Young, Idaho (BYU-I), mathematics faculty mentors work on course selection and explore graduate school options with juniors and seniors. In addition, the department employs a professional adviser who has a background in math and a master’s degree in environmental science. This individual does the bulk of advising of lower-level majors, which includes providing information about general education requirements. He also works with students to secure relevant internships.

Students need to be thinking about career readiness from the beginning of their college experience. Waiting until junior year to think about your career is a little late.

In general, however, students are assigned a math faculty adviser only after declaring their major, which usually happens at the end of their sophomore year.

TIMING AND FREQUENCY OF STUDENT ADVISING

Survey responses indicated that most faculty advisers meet with students at least twice each academic year, usually during the registration period preceding each semester. Some respondents reported that their colleges require students and advisers to meet more often, while others indicated that advising is more informal, if not entirely ad hoc: “We meet with students when they need us.”

MODE OF ADVISING

Faculty use a variety of methods to advise their students. In addition to the frequent use of office hours for face-to-face meetings, faculty send emails to students and engage with them at departmental events. A few faculty members wrote that they also provide advice about math subfields and career pathways in their department's first-year seminar, as part of a math course, and/or during departmental outreach events and workshops.

Several faculty respondents also suggested the importance of sending frequent e-mails to math students about departmental news, professional conferences, research, and internship opportunities. They stated that such communications stimulate student engagement and create a community for students enrolled in math courses.

THE PROCESS AND FOCUS OF FACULTY ADVISING

Most colleges will not permit students to register for courses without the approval of their math faculty adviser. The primary focus for many advising sessions is therefore course selection for the upcoming semester. Demonstrating how courses and course content connects to future employment can also help with recruiting students into math programs and retaining them.

Some faculty members indicated that they often use their registration sessions to explore students' career goals and *"to help them find opportunities that fit their objectives,"* such as an internship or a National Science Foundation-funded research experience for undergraduates (REU).

As relevant, faculty advisers will also discuss the possibility of transferring to four-year colleges or enrolling in graduate programs. Thus, even though registration generally structures the timing and core focus of required advising sessions, faculty advisers frequently use these sessions to help students define their career pathways by integrating their decisions about academics with their career goals.

Of note, the respondents who meet more frequently with students tend to focus on career choice and career pathways. One respondent from a liberal arts college used the term *"high touch"* to describe her advising. She explained that the college and her department recognize that many students are unsure which major or career pathway to pursue, so advisers are there to help them explore and sort through various options:

We are active at all stages in student development, in helping them build an academic portfolio that also allows them to test and pursue various career interests.

This approach was echoed by another respondent:

. . . faculty advisers regularly start their advising appointments [by] asking the students what their long-term professional goals are and discussing appropriate professional options to support those goals.

Respondents from actuarial programs reported the most formalized approach to career readiness. One respondent reported that their college provides one-on-one advising/mentoring that addresses a wide range of topics, including *" . . . communication skills, person-to person skills, business etiquette, and the general 'soft' skills that business employers expect their employers to have."*

Faculty's accumulation of real knowledge - *"formative and explicit information"*—about their student advisees over time enables not only better advising but also the drafting of better tailored and more personal graduate school or employment recommendations. In fact, the word *"mentor"* was used by some respondents instead of or in conjunction with their comments about student advising. Use of this term and the use of faculty advising suggests that many colleges engage in advising that is more developmental—occurring over a series of systematic interactions—than prescriptive—composed of a single interaction in which adviser and advisee do not know each other.

Intentional advising involves faculty members getting to know their student advisees and engaging in a developmental approach to advising that addresses both academics and career pathways. According to one faculty respondent, *"Intentional advising through individual conversations helps best meet the needs of each student."* Another faculty member wrote that this form of advising helps to *"personalize [students'] learning experience,"* adding that, *"knowing a student's intended career path can help the faculty member speak to what lies ahead"* and can facilitate early matching of a student's interests with internship and research opportunities.

SPECIFIC SPHERES OF FACULTY ADVISING

Research projects. A few faculty members indicated they advise undergraduates and graduate students involved in an REU or in a project at a campus research lab, e.g., the Illinois Geometry Lab.

Senior projects. Many math majors are required to take a senior seminar in which they must complete a capstone or research project. Honor students are often required to complete a thesis in addition to that project. Faculty reported advising students on such projects and helping students access the resources they need to complete them.

Internships. Faculty frequently mentioned helping students to identify relevant internships and providing guidance during those internships. (For more on this see the EERC brief: *Preparing Math Majors for Careers: Practices and Policies for Career Readiness*). Faculty in actuarial sciences or statistics departments often referenced their active ties to industry employers that facilitated the identification of internship opportunities for their students. It is worth noting that faculty connections to industry were also mentioned in relation to many of the research activities described in previous subsections. (For more on this see the EERC brief: *Preparing Math Majors for Careers: Partnering with Industry*).

Career-related seminars and other forms of support from advisers. Several respondents wrote that they advise students when they teach one of their department's required or recommended career readiness seminars. For example, one four-year college requires all first- and second-year students to take a Vocational Seminar course. Other colleges require their seniors to enroll in such seminars.

Career readiness seminars provide students with information about the wide array of academic and career opportunities that a major in math can lead to - careers in technical fields such as actuarial science, financial mathematics, biomathematics, and aerospace as well as careers in business and government. During career readiness seminars, faculty also discuss graduate programs and their application processes, provide instruction how to write a resume, and engage in mock interviews. In addition, students might learn how to prepare a professional presentation (oral, poster, etc.) or write a technical report. Many of these elements are combined in Villanova University's one-credit Mathematics Communities seminar course, which students are required to take. The seminar includes presentations from faculty about their own research, industry and alumni panels discussing careers, upperclassmen panels discussing internship opportunities and experiences, and career center presentations discussing the job search process.

In addition to these formal seminars, or instead of them, faculty at many colleges talk informally with their advisees about employment options, how to craft a resume, and developing an interview style. At times, faculty will also write an employment reference letter.

Transfer and articulation to four-year colleges. As anticipated, the major focus for community college faculty advisers was helping their students decide next steps—whether to enter the labor market or to transfer into a four-year program, either before or after earning an associate degree. Advisers who worked with potential transfers said they provide guidance about relevant course requirements and ways to prepare for a successful transfer.

Graduate school. Some faculty respondents reported working with students who are contemplating and/or actively applying to graduate school. Such advising involves helping students identify the best program for their specific interests and career goals as well as the courses they need to graduate or to fulfill graduate school requirements. Some faculty also wrote letters to support students' applications.

CHALLENGES FOR FACULTY ADVISERS

The diversity of faculty members' backgrounds and experiences, and their varying levels of comfort advising students, was evident in their answers to the TPSE-M survey. In the absence of formalized advising protocols at some colleges, and in the absence of professional development opportunities focused on advising and career readiness, many respondents felt that the chances of students receiving career-focused advising at their institutions were "hit or miss depending on the faculty member." The major challenges that contributed to this reality are discussed in the sections below.

Knowledge about non-academic math, career pathways, and career readiness.

Despite exceptions - departments with applied math faculty, and among actuarial faculty - a common thread across survey responses was a concern about faculty's "limited real-world experience," perhaps best described as a gap between their academic training, experience, and research interests on the one hand, and knowledge of career pathways beyond teaching and the academy on the other.

The greatest challenge is that most of the faculty were trained as pure mathematicians and do not have the industry connections that would be most useful for our students.

Faculty mentors struggle to provide good advice to mathematics students who do not plan to go on to graduate school because they do not understand the opportunities that are out there, as it is a very different path than they followed.

Some faculty wrote on the survey that they felt unprepared to advise students about opportunities in applied math.

What we and most schools called “applied math” was not the math that students were using in industry and science, except for the few that went into physics or traditional engineering. Modern applied math is more about data and information, and no one was teaching that, but our students obviously need it, and math is moving in that direction. It was embarrassing that some of the most exciting and important applied math was better understood by students outside the math department than by math majors.

Many faculty respondents also indicated that they or their colleagues have few if any ties to employers or specific industries.

Some faculty indicated that they or their department were actively seeking ways to expand their knowledge of career pathways and real-world problems to enhance their advising of students. A number indicated that they were working with their campus career center (see below) or were considering hiring a career training professional to better advise students on career pathways and to help students develop career readiness skills. (For more on this see the EERC brief: *Preparing Math Majors for Careers: Professional Development for Faculty and Staff*).

Lack of time for advising. Another challenge for faculty was feeling that their student advising commitments and the need to develop career-related materials stretched their time “*beyond capacity*.” Frequently, respondents cited the lack of sufficient faculty to advise all the students in their departments. Some placed the blame for this on shrinking faculty numbers, while others related it to the increase in the use of adjuncts at the expense of full-time faculty lines. Still others cited the size of their course loads as well as the multiple expectations placed on them by their department and their institution. Given the multiple demands they already juggle, these respondents indicated, they simply lack the time or the resources “*to do this [advising] work*.”

Limited departmental or college support. Although a good number of faculty indicated feeling supported by their departments or institutions with respect to their efforts to provide effective, career-oriented advising and the time involved in doing so, there were an equal number of respondents who did not feel supported in those efforts. These faculty reported a lack of explicit support, such as a “*formal compensation or reward structure*,” for their advising. One faculty member noted that because her work was “*not easily or directly connected to career readiness or real-world problems*,” her career could suffer if she were to expand her repertoire into those realms:

[It would come at] a huge cost in terms of time for me, and something I have not done much of, since I need to put additional time into my research in order to earn tenure.

Faculty also reported a lack of professional development opportunities focused on expanding their skills and knowledge about career readiness.

ISSUES OF SUSTAINABILITY

When asked about the general sustainability of career readiness activities, 70 percent of respondents to the TPSE-M survey answered affirmatively: "Yes, they are sustainable." However, there were no further questions specific to the sustainability of career-focused faculty advising—information that would be helpful given some of the real challenges departments and faculty face in terms of time and experience. Nevertheless, several respondents indicated existing strategies or suggested additional ones that could be used to develop and sustain a focus on career readiness in the student advising practices of math faculty.

The most frequent comments made by respondents with regard to sustainability were about the need for greater encouragement, support, and recognition from department chairs. Some respondents mentioned a need for department-wide conversations about "vocations" and how best to work with students around career pathways and career readiness.

Several respondents linked sustainability to "pats on the back" given to faculty, along with ". . . kudos and credit in annual evaluations [that may be counted] towards their service contributions."

Respondents also wrote that there needed to be increased and enhanced coordination between faculty advisers, math departments, and campus-based career services centers. The last of these, campus career centers, are discussed in the next section in terms of their usefulness as a resource for strengthening the career readiness of math students entering the contemporary workforce.

CAREER CENTERS

The establishment of a dedicated campus career center or office is one of the many strategies that colleges have developed to meet their students' needs and to address career readiness. These centers go by diverse names that often reflect their mission, goals, or the services they provide (e.g., Student Success Center, SuccessWorks, Career and Professional Development Center, Career Education Center, and the Student Career Planning and Development Center). A few colleges combine academic resources (e.g., coaching, mentoring, tutoring); resources related to career choices; internship listings; and program offerings related to career readiness into one campus center. A respondent from the University of South Carolina indicated that its Student Success Center also addresses *“psychological concerns and [provides access to] other important support networks for undergraduates and graduate students.”*

ACADEMIC SUCCESS COURSES

Goucher College's Academic Center for Excellence provides resources related to academic success. These include supplemental instructors for courses as well as a series of academic and career readiness programs (e.g., How to Study, How to Write a Resume, How to Manage Time, How to Prepare for a Job Interview).

STAFFING

Career centers commonly employ dedicated career counselors, including those referred to as *“professional advisers.”* On some campuses, faculty are available as mentors through the career service center or participate in the center's activities by forming mentoring teams. Many respondents reported some degree of coordination between faculty, departments, undergraduate deans, and campus career centers for services such as referrals for mentoring and career guidance. Career center staff also make classroom presentations and engage with students in courses that involve community-based learning to *“help students create resume bullets, for example, related to coursework.”*

WHO IS SERVED?

Across the colleges, campus career centers principally work with students interested in exploring different career pathways or preparing to make a transition into the world of work. A number of respondents indicated that their career centers also work closely with faculty and engage college alumni in developing networks, internships, and career opportunities.

ENGAGEMENT

Generally, advisers inform students about the services and availability of counselors at the college's career center. Two four-year colleges discuss these resources during orientation activities. Others discuss during vocational seminars or as part of a math course. Some actively publicize through campus venues.

A few colleges refer their math majors to their career centers early in their *"academic trajectory."* In some cases, first-semester students are referred to their campus career center to begin to explore their interests and to be introduced to various resources, including internships, that match their interests. A few colleges pair entering students with a professional adviser at their career center. Only later, once students have declared a major, do they get assigned to a departmental or faculty adviser.

Other departments send their majors to their campus career centers later, as they begin to contemplate a transition into employment. As noted above, respondents from some departments, feeling ill-equipped to provide career guidance to their students, rely more heavily on their centers' professional staff.

In addition, some colleges encourage or require any students who *"apply to be tutors or instructional assistants"* to use the career center on their campus to develop their resumes.

FUNCTIONS/SERVICES

The campus career centers identified in the survey shared a primary goal: to *"help students to think broadly about their futures"* and to assist and support both those students planning graduate work as well as those *"not planning to go to graduate school."* The principal activities of the centers described by respondents included: general academic help; career exploration and planning; internship/externship opportunities; job readiness programs; assistance with transition into employment; and exploration of transfer and graduate opportunities. These services are briefly described in the sections below.

General academic help. Many career centers provide individual tutoring, mentoring and workshops on study skills and time management.

Career exploration and planning. When asked to describe a major activity of their campus career centers, respondents frequently cited working with students individually and in groups to explore their interests and identify potential career pathways. Center staff hold workshops as well as invite alumni (For more on this see the EERC brief: *Preparing Math Majors for Careers: Working with Alumni*) and representatives from different industry sectors to speak with students about the work they do and about employment possibilities in their respective fields. One respondent indicated that the career center on her campus also provides personalized career assessments. It was not clear in this study the extent to which individual colleges use personality inventories or career assessment tools.

At some colleges, career centers participate in a departmental seminar (e.g., Villanova University's DREAMS program) that provides students with an opportunity to learn about different fields of math, career pathways in math, and resources for employment and graduate school.

Internships/externships. The fields most frequently referenced in relation to internships/externships were actuarial sciences, statistics, and math education. Several respondents indicated that at their institutions, individual faculty and/or the math department help students with internships/externship or provide the supervision of internships/externships. More frequently, however, internships/externships are handled by campus career centers, whether as part of a college's undergraduate advising program or by means of a dedicated internship/externship center. A few respondents noted that their institutions house other centers that promote or sponsor math-related internships/externships (e.g., the University of Utah's Center for Science and Math Education) in addition to their campus career center. Regardless of the institutional entity, the goals remain the same: *"to match students with opportunities that will help inform them of their interests and career possibilities."* (For more on this see the EERC brief: *Preparing Math Majors for Careers: Practices and Policies for Career Readiness*).

VILLANOVA UNIVERSITY'S DREAMS PROGRAM

Villanova University's DREAMS program is a weeklong career-focused seminar for sophomores and juniors at the end of every other Spring term. Faculty discuss various topics in math and statistics, *"do applied math, modeling, bio stats, data mining, other [kinds of math], topology, etc."* The seminar includes presentations, discussions, and hands-on work. Staff from the career center also participate, sharing information about *"grants, grad schools, internships, jobs, how to create a resume, etc.,"* with time set aside for students to actually work on their resumes. In sum, *"it's [a] more hands-on, active,"* participatory approach to career readiness.

Several respondents indicated that an “*experiential learning*” encounter was a graduation requirement. At these colleges, internships were a major focus. Other colleges simply recommend that students participate in “*career-leaning internships*.” The target population for internships varied across the colleges, with some encouraging first-year students to participate and others focusing on juniors and seniors. Some internships were local and others national; some took place during the semester and others during the summer. A few respondents indicated that their students’ internships/ externships were supported by their department, college, or external funding. One college provides students with a \$2000 stipend to support their participation in a summer internship.

Job readiness. As one might expect, respondents indicated that their career centers provide students with training in a variety of hard and soft skills such as resume writing, preparing for an interview, and professional workplace behaviors (e.g., attendance, punctuality, dress). Some centers work with students individually and some through workshops. Career center staff also develop “*tailored presentations*” applicable to specific majors and seminar classes.

Transition into employment. Career centers work with regional employers and alumni to maintain job listings and to help students connect with individual employers whenever possible. A few respondents stated that their centers work with industry and professional recruiters. The University of Wisconsin’s SuccessWorks at the College of Letters & Science, for example, has its own recruiter coach who “*supports students as they prepare for employment,*” cultivates industry relationships, and helps to integrate employer recruiters into career center programming. Many career centers host career fairs or sponsor panels featuring industry representatives, some of whom review students’ resumes and interview skills.

Transfer and graduate school. In addition to helping students explore career pathways and prepare for the workplace, some career centers also help students to explore transfer and graduate school opportunities. In some cases, this occurs during one-to-one counseling sessions; at other times, the center may host a fair where students can meet representatives from graduate and professional schools as well as alumni who have attended those institutions.

THE BENEFITS OF CAREER SERVICE CENTERS

Campus career centers reflect a college’s recognition of the specialized skills and knowledge required to mentor students about career readiness and career pathways, as well as the importance of having someone on campus with access to employers and industry networks which can lead to both internship and job opportunities for students.

Career centers provide unique opportunities for faculty to refer students to someone who can better serve them while also inviting close collaborations either within the classroom or as a follow up to coursework related to job readiness.

We know that great math faculty want their students to know about pathways, but is it asking too much of already pressed faculty to send out these opportunities to students? . . . [H]aving [a career services] office like mine embedded in the college is so helpful. They [faculty] trust me to make sure it's valid and appropriate and aligned with the mission. It's these collaborations that are so important.

Indeed, many faculty respondents viewed their campus career services center as a critical and valued resource that relieved the burden of being the sole or even primary source of career guidance for their undergraduate advisees. Several respondents wrote that dedicated center staff often have a greater flexibility than faculty do when it comes to scheduling multiple appointments with a student. This allows them to build a more personalized and knowledge-rich relationships. Such personalization can lead to more effective matching of students with internship and employment opportunities.

The work performed by career center staff to maintain contacts with employers and with alumni already in the workforce was also viewed as extremely helpful by survey respondents. One center staff member wrote that her work with alumni has helped her understand which job readiness strategies are most relevant for current students. Further, center staff's *"interface to industry has been incredibly effective in helping students find employment."*

CHALLENGES

Although TPSE-M respondents identified career centers as an important resource for students and acknowledged that they relieve some pressures on faculty, many expressed concerns about the centers' capacity to help math majors. Some respondents thought the limited capacity of their campus career center to help math majors was the result of that center being a *"general-purpose career readiness resource."* Respondents often indicated that center staff lack awareness about what math students *"are actually learning in their courses."*

One respondent wrote, *“some departments have historically had problems effectively communicating with their career center staff . . . exactly what types of jobs mathematics graduates can do.”* And many indicated that general advisers tend to be unfamiliar with the range of career opportunities available to math majors - *“what career pathways might be available to them.”* They *“don’t know the kinds of skills math majors can bring and don’t advocate successfully for them.”* Another wrote, *“the staff has essentially no understanding of what math majors can bring or what corporations would be interested in math majors.”*

Respondents also noted that students generally do not discuss their use of their campus career center with their faculty adviser. Therefore, faculty often do not know if and in what ways their colleges’ centers have been helpful. In addition, students who are advised to visit their campus career center, in one respondent’s view, may be *“intimidated by it and often fail to visit.”* Further, when faculty advise new undergraduate math students to attend career fairs and make use of the campus career center, students indicate that *“it’s too early to look for jobs or internships and [that] they don’t want to think about it yet.”*

CAREER PANELS AND FAIRS

Career panels and fairs are hosted or sponsored independently or jointly by campus career centers, math departments, and other departments or divisions (e.g., education, computer science, business). Many colleges offer biannual career fairs while others hold multiple career fairs throughout the year. These fairs include both regional employers and alumni from various industries. The fairs give students an opportunity to learn about industries that currently employ math students, as well as those sectors that may be expanding. At some fairs, employer recruiters are present to speak with students. Some fairs also include panelists who talk about internship/externship opportunities. Several respondents noted that alumni are invited to fairs at their institutions to give students an opportunity to hear about the transition from school to work and to observe how former students have used their math degree to move forward professionally. The presence of alumni also creates opportunities for graduates to *“provide advice and mentoring to current students.”* Alumni also play a role in increasing the career readiness of math students at Wellesley College, where the math department sends out a post-graduation survey asking alumni to report on their current employment. The results of this survey become a virtual career panel for current students. Faculty encourage students to attend career panels and job fairs early in their studies to help them identify different career pathways and, as one faculty member said, because *“they give away tons of great swag.”*

CHALLENGES

According to most respondents, students often do not attend career fairs until they are seniors. As such they lose out on opportunities to hear about different career pathways that could shape their choice of majors and electives. Further, many students, and faculty members, do not realize that the fall is the peak recruiting season. Students who wait until the spring to begin to attend career fairs or seek out employers, therefore may be missing out on exciting job opportunities.

Another challenge has to do with a lack of human resources. Coordinating and hosting career panels with employers and alumni require time that department and career center staff may not have.

RECOMMENDATIONS

Several promising advising practices emerged from both EERC's interviews and the TPSE-M survey. They are presented below as suggested recommendations for strengthening the capacity of colleges and departments to recruit a diversity of students and to help students with career pathways and career readiness.

RECRUITMENT

Outreach to all students. Many students are unaware of the opportunities in math – especially students who come from under-resourced high schools. It is therefore important to provide information early in their college career about the many benefits a major or minor in math can provide.

FACULTY ADVISING

Early and continuous advising. Career pathway advising that begins in the freshman year is an important investment for both math students and departments. The intensity and content of advising will no doubt change over the course of a student's academic career. However, early knowledge about the range of math-related careers can help students be more strategic in their choice of courses. Further, while advising structured around registration periods may not be the most effective, given potential "*information overload*," such advising can be a springboard to engage students in a way that inspires them to seek out and use advising at other times during the semester.

Intentional advising. Intentional advising enables faculty members to get to know their student advisees and engage in a developmental approach to advising that addresses both academics and career pathways. As such, it can facilitate early matching of a student’s interests with internship and research opportunities. Further, knowing a student well can facilitate the writing of tailored and more personal graduate school or employment recommendations.

Joint faculty appointments between departments and schools. Given math’s overlap with fields such as computer science, engineering, and business, joint faculty appointments between departments can expand faculty’s knowledge of modeling topics for their classrooms as well as for research, internship, and employment opportunities for math students. Alone and in combination these benefits can enhance math faculty’s preparation of students for employment. In addition, joint appointments can foster interdepartmental teaching and research collaborations, which might in turn yield research or internship opportunities for students.

CAREER CENTERS

Increased communication and collaborations between math departments and career service centers. Career center staff need help to better understand what math students are “*learning in their courses*” and how they might use those skills in a range of industries and job titles. Professional development workshops and materials exchanges between math departments and career center staff could remedy some of these gaps.

Specialization of career center advisers. Given the wide range of college majors and career pathways, career centers might consider the use of specialized advisers—individuals who either have a background in or can be trained to focus on a cluster of occupational sectors that employ math students. Such specialists could closely work with one or more departments from which such sectors recruit. They might also partner with math faculty to develop relevant career-related classroom presentations and serve as the primary adviser to which math department faculty refer students.

Career pathways seminars. The earlier, the better: Students benefit from participating in seminars or workshops early in their academic career that showcase career pathways in math and introduce them to research and internship opportunities.

First year seminars. Math faculty should consider inviting career center staff to large first-year courses where they can discuss career preparation topics. Career staff might also bring industry representatives or alumni to some of these presentations to describe their own career pathways using mathematics.

Class visits to the campus career center. To counteract students' hesitation to visit campus career centers on their own, faculty might consider setting aside a full class session during which the class goes to the center for a group orientation. If the center has assigned a specialized adviser to work with the department, this individual would be introduced to the students, potentially improving the success rate of faculty referrals.

CAREER PANELS AND FAIRS

Early attendance at career fairs. Faculty can encourage students to attend career fairs and panels early in their academic career through the use of required or extra credit assignments.

Use of alumni. Math departments might consider asking a group of alumni to take on the responsibility of hosting an annual career panel.

CONCLUSION

A misconception among some math department staff and faculty is that integrating 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 support, 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 strategies that have proven successful and that, with a minimum of resources, can be replicated and scaled to fit diverse institutions, e.g., offering elective 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 is 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 EERC'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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TPSE Math

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