



# PBL BRIEF #9.0 SERIES

## WPI ALUMNI SURVEY FINDINGS



# WPI

## 9.1 Career Preparation Outcomes of Project-Based Learning

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### Briefer Brief

- Worcester Polytechnic Institute (WPI) offers clear evidence of PBL's ability to support career preparation and success through a recent alumni study.
- Many of the skills that are in high demand by employers are better developed through PBL than teacher-centered, lecture-based approaches to undergraduate education.
- Project-based learning can help prepare students for success in a changing workforce by supporting the development of professional skills in areas such as knowledge mobilization, teamwork, and communication.
- Alumni of WPI's PBL-based undergraduate programs attribute the power of PBL to prepare them for successful transitions to careers to its authenticity and the way it empowered them.

### Introduction

A large evidence base clearly suggests that project-based learning (PBL) can support strong career preparation, arguably better than more didactic, lecture-based methods of teaching.<sup>1</sup> This is due in part to the changing nature of work in the knowledge economy of recent decades: PBL is particularly good at developing the kinds of skills and mindsets that allow students to become collaborative problem solver<sup>2</sup>, adept at communication among team members and with multiple stakeholders<sup>3</sup>, and comfortable with managing information across disciplines and sources.<sup>4</sup> In addition to directly developing skills that are critical in the workplace, PBL also teaches students to learn how to learn.<sup>5</sup> This prepares them to be ready to retool on the job

when necessary and can protect them from being out-skilled when the job market shifts.<sup>6</sup>

This research brief illustrates the impact of PBL on career preparation among undergraduate science and engineering students at Worcester Polytechnic Institute using the results of a recent alumni study. The first section lays out the current landscape of expectations among employers and the second section describes the impact of having multiple high-quality PBL experiences on professional skills that are in high demand. The brief then summarizes the impact of undergraduate PBL on career preparation and satisfaction using both quantitative analyses, as well as qualitative testimonies.

### In Demand Skills and Experiences

In 2020, the Association of American Colleges and Universities in collaboration with Hanover Research conducted a survey of 496 business executives and hiring managers.<sup>7</sup> The study included a broad range of industries and, while the majority represented private companies, publicly traded companies, government agencies, and other nonprofit organizations were also included. The study identified the top skills deemed "very important" for college graduates by employers (Table 1).

The findings also establish that employers are more likely to hire job candidates who have applied experiences. Among the types of experiences surveyed, 88% of employers indicated they were somewhat or much more likely to hire college graduates who had an experience that involved working in community settings with people from diverse backgrounds or cultures; 85% were more likely to hire graduates who had an advanced, comprehensive project in the senior year, such as a thesis, senior project, or other major assignment; and 84% were more likely to hire graduates who had a global learning experience that included exposure to diverse experiences and perspectives and application of learning to their major and their own life.

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**Table 1. Top Skills In Demand by Employers**

Skill	Employers Indicated Skill as Very Important*	WPI Alumni Survey Item	WPI Alumni Reported PBL Improved Skill
Ability to work effectively in teams	62%	Function effectively on a team Effectively manage interpersonal skills Interact effectively as a professional within a professional capacity	93% 89% 91%
Critical thinking skills	60%	View issues from several different perspectives Develop ideas Integrate information from multiple sources Solve problems	88% 94% 94% 93%
Ability to analyze and interpret data	57%	Mastery of fundamental major concepts and methods	88%
Application of knowledge/skills in real-world settings	56%	Effectively manage a project Succeed in business or industry	92% 83%
Digital literacy	55%	Use current technology Understanding of the connection between technology and society	89% 82%
Ability to demonstrate complex problem-solving skills	54%	Develop ideas Solve problems	94% 93%
Ethical judgment and reasoning	54%	Understand ethical responsibilities Awareness of how decisions affect and are affected by others	74% 79%
Ability to communicate through writing	54%	Ability to write clearly and effectively	90%
Ability to locate, evaluate, and use information in decision making	53%	Integrate information from multiple sources Make connections across disciplines	94% 86%
Working with people from different cultural backgrounds	53%	Understanding of global issues Respect for cultures outside your own Understand people of other cultures Understand people of other racial and ethnic backgrounds	71% 70% 69% 66%

\*Source: Finley, A. (2021). How College Contributes to Workforce Success: Employer Views on What Matters Most. Association of American Colleges and Universities.

Each of these experiences also describes the types of projects that students at WPI must complete to graduate. WPI's project-based education starts with the elective Great Problems Seminar (GPS) during the first year. After completing preliminary small projects that explore the complexity of the great problem and develop key skills, students choose a challenge and work in small teams to propose solutions to a localized instance of that problem. In the first and second year, all students complete a self-designed minor in the Humanities and Arts, which culminates in either a seminar or practicum that involves individual creative work. Students spend a quarter of their junior year completing an interdisciplinary team-based

project coached and facilitated by faculty. Nearly 90% of students complete this project off-campus at one of WPI's global project centers in Africa, the Americas, Asia-Pacific, or Europe, where WPI students and faculty spend seven weeks tackling a problem of local importance, sourced from local organizations, that lies at the intersection of society and technology. In the final year, students work in small teams supported by faculty on a design or research project of significant scope in their major field. Projects may focus on a problem chosen by the students, posed by external sponsors, or derived from faculty research. All projects involve developing innovative solutions at a professional level.

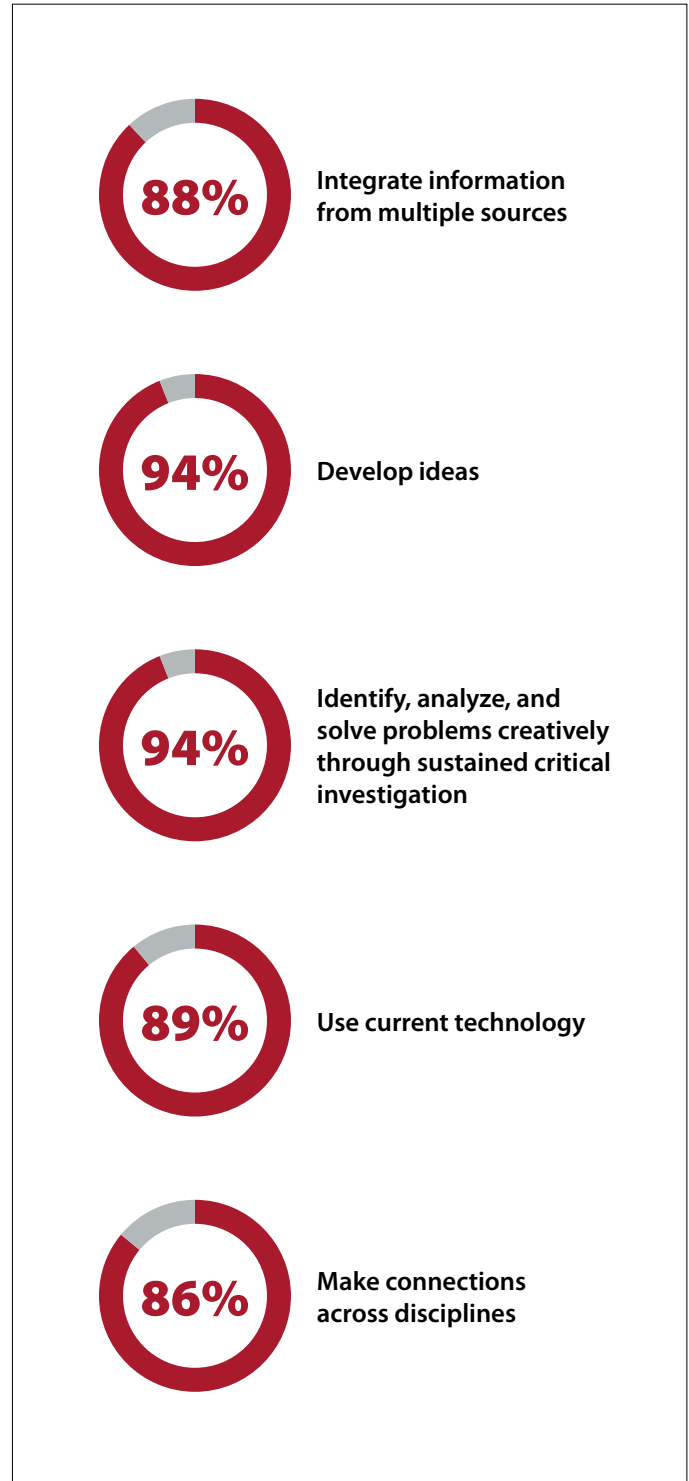
## Developing Professional Skills through PBL

In light of the role professional skills play in preparing students for careers, we also examined the impact of PBL on three broad categories of professional skills: knowledge mobilization, teamwork, and communications. These categories include a number of distinct skills for which alumni were asked whether their project work enhanced, increased, or otherwise improved, all of which are statistically more related to each other within a category than across them.

Knowledge mobilization skills involve the ability to critically find, interpret, and use information. PBL can be an effective way to structure student learning in ways that allow them to practice scoping problems and determining what they need to know to construct a well-informed solution. At WPI, alumni reported strong impact of PBL experiences on their knowledge mobilization skills (see Figure 1). After controlling for the impact of marginalized identities (gender, race/ethnicity), type of major (engineering or other), courses in that major, and sense of self-efficacy, knowledge mobilization skills gained from project work were a significant predictor of the extent to which alumni report being prepared for their current career (see Table 2). In fact, the level of influence was twice that of courses in the major, whose technical content we often consider foundational to careers for STEM students such as those at WPI.

The ability to collaborate with colleagues is a necessity in today's world as fewer jobs can be effectively conducted without engaging in a team. Alumni report very strong benefits of PBL on their ability to effective work with others while advancing a project (see Figure 2). Students at WPI have multiple projects that require them to work in teams and many faculty explicitly teach teamwork skills. The SWEET Center (Supporting WPI through Effective and Equitable Teamwork) also offers a first-of-its-kind set of supports for students to develop better coping strategies for managing challenging team dynamics. Individual students, student teams, and faculty and staff can bring questions and problems related to their teamwork to the SWEET Center and receive support and guidance from staff, faculty, and peer facilitators. Faculty can refer student teams for a consultation or teams and individuals can seek assistance on their own.

**Figure 1. Alumni Indicating Knowledge Mobilization Skills Increased with Project Work**



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**Table 2. Hierarchical Multiple Linear Regression Model of Knowledge Mobilizations Skills' Effect on Career Preparedness**

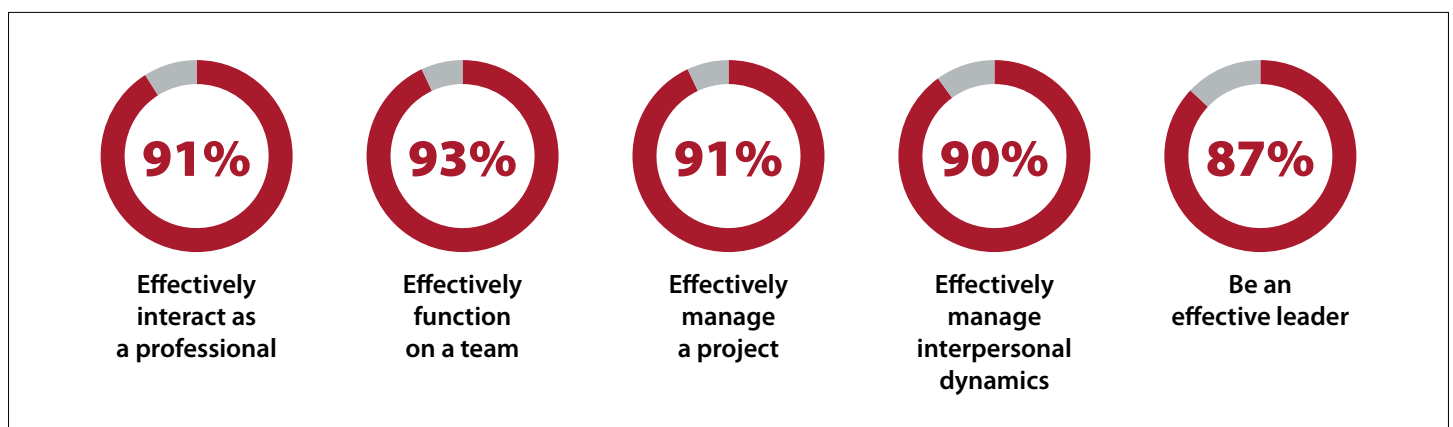
Effect	Model 1: Student Demographics					Model 2: Major Courses & Self-Efficacy					Model 3: Knowledge Mobilization Skills				
	β	SE	95% CI		p	β	SE	95% CI		p	β	SE	95% CI		p
			LL	UL				LL	UL				LL	UL	
Intercept	4.02	.05	3.93	4.11	<.001	.91	.15	.62	1.19	<.001	.50	.14	.22	.78	<.001
Woman	.03	.05	-.07	.12	.59	-.07	.04	-.15	<.01	.05	-.07	.04	-.14	<.01	.05
BIPOC	-.26	.07	-.39	-.12	<.001	-.27	.05	-.37	-.16	<.001	-.26	.05	-.36	-.16	<.001
Major	.04	.04	-.05	.13	.39	.01	.04	-.06	.08	.76	-.01	.03	-.08	.06	.79
Courses in Major						.32	.04	.24	.39	<.001	.23	.04	.16	.30	<.001
Self-efficacy						.58	.02	.53	.62	<.001	.31	.03	.25	.37	<.001
Knowledge Mobilization Skills											.42	.03	.35	.49	<.001
R <sup>2</sup>	.01					.37					.42				
Δ R <sup>2</sup>	.01					.36					.05				
F for Δ R <sup>2</sup>	5.20					482.31					150.24				
p	.001					<.001					<.001				

Note. Dependent Variable: Career Preparedness as measured by the survey item, "How well did your project experience at WPI prepare you for your current career?" Response options were on a five-point scale with "very poorly," "less than adequately," "adequately," "more than adequately," and "very well."

BIPOC = Black, Indigenous, Person of Color; includes any individual who indicated a race or ethnicity other than White and Asian.

Significance set at  $p \leq .05$ .

**Figure 2. Alumni Indicating Teamwork Skills Increased with Project Work**

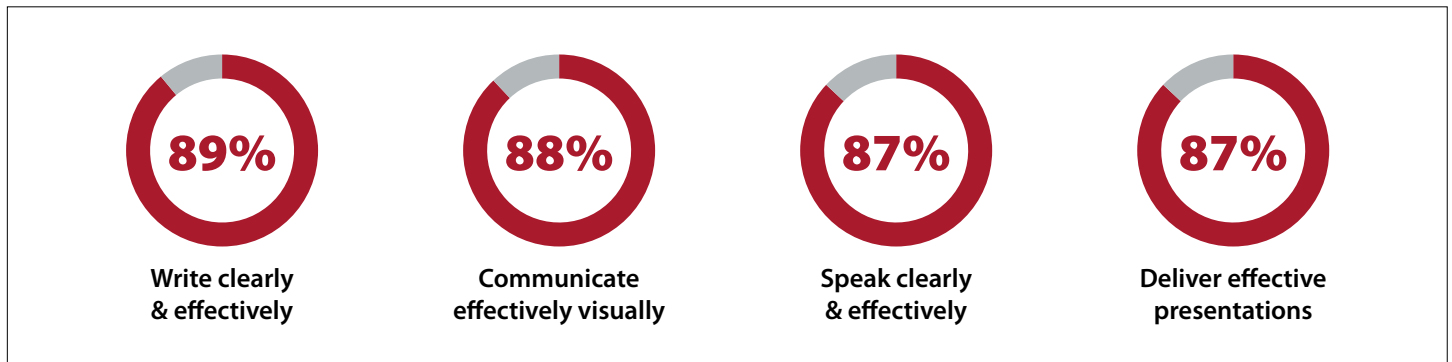


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Finally, projects—particularly when conducted in teams and when external sponsors are involved—can strengthen students' communications skills. Alumni in this study attributed substantial growth in multiple modalities of communicating (e.g., visual, text-based) to their project experiences (see Figure 3). PBL requires students to create

authentic communication in place of essays and term papers to be read by teachers. These communications are often with actual stakeholders, which heightens engagement and requires more thoughtfulness around intentionality, as well as unintended consequences of various choices.

**Figure 3. Alumni Indicating Communications Skills Increased with Project Work**



### Career Preparation and Success

The connection between what employers want in the newly college-graduated workforce and the skills and knowledge developed through high-quality PBL is clear. But does this translate into career success? Alumni from WPI indicate that it does.

On the whole, alumni report that their project experiences at WPI prepared them for their current career, with 68% more than adequately or very well prepared and another 27% adequately prepared. Only five percent of alumni indicated that their project experiences less than adequately or very poorly prepared them for their current career. With a second indicator, 63% of alumni indicated that their project experiences much or very much enhanced their ability to succeed in business or industry and another 20% reported it moderately enhanced this ability; 17% indicated that their project work only enhanced their ability to succeed in business or industry a little bit or not at all.

The qualitative data from the alumni survey confirms the relationship between high-quality PBL experiences and career preparation that leads to success. Several alumni spoke about being better prepared for the demands of the workplace compared to colleagues who had a more traditional undergraduate engineering education. As one alumnus of the Electrical and Computer Engineering Program stated,

Working on long-term projects along with a team of other engineers is what I've done in the work place in the 25 years since graduation and I felt that my project experience with my projects at WPI prepared me for that in ways that graduates of other universities don't experience.

As another alumnus from the Biology and Biotechnology Program elaborated,

These projects really give you a taste of what you are expected to do at work: independent work, check-ins with your boss, piecing things together and figuring out how to communicate know-how, questions, thoughts, and reflections to others, and to be a teammate and/or leader. I was definitely more prepared to enter the workforce than many of my peers.

This preparation has translated into success for the majority of alumni who have entered the workforce after graduation. Financially, this has involved a relatively high average starting salary. In 2019 – the final year of alumni included in the survey – WPI alumni earned \$10,000 or more per year above the national average salary in all but one area of study. In terms of career advancement, alumni report a strong ability to compete for promotions.

## The Mechanisms at Work

Qualitative data from alumni reveals insights into why PBL can be particularly powerful for preparing students to enter and successfully navigate 21st century workplace expectations. Three themes emerged from this data. First, projects are highly authentic to the future of work for students, allowing them to essentially practice what it will be like once they join many types of careers. One alumnus phrased this particularly well, stating that “My 35 years of professional experience—thru 4 industries and 3 technical disciplines—have been nothing but working on projects with other engineers and professionals.” As another WPI alumnus from the Chemical Engineering Program expanded upon this statement that projects simulate an authentic work environment.

There is no better way in my mind to understand who you will be out there in the “real world” than to take part in the WPI project curriculum, particularly the IQP [Interactive Qualifying Project] experience. This is the project that best simulates what day to day work is like (working on real life problems with interdisciplinary teams, possibly outside your normal geography) and shapes you into the person you’ll be at work.

Providing students with opportunities to engage in real world problems, often in collaboration with not only each other, but with organizations and companies beyond the university, allows students to see themselves beyond the classroom.

Related to authenticity, the second theme that emerged is that PBL’s active learning approach empowers engineers to take action. An alumnus of the Electrical Engineering Program who attended WPI in the 1980s pointed to this PBL phenomenon. “Project work transformed my educational (and later professional) mindset from passive repetition to an active/proactive (empowered) participant. I became actively responsible and vested in my educational and problem solving process.” Another alumnus from the Mechanical Engineering Program noted that WPI’s projects “created an environment of how to learn by doing and tying the theoretical to the practical. This built a tremendous amount of self-confidence and motivation to excel both at WPI and later throughout my career.” The theme of being empowered through project work was widespread in alumni testimonies.

As an active learning approach, PBL teaches students how to take initiative and own their decision-making and follow through; these mindsets are critical to managing the

expectations for navigating ambiguity in the workplace. The teacher-centered learning experiences that students have for much of their education position students as passive individuals and knowledge as discrete pieces of information to be memorized. Engineers need to unlearn these expectations – and PBL provides a more realistic view of what will be expected of them when they leave the classroom.

The third theme that emerged from alumni testimonies is the way that PBL provides opportunities for students to learn how to manage ambiguity. As many alumni pointed out, projects change over time—often in unanticipated ways. An alumnus from the Actuarial Mathematics Program described this well.

The length and complexity of the projects—and needing to understand and complete a larger assignment than would be possible in a typical course... allowed for unanticipated complications, and gaining experience in setting timelines and reacting to set-backs or changes in our understanding of what the end-result would be.

Another alumnus from the Biology and Biotechnology Program noted, “I also enjoyed learning in environments where there isn’t always a right answer, but needing to think critically and logically to come to good solutions was key. This makes me a better scientist, employee, and world citizen.”

Teacher-centered approaches to education often involved overly-determined processes with explicit, inflexible procedures provided to students and canned answers. The real world that students face when they join the workforce is seldom so simple or easy to navigate. PBL increases the amount of ambiguity by tackling real world problems in all of their complexity and transferring ownership over process decisions to students.

## The WPI Alumni Study

WPI conducted an alumni survey of its signature PBL offerings in 2021. A survey with closed and open-response items was emailed to 15,528 alumni who graduated from WPI between 1980 and 2019. Data were collected through Qualtrics. One reminder was sent one week after the original invitation to participate to alumni who had not yet submitted a response.

Of those invited, 2,236 alumni responded, yielding a low—but typical—response rate of 14%. The sample included

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in the analyses presented here includes 61% men, 39% women, and less than one percent non-binary or gender fluid alumni. The majority of respondents were white (89%), 6% identified as Asian, 4% identified as Hispanic/Latino (any race), 1% identified as Black/African American or African, and 1% identified as Middle Eastern or North African. Within the sample, 62% were engineering majors, 35% science majors, and 3% majored in other subjects, such as business or social sciences, without also earning a science or engineering degree. These characteristics reveal a sample that is largely representative of alumni demographics within these years. (Women students are slightly overrepresented and non-binary and gender fluid students are underrepresented).

### Notes

<sup>1</sup> Ralph, R. A. (2016). Post secondary project-based learning in science, technology, engineering and mathematics. *Journal of Technology and Science Education*, 6(1), 26-35; Nilsook, P., Chatwattana, P., & Seechaliao, T. (2021). The Project-Based Learning Management Process for Vocational and Technical Education. *Higher Education Studies*, 11(2), 20-29.

<sup>2</sup> Zhang, L., & Ma, Y. (2023). A study of the impact of project-based learning on student learning effects: A meta-analysis study. *Frontiers in Psychology*, 14; Hussein, B. (2021). Addressing collaboration challenges in project-based learning: The student's perspective. *Education Sciences*, 11(8), 434; Cheng, C. C., & Yang, Y. T. C. (2023). Impact of smart classrooms combined with student-centered pedagogies on rural students' learning outcomes: Pedagogy and duration as moderator variables. *Computers & Education*, 207, 104911.

<sup>3</sup> Stoddard, E. L., & Pfeifer, G. (2018, April). Working toward more equitable team dynamics: mapping student assets to minimize stereotyping and task assignment bias. In *2018 CoNECD-The Collaborative Network for Engineering and Computing Diversity Conference*; Owens, A. D., & Hite, R. L. (2022). Enhancing student communication competencies in STEM using virtual global collaboration project based learning. *Research in Science & Technological Education*, 40(1), 76-102.

<sup>4</sup> Hanlan, L. R., & Riley, E. M. (2015, June). Information use by undergraduate STEM teams engaged in global project-based learning. In *2015 ASEE Annual Conference & Exposition* (pp. 26-963).

<sup>5</sup> Almulla, M. A. (2020). The effectiveness of the project-based learning (PBL) approach as a way to engage students in learning. *Sage Open*, 10(3), 2158244020938702; Stolk, J. D., & Martello, R. (2015). Can disciplinary integration promote students' lifelong learning attitudes and skills in project-based engineering courses. *International Journal of Engineering Education*, 31(1), 434-449; Heinricher, A. C., Quinn, P., Vaz, R. F., & Rissmiller, K. J. (2013, June). Long-term impacts of project-based learning in science and engineering. In *2013 ASEE Annual Conference & Exposition* (pp. 23-874).

<sup>6</sup> Fletcher Jr, E. C., Warren, N. Q., & Hernández-Gantes, V. M. (2018). Preparing high school students for a changing world: College, career, and future ready learners. *Career and Technical Education Research*, 43(1), 77-97.

<sup>7</sup> Finley, A. (2021). How College Contributes to Workforce Success: Employer Views on What Matters Most. *Association of American Colleges and Universities*.

<sup>8</sup> The comparison was made between the National Association of Colleges and Employers (NACE) using their dashboard for the First Destinations Survey for the College Class of 2019 (<https://shorturl.at/rCVWZ>) and WPI's public dashboard for the First Destinations Survey for the same class year (<https://shorturl.at/uDGH4>). Analogous groups of major areas of study were compared for students graduating with a Bachelor's degree (excluding those earning a Master's degree in a combined program). In all comparisons, multiple programs of study at WPI were grouped together to align with the larger major areas used by NACE.

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