9.4 PBL at Scale: The Long-term Impact of Multiple Projects on Careers

Kimberly LeChasseur, PhD & Kris Wobbe, PhD • Center for Project-Based Learning • April 2024

Briefer Brief

- There is little research that examines whether the benefits of project-based learning encountered in college persist through adulthood and, if they do, under which conditions.

- There was no significant increase in career preparation between those with no PBL courses and those with projects in about 25 percent of their courses at Worcester Polytechnic Institute; however, alumni with a moderate dose of PBL in about 50 percent of their courses reported a significantly higher level of career preparation.

- Increasing the percentage of PBL courses to 75% or more does not yield further increases in skill development or career preparation.

- The relationship between dosage of PBL and career preparation can be explained, in part, by the gains in professional skills. However, growth in self-efficacy, professional networks, and work-life balance also contribute and all increase with multiple PBL experiences.

Introduction

Project-based learning (PBL) is often chosen by instructors for its ability to aid the development of skills that are not well-supported by lectures, such as teamwork and communication. There is a wealth of scholarship demonstrating growth in students' professional skills and mindsets[1] over their time in individual courses[2] and, in smaller body of literature, programs.[3] There is less research that examines whether the benefits of PBL encountered in college persist through adulthood and, if they do, under which conditions.[4] It is possible that a single highly impactful project experience transforms a student's perspective so much that it becomes a turning point in life.[5] It is also possible that students who are provided with multiple opportunities to engage in authentic, challenging problem-solving through projects might report stronger long-term effects. With so few examples in the scholarship of PBL offered beyond individual courses, this gap in our knowledge base remains underexplored.

This research brief examines the long-term impact of providing students with multiple opportunities to experience PBL on both career-related outcomes. The first section describes the projects at WPI that position the university as a natural place to examine their impact on student learning.[6] After establishing WPI as providing a natural experiment, the following sections describe findings from a 2021 alumni study on career outcomes associated with experiences of PBL at various doses.[7]

PBL at Scale

All undergraduate students at WPI are required to complete three major projects to graduate, with an optional fourth project. The senior year project is a capstone in the major where students work with faculty advisors on a significant research or design project. The junior year project asks students to solve some problem at the intersection of science, technology and society. The vast majority of students do this in collaboration with a sponsoring organization, many at sites off-campus, locally or around the world. Finally, there is a capstone in the humanities and arts, which can be a creative endeavor (e.g., designing lighting for a play, composing music) or a significant exploration of a humanities problem at a deeper level of intellectual engagement than in a traditional course. The optional project is in the first year where students, after exploring the breadth and depth of one of the world's great problems, propose a potential solution to this problem for a localized population, culminating in a campus-wide poster presentation.

This scale of PBL is unique to WPI. In June 2023, Duke University facilitated a symposium of colleges and universities at the forefront of PBL practice in the US. The convening

included 15 institutions, of which five were providing at least 750 students per year with project experiences: Ball State University, Clemson University, Duke University, Georgia Tech, and WPI. Of these, WPI is the only university to provide PBL at full scale to all students.

In addition to expecting all students to engage in multiple projects, many courses at WPI include PBL in various forms. For example, students in a biodiversity course authored an open educational resource titled 'Biodiversity Loss in the Age of the Sixth Mass Extinction'. An industrial engineering course asked students to analyze the process flow of Covid testing on campus.

Robotics courses ask students to design and build robots of increasing sophistication as they move through the curriculum.

On average, approximately two thirds of alumni indicated that half of their courses or more included projects (see Figure 1); this has doubled over the past four decades from 43% to 85% of students (see Figure 2). In 2018, an independent study conducted by the One8 Foundation found that 69% of faculty use projects in at least one course that they teach, allowing us to triangulate high levels of course-based PBL.

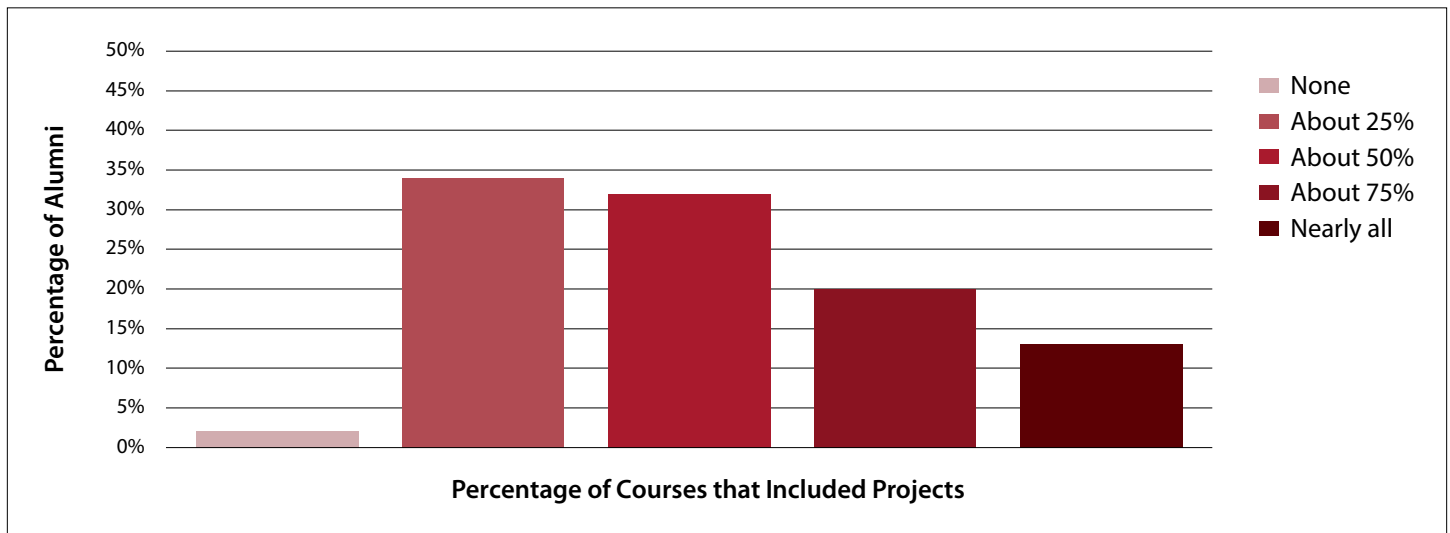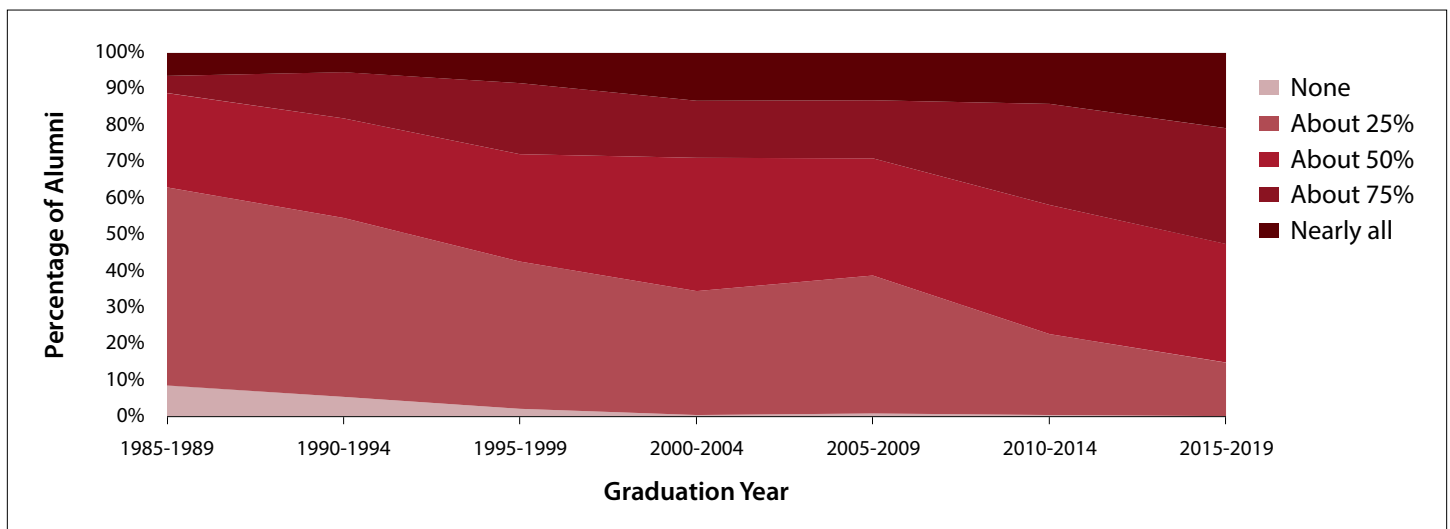## Figure 1. Student Experiences of Courses with PBL at WPI

Figure 2. Change in Percentage of Courses with PBL Reported by Alumni over Time at WPI

Preparing Students for Lifelong Careers

At WPI, the vast majority of alumni reported being satisfied with their current career and attributed being prepared for them by their project work (see Figure 3).
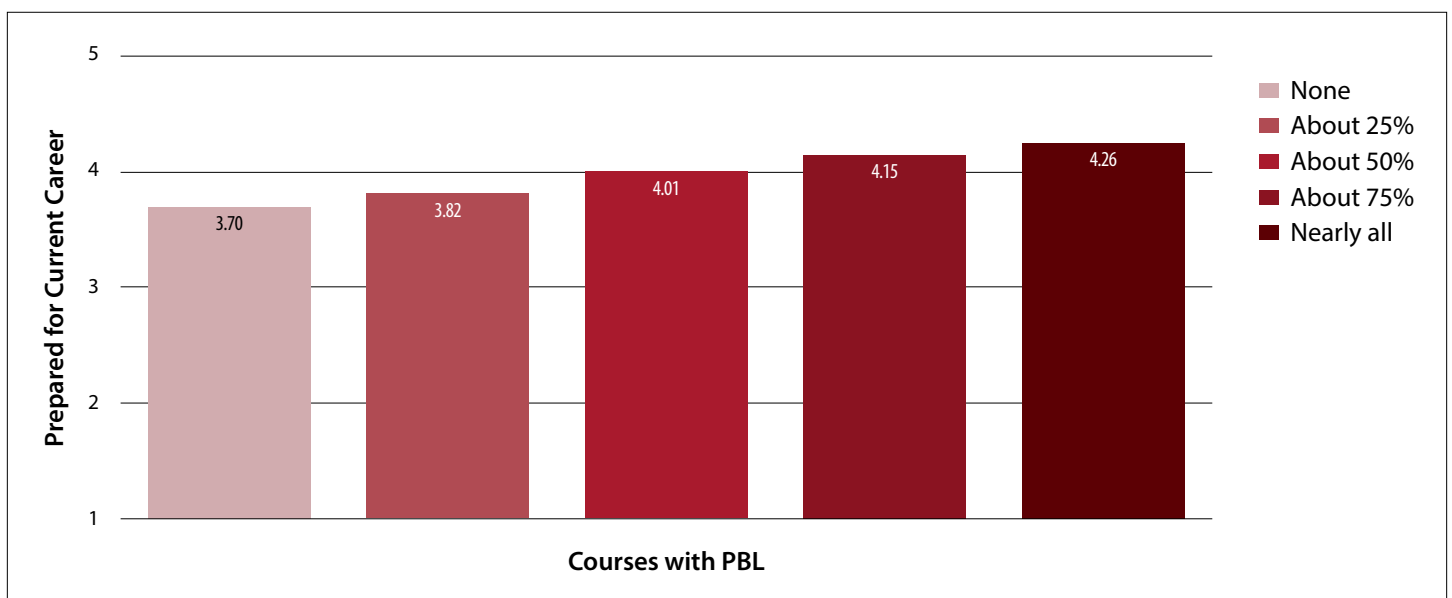
Figure 3. Alumni Indicating Career Satisfaction and Preparation

97%

Satisfied with Current Career

95%

Prepared for Current Career
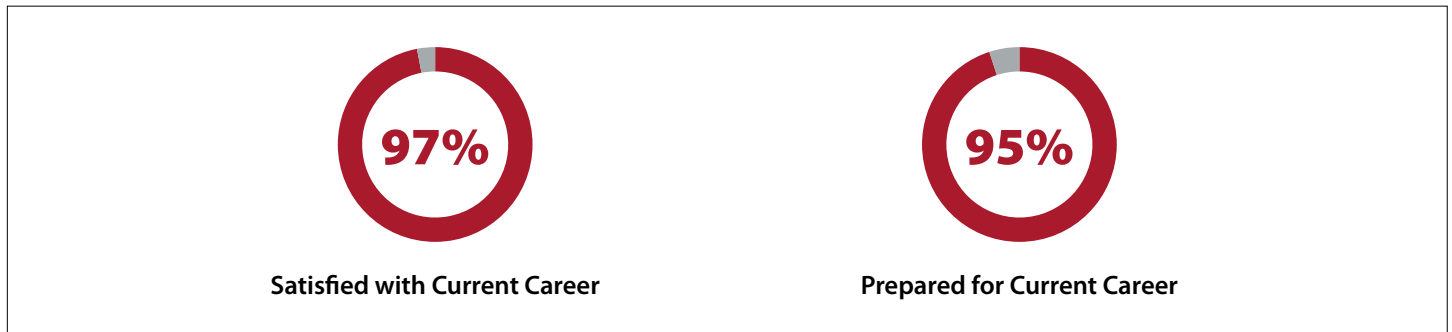
When asked how satisfied they are with their current career, alumni did not indicate any significant difference depending on the percentage of their courses that included projects, with $F_{(4,1840)} = 2.09$, $p = .08$. Alumni in the study were generally between much and very much satisfied with their current career ($M = 4.45$, $SD = .75$).

There were, however, differences in how prepared alumni felt for their current career depending on what percentage of their coursework included projects; a one-way analysis of variance was significant, with $F_{(4, 1797)} = 12.60$, $p < .001$ (see Figure 4). A post hoc Dunnett T3 test revealed no significant increase in career preparation between those with no courses with projects and those who indicated about 25 percent of their courses included projects. There was a significantly higher reported level of career preparation for those alumni with a moderate dose of PBL in about 50 percent of their courses, with $p = .01$. Increasing the dosage to PBL in about 75 percent of courses or in nearly all courses did not result in additional significant increases in career preparation.

Figure 4. Dosage Effects of Projects in Courses on Preparation for Current Career

Legend: None, About 25%, About 50%, About 75%, Nearly all

Values: 3.70, 3.82, 4.01, 4.15, 4.26

Y-axis: Prepared for Current Career (1–5)

X-axis: Courses with PBL

Unpacking the Relationship

Why does more PBL support stronger preparation for careers in the future? The relationship can be explained, in part, by the gains in professional skills.[7] Also contributing to this preparation, however, are gains in career-related self-efficacy, the professional networks developed, and learning work-life balance through project experiences – all of which increase with multiple PBL experiences. After controlling for the impact of marginalized identities (gender, race/ethnicity), type of major (engineering or other), courses in that major, and career satisfaction, and then accounting for the contribution of skills development to career preparation, this set of learning outcomes explains for a significant portion of career preparation

(see Table 1). Specifically, the ability to function effectively in the real world – an indicator of self-efficacy – and professionally beneficial connections from projects contributed significantly and positively to career preparation.

Furthermore, the study revealed that those with more PBL in their courses developed more career self-efficacy and greater professional networks from their project work than those with fewer courses with projects (see Table 2). For each outcome, there was a significant increase from those with a small dose of PBL in about 25 percent of courses to those with a moderate dose of PBL in about 50 percent of courses. None of the outcomes increased further when the dose increased to about 75 percent of courses or projects in nearly all courses.

Table 1. Hierarchical Multiple Linear Regression Model of Influences on Career Preparation from Project Work

| Effect | Model 1: Student Demographics | | | | | Model 2: Major Courses & Self-Efficacy | | | | | Model 3: Knowledge Mobilization Skills | | | | |
| | | | 95% CI | | | | | 95% CI | | | | | 95% CI | | |
	β	SE	LL	UL	p	β	SE	LL	UL	p	β	SE	LL	UL	p
Intercept	.29	.19	-.09	.66	.13	-.44	.17	-.77	-.12	/01	-.19	.17	-.52	.14	.25
Woman	.03	.04	-.02	.15	.15	-.02	.04	-.12	.03	.29	-.02	.04	-.11	.03	.28
BIPOC	-.05	.06	-.28	-.03	.02	-.08	.05	-.32	-.11	<.001	-.07	.05	-.31	-.10	<.001
Major	.04	.04	-.01	.15	<.001	<.01	.04	-.08	.06	.83	<.01	.04	-.08	.06	.87
Courses in Major	.24	.04	.36	.53	<.001	.11	.04	.14	.29	<.001	.11	.04	.13	.27	<.001
Career Satisfaction	.35	.03	.40	.52	.01	.20	.03	.21	.32	<.001	.19	.03	.19	.30	<.001
Information Use Skills						.37	.04	.37	.52	<.001	.22	.05	.16	.36	<.001
Teamwork Skills						.04	.03	-.02	.10	.21	.01	.03	-.05	.08	.64
Communications Skills						.12	.03	.07	.19	<.001	.11	.03	.06	.18	<.001
Cross-Cultural Awareness						.03	.02	-.02	.07	.26	.02	.02	-.03	.06	.50
Career Self-efficacy											.03	.03	-.03	.08	.34
Self-efficacy											.14	.03	.06	.19	<.001
Network											.11	.02	.04	.10	<.001
Balance											<.01	.02	-.03	.03	.91
R^2	.22					.43					.45				
ΔR^2	.22					.21					.02				
F for ΔR^2	89.88					152.62					12.65				
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 ≤ .05.

Table 2. One-Way ANOVA of Career Preparation Experiences by Dosage of Course-Based PBL

Variable	Courses with PBL										F (4,1931)	p	η²
	None		About 25%		About 50%		About 75%		Nearly All				
	M	SD	M	SD	M	SD	M	SD	M	SD			
Succeed in business or industry	3.42	1.50	3.56	1.27	3.89	1.14	3.76	1.19	4.04	1.21	10.26	<.001	.02
Function effectively in the "real world"	3.51	1.50	3.80	1.23	4.07	1.06	4.09	1.08	4.16	1.13	8.74	<.001	.02
Professionally beneficial connections	2.05	1.47	2.43	1.38	2.74	1.38	2.98	1.38	3.01	1.47	15.16	<.001	.03
Achieving work-life balance	1.84	1.17	2.65	1.36	2.89	1.37	2.95	1.36	3.09	1.53	9.71	<.001	.02

Note. Variables were measured by the survey prompt "Indicate the extent to which your WPI formal project experience…contributed to…" followed by the items assessed here. Response options were on a five-point scale with "not at all," "a little bit," "moderately," "much," and "very much."
Significance set at $p \leq .05$.

Discussion and Future Research

The scale of PBL at WPI allowed for our recent alumni study to provide strong evidence that having multiple project experiences matters for career preparation. The vast majority of the current scholarship examines individual courses and programs where students engage in an isolated project. The findings of this study justify the need for more extensive, coordinated effort to shift from lecture to PBL to fully realize its potential for preparing students for the future of work.

We also found that PBL promotes career preparation through multiple mechanisms. While the development of professional skills through project work does improve career preparation, so does developing students' beliefs in themselves and improving their professional networks. Both of these mechanisms were increased with higher doses than a single project experience. That said, the study did find a diminishing return on scaling projects. Students do not need to experience PBL exclusively to realize its full benefits.

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 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

[1] Johnson, B., Ulseth, R., Smith, C., & Fox, D. (2015, October). The impacts of project based learning on self-directed learning and professional skill attainment: A comparison of project based learning to traditional engineering education. In *2015 IEEE Frontiers in Education Conference* (FIE) (pp. 1-5). IEEE; 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.

[2] Vogler, J. S., Thompson, P., Davis, D. W., Mayfield, B. E., Finley, P. M., & Yasseri, D. (2018). The hard work of soft skills: augmenting the project-based learning experience with interdisciplinary teamwork. *Instructional Science, 46*, 457-488; Hart, J. (2019). Interdisciplinary project-based learning as a means of developing employability skills in undergraduate science degree programs. *Journal of Teaching and Learning for Graduate Employability, 10*(2), 50-66.

[3] Wiek, A., Xiong, A., Brundiers, K., & Van der Leeuw, S. (2014). Integrating problem-and project-based learning into sustainability programs: A case study on the School of Sustainability at Arizona State University. *International Journal of Sustainability in Higher Education, 15*(4), 431-449; 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).

[4] 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).

[5] Fortune, T., Borkovic, S., Bhopti, A., Somoza, R., Nhan, H. C., & Rangwala, S. (2019). Transformative learning through international project-based learning in the global south: Applying a students-as-partners lens to a "high-impact" Capstone. *Journal of Studies in International Education, 23*(1), 49-65.

[6] This section overlaps with *Research Brief 9.3 PBL at Scale: Developing Skills and Knowledge through Multiple Projects*

[7] described in more depth in *Research Brief 9.3 PBL at Scale: Developing Skills and Knowledge through Multiple Projects*