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WORCESTER POLYTECHNIC INSTITUTE:
PROJECT-BASED EDUCATION

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PROGRAM SUMMARY

At Worcester Polytechnic Institute (WPI), 100% of students complete multiple project experiences, and 100% of faculty are involved in project-based learning.

For over 50 years, WPI has used a project-based curriculum that leads students through four years of increasingly complex challenges in the form of substantial open-ended projects. Students complete first-year projects on "Great Problems" such as energy and sustainability, second-year capstones in the humanities and arts, junior-year interdisciplinary projects relating technology to society, and senior research or design projects, the latter two often for external sponsors. The curriculum is decidedly global, with students tackling problems that are locally situated but of global importance and 90% of students completing at least one project off campus. In addition to projects required for graduation, 70% of our courses include projects. This curriculum was recently recognized with the prestigious Council on Undergraduate Research 2023 Award for Undergraduate Research Accomplishments.

The strength of the curriculum is that it places projects at the center and coursework in a supporting role. The primary graduation requirements for all majors are two significant (9-credit) projects, one in the student's major — Major Qualifying Project (MQP) — and one at the intersection between technology and societal need — Interactive Qualifying Project (IQP), but the entire four-year curriculum is influenced by the clear importance assigned to the qualifying projects. WPI adopted a seven-week term to allow for in-depth dedicated terms devoted to projects without sacrificing rigor within disciplinary majors. A policy of no failing grades encourages intellectual risks and mediates the discomfort of ambiguity during open-ended, authentic projects. Faculty can ask students to take more responsibility for their learning in every course with the rationale that this prepares students for the required projects.

WPI's project-based education starts with the elective Great Problems Seminar (GPS) during the first year. Here, students dive into global grand challenges such as climate change, food scarcity, energy independence, health equity and sustainability. Each topic area has both social and technical implications and can be mapped onto the United Nations Sustainable Development Goals. Students choose a challenge and work in small teams under the supervision of faculty with interdisciplinary expertise to propose solutions. Courses are team-taught, with the intent that the faculty are bringing diverse perspectives and expertise to the classroom. The GPS courses culminate in written project reports and a joint poster presentation attended by faculty, students, administrators and external judges. The GPS experience has proven effective in igniting student passion and commitment to tackling the world's most pressing problems, while at the same time introducing the value of interdisciplinary learning.

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In the first and second years, students complete a self-designed minor in the Humanities & Arts (HUA), which culminates in either a seminar or practicum that involves individual creative work. Students interested in the history of technology, for example, may write an in-depth paper, while students who have pursued studies in music may compose and perform an original piece. There are also opportunities for students to travel to an international off-campus site to fulfill this requirement.

The Interactive Qualifying Project (IQP) is the centerpiece and perhaps most unique feature of the WPI experience. The IQP builds on previous project experiences, including the GPS and projects embedded in courses. Students typically complete the IQP during the junior year by conducting an interdisciplinary project in small teams coached and facilitated by faculty. Nearly 90% of students complete the IQP 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 away from courses tackling a problem of local importance that lies at the intersection of society and technology. These problems are sourced from local organizations, which then serve as project sponsors. The IQP concludes with a written report (publicly accessible) and presentation of results and recommendations, both to local project sponsors and to the WPI community. Completing the IQP off campus has a significant positive impact on students' understanding of context, teamwork skills, communication skills and ethics. Alumni also report that these global experiences enriched their personal lives in ways that continue after graduation.

The Major Qualifying Project (MQP) is carried out in the senior 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. As with the IQP, students can elect to conduct their MQP off campus. For example, WPI chemical engineering students can work with French students in France, resulting

in a truly international collaborative experience. Some projects are sponsored by global firms, adding real-life excitement and underscoring the need to integrate theory with practice to develop locally appropriate solutions. Student project work is publicly shared during our annual Undergraduate Research Projects Showcase, a day free of classes. When appropriate, students receive support for filing patents. All student project reports are archived and publicly available through Digital WPI. These student products (GPS posters, IQP and MQP reports) in aggregate were viewed more than 125,000 times in 2022.

RESOURCES AND ADMINISTRATIVE MODEL

The Great Problems Seminars are led by a faculty director who is responsible for 1) recruiting faculty from across campus to teach in the program; 2) organizing the faculty development necessary to teach in this very different program; and 3) overseeing the production of the culminating poster session across courses. There is a small cadre of faculty hired expressly to teach in this program, as well as in their disciplinary field, alongside faculty from across campus. Faculty teach these courses in pairs, and any new pair is given a summer stipend to co-create course materials and activities and otherwise prepare to teach together. Participation in the annual faculty development program (five half-days) is also stipended, as it is scheduled out of contract. The program has an operating budget to support these expenses.

The Humanities & Arts capstone requirement is organized by the HUA department. Each faculty member in the department is responsible for offering one to two Inquiry Seminars or Practica (enrollment of 12) per year. This teaching is in-load for faculty.

Each degree program is responsible for providing MQPs to their majors. Generally, there is matching of student interests with faculty projects; we have an electronic platform, e-Projects, that organizes information to aid in securing matches. Students are often working in vertically integrated teams, with graduate students and post-docs also supporting the learning of the undergraduates. Project advising is considered teaching during tenure and promotion processes and all faculty are expected to advise MQPs and/or IQPs as part of their in-load work. There is funding available from departments to support purchasing materials for these projects; some faculty subsidize student projects with their research funding.

Each year, WPI's Global School matches approximately 1,200 students to project centers around the world.

The IQP program requires considerably more infrastructure and funding. The Global School is charged with administering the IQP with substantial collaboration across campus. There is a mandatory prep course prior to off-campus projects in which students learn research methods, conduct initial background research, identify a scope of work and learn about their project site. Faculty within The Global School generally teach these courses. The projects themselves are solicited by project center

directors — faculty with connections to the location who cultivate partnerships with community organizations. The Global School matches approximately 1,200 students to their desired sites each year using a home-grown algorithm. For the fraction of students who choose not to fulfill the requirement through attending a project center, e-Projects is used to post and find project ideas, as well as handle registration and grade assignment. The Global School is also responsible for recruiting, training and supporting the 70–80 faculty who advise at project centers each year. Faculty from across campus are encouraged to advise at project centers with the approval of their department head. Typically, two faculty accompany 24 students (six project teams) to the project site where they spend seven weeks supporting the students in their full-time project work. This is considered the equivalent of teaching two classes.

Locations of WPI Global Project Centers

To support students who are traveling to residential, often international sites, we have a Global Experience Office with a staff of seven. They provide risk management, travel education and preparation, and administrative support to students, faculty and staff participating in all WPI-sponsored off-campus travel. To ensure that all students, regardless of means, can participate in off-campus projects, all students are awarded a Global Scholarship of up to $5,000 for the costs of participation (travel, housing, food). These funds largely come from reallocated financial aid and an endowed fund.

BEST PRACTICES AND LESSONS LEARNED

Over the 50+ years WPI has had our project-based curriculum, we have accrued a wealth of lessons learned and developed key best practices. Several are summarized here; for more, see our Center for Project-Based Learning FAQs.

ADVANTAGES OF A FACULTY CORE: For two of our programs, the GPS and IQP, hiring a core group of faculty specifically to contribute to these programs has been key to the rapid advancement of the program in terms of developing and disseminating best practices. These faculty are committed to their programs and work together to try different approaches and

share assignments, assessments and strategies — all with an eye to deepening student learning and optimizing the experience for all. Both GPS and IQP also require faculty from across campus to participate; however, their participation is eased by the development of resources and the deep knowledge and camaraderie of the core groups. Since the GPS courses are co-taught and IQPs are most often co-advised, the core faculty can also serve as models in apprenticeship relationships with faculty new to participation in either program.

FACULTY TRAINING: Training in project-based learning is critical and is provided for all WPI faculty. For faculty contributing to the GPS (~14–19 per year) there is a week-long summer institute that functions as a learning community to support faculty by sharing best practices, airing concerns, identifying challenges and sharing potential solutions. These sessions also are used to brainstorm potential publications, conference presentations, research ideas and grant proposals. The result of these sessions is a group with a sense of shared mission and agency. The Morgan Teaching and Learning Center, together with several collaborators across campus, provides a set of sessions for faculty new to advising MQP or IQP projects that covers learning outcomes, sample syllabi, setting student expectations, grading criteria, scaffolding ideas, giving feedback on writing and other best practices. For off-campus IQP advising there is additional training more focused on the issues involved in taking students on residential programs in a new, often foreign, location (e.g., crisis management, available supports).

PROJECT AND PROGRAM ASSESSMENT: Key elements of our faculty training for guiding projects revolve around structuring projects and how to assess them. Not only do we provide sample syllabi and rubrics, but we also seek to instill the philosophy that projects should provide spaces for students to do self-directed work, but with guidance. Students should know that not only are the products of their work going to be assessed, but also their processes. We help faculty identify feasible mechanisms to evaluate process and promote its importance. We encourage faculty to consider individual grades even when projects are done in teams and provide guidance on how to differentiate grades within student teams. Student products are routinely used to assess the extent to which each program is achieving its program outcomes, both internally and by accrediting bodies (NECHE, ABET, etc.).

During the 50+ years that WPI has maintained a project-based curriculum, its leaders have discovered the importance of a faculty core, consistent self-assessment and intentional support for student teamwork.

SUPPORTING STUDENT TEAMWORK: While having students work in teams provides many advantages, it is essential to provide them with support in learning how to be effective and equitable teammates to reduce the damage that can also occur in student teams. Students need direct instruction on what productive teaming is and tools to develop good communication and feedback. Assessment of teaming is also important and faculty use a variety of strategies, including team-generated contracts and formative and summative self- and peer-evaluation. More recently, we have adopted a suite of tools that promote an asset-based approach to proactively help students divide work based on assets and areas of growth. This has seen

real benefits. For teams that need more than a simple assist, WPI has created the SWEET Center (Supporting WPI through Effective and Equitable Teamwork) which brings together experts on teamwork from across campus and beyond, creating space for partnerships with students, faculty and staff that support high-quality teamwork experiences for all. 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.

DEMONSTRATED BENEFITS OF PBL: WPI has conducted two alumni studies to document the benefits of PBL experiences post-college. Alumni indicated that projects had extensive, positive impacts on the academic skills most relevant to current and future work demands — fostering both timely and timeless knowledge, skills and attitudes. According to these data, the majority of our students reported that their formal project work at WPI much or very much enhanced their ability to effectively function on a team (78%); identify, analyze and solve problems creatively through sustained critical investigation (76%); integrate information from multiple sources (78%); write clearly and effectively (69%) and take responsibility for their own learning (83%). These benefits directly align with the skills employers seek. Personal character and self-efficacy were also deeply impacted. Notably, our women scientists and engineers attribute significantly greater benefits to PBL, further strengthening our contributions to more equitable STEM education ecosystems. These analyses advance the field's understanding of PBL as a high-impact practice by demonstrating that repeated project experiences provide greater impact on nearly all student outcomes, both immediate and long-term. Small doses of PBL in isolated courses are insufficient for reaping the full benefits of PBL. Furthermore, even students who have a negative project experience report positive impacts, particularly when followed by a more positive project experience.

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These results were so compelling that WPI initiated two key things: the Global Scholarship to allow all students to participate in off-campus projects (recently recognized by IEE and NAFSA) and the creation of the Center for Project-Based Learning. The Center's role is to share our decades of experience with other institutions that are interested in advancing PBL on their own campuses. Since 2017, the CPBL has worked with over 180 institutions in the U.S. (nearly 200 worldwide) and more than 2,000 faculty and staff to create and curate a wealth of resources that are shared broadly.

CHALLENGES AND PRIORITIES FOR THE FUTURE

FACULTY PARTICIPATION: As our undergraduate population has grown, departmental needs for instruction have decreased the ability of faculty in traditional departments to contribute to our GPS and IQP programs, both of which use faculty from across campus. Faculty enjoy the opportunities these programs provide to try new pedagogies, learn outside their discipline and travel. They also don't want to leave their departments short-handed. This has led to faculty feeling conflicted about volunteering, as well as tensions between faculty who do want to participate and their department heads who need to make sure that all their courses are fully staffed and between department heads and administration regarding the availability of faculty resources. We are committed to offering these very distinctive and transformative programs; therefore, identifying creative ways to solve the person-power dilemma is of primary importance.

ADVANCING OUR WORK IN EQUITABLE TEAMWORK: While the tools and strategies we have been using to help students work equitably in teams have resulted in better teaming behavior, we know students who hold marginalized identities still suffer microaggressions and tensions from largely well-meaning teammates with privileged identities. Additional work to support faculty and students to minimize these traumatic experiences for our students holding marginalized identities is needed.

GREENING OUR CARBON FOOTPRINT: In our Global Projects Program, we put over 1,000 students and faculty each year on airplanes to our off-campus project centers. Evidence shows that these immersive project experiences are transformative for the students, and that being away from campus is a key ingredient in that transformation. How can we create equally transformative experiences that do not have the same environmental costs?

Worcester Polytechnic Institute is private research university located in Worcester, Massachusetts. It enrolls 5,000 undergraduates and 2,000 graduate students.