To learn more about this case study, see note on page 5.

WORCESTER POLYTECHNIC INSTITUTE

A sequence of independent projects completed over four years provides practice in applying disciplinary learning to authentic problems that matter to society.

Athena Casarotto, a mechanical engineering major, spent most of her senior year intensely studying elastoplasticity. Her experience is exceptional in that she did this not through coursework, but as an independent project she completed with two other students. Specifically, she says, they were studying the elastoplasticity of ice cream—"finding the best ways to manufacture it, package it, ship it, all of that."

"A lot of our senior-year projects come from a company," says Laurie Leshin, president of Worcester Polytechnic Institute (WPI). "Our students are learning to solve problems that employers really care about from the time they are here. WPI was founded on the idea of joining theory and practice together."

WPI, a private research university with approximately four thousand undergraduate students inWorcester, Massachusetts, has organized its curriculum around a sequence of projects since 1970, when the curriculum was redesigned to focus on project-based learning. The change came after a committee of faculty and administrators determined that the traditional major/general education system was not on its own adequate to prepare WPI's students, most of whom are aspiring scientists and engineers, to apply their disciplinary learning to authentic problems that matter to society.

In the redesigned curriculum, known as the WPI Plan, students complete a sequence of independent projects over four years, usually working in teams and in many cases working in settingsoutside of the classroom. The culmination of this curriculum is the Major Qualifying Project.

FOUNDATIONS FOR PROBLEM SOLVING

While this particular sequence may be most appropriate for students in the STEM fields (science, technology, engineering, and mathematics), the WPI curriculum offers lessons for institutions educating students in all fields and for institutions of all types. Perhaps most notable is the deliberatescaffolding of skills. Students begin developing key skills—working in teams, solving open-ended problems, and integrating knowledge from diverse disciplines—in their first year at WPI.

Many students enroll in a Great Problems Seminar (GPS), a two-course, team-taught sequence organized around a topic of global importance that crosses disciplinary boundaries, such as food, energy, or water. Over the course of just seven weeks, the students work in teams to identify a local example of a problem relatedto the course topic and research potential solutions, culminating in a poster presentation. All GPS sections alsoinclude sessions on information literacy; each seminar hasa designated research librarian who visits the classroom periodically to facilitate assignments that help students learn how to evaluate sources.

This may be the first time students are confronted with problems that don't have a single right

answer, or a correct answer at all, says Kristin Wobbe, associate dean of undergraduate studies. These seminars also offer an early opportunity to help students rethink their previous conceptions ofteamwork. "Part of our job is to disabuse them of the notion that teamwork means somebody takes charge and tells everybody what to do," Wobbe says. "We help them learn how to share ideas and construct a team for the project, rather than one person's project divided up between four people.
That becomes ... critically important."

The WPI Plan has evolved to include a familiar division of discrete majors and a selection of general education requirements in the arts, humanities, and social sciences, along with a three-course concentration in a single arts or humanities discipline, usually completed in the sophomore year. While all these curricular elements are designed to help students achieve WPI's institution-wide learning outcomes, they don't all build toward the culminating project in a linear fashion.

"It's very easy to interpret our projects across the four years as a sequence that builds on itself, but I would say that the humanities and arts requirement, while it develops some of the same skills and abilities, sort of stands alone. It's less about problem solving and more how a particular discipline in the humanities and arts is engaged," says Rick Vaz, dean of interdisciplinary and global studies. "The idea behind this was always something a little bit different—it was always to try to havestudents cultivate a lifelong passion in a particular area by having them do some really mature work in that area and study it for a while."

Still, many students do bring the skills in their arts and humanities concentration to bear in theirlater project work. Those who concentrate in philosophy or history, for example, will get extensive practice in evidence-based writing, which will prove useful for the independent research and writing they will complete in their junior and senior years.

FACING OUT TO THE WORLD

In the junior year, students turn their focus outward, applying the tools of science and engineeringto a real-world problem in a community beyond the campus.

"If you asked our students, you'd find to a person they would talk about how they use these skills they are developing for their Major Qualifying Projects," says Vaz. "They'd be talking about project management, writing, organizing a meeting, seeking out and analyzing information—a wide range of problem-solving, critical thinking, and teamwork skills. But the junior year is also intended to inculcate a particular mindset—keeping in mind most of these kids will be engineers or scientists—to be more cognizant of how science and technology exist in social contexts and have implications for the human condition. It's our hope that while this prepares them for subsequent professional experiences, it also gives them a broader social perspectiveon science and technology."

The junior year project—the Interactive Qualifying Project, or IQP—is in some ways a more advanced version of the assignment given in the Great Problems Seminars. The IQP, a requirement for all students that exists independently of any course or major, addresses a real-world problem, often one that is faced by an externalsponsor in a community with whom the students will work. Teams of students complete the project under the guidance of one or more faculty mentors, who might come from different disciplines. As Vaz mentions above, the focus of

the project is to integrate knowledge from a range of areas and situate it in a real-world context- to consider the human implications of science and technology. The culmination of the IQP is an extensivewritten document and presentation.

Many students choose to complete the IQP at one of one WPI's off-campus project centers—they currently have forty-six different sites around the globe. Casarotto studied at WPI's Bangkok site as part of a teaminvestigating the impact of a recent oil spill. "I got to see how the economy was impacted, how socially they were affected by the oil spill. The biggest challenge was overcoming the social differences," she says. Overcomingthat ... communication barrier took a while, but in the end we were more comfortable with each other and we produced a list of recommendations for Thailand to better respond to spills in the future."

Each site is overseen by a faculty director who recruits and selects students, builds relationships with the local community organizations with which students will work, and coordinates housing and other logistics. WPI faculty work with project sponsors, typically nongovernmental organizations or government agencies, to define the projects in some cases. Faculty advisors accompany the students on-site, but while they offer guidance they rarely work directly on the research and data-gathering with students. The students more typically interact directly with the sponsor for the project, and their field work in some locations, such as Thailand, often involves direct contact with communities.

The faculty site director helps prepare the faculty members who will be advising there. "We don't put that onto a staff office because the most important element of being a center director is crafting a good project," Vaz says. "That very often requires a very careful shaping of a community organization's needs into the kind of problem that's going to give our students an interdisciplinaryproject experience that will build the skills we're hoping for them to develop."

Faculty who advise at global project sites undergo several days of intensive training focused on both academic and nonacademic aspects of supervising projects abroad. The Morgan Teachingand Learning Center at WPI also offers workshops focused on project-based learning in the classroom, particularly for new faculty. But the primary model of faculty development at WPI is apprenticeship, Vaz says. New faculty co-advise their first few projects with more experienced facultymembers—both from their own and other departments—and learn a variety of advising and project management strategies.

FOCUSING ON THE MAJOR

The Major Qualifying Project (MQP) is the final piece of signature work that students do—an independent project applied to a real-world problem of the student's choosing. Completed in the final year, the MQP differs from the IQP in a few key ways. Most MQPs are team based, like the IQP, but, as the name suggests, the project is completed within the student's major, with faculty mentors and student collaborators all coming from the same or similar disciplines. MQPs can vary considerably, but in all of them, students will apply disciplinary knowledge and skills in a setting appropriate for their future professions. Students in laboratory sciences such as biology or chemistry usually work on a research project that is part of their faculty mentor's research agenda; engineering students usually design and create a prototype of some kind of technical object or artifact. All students must also complete an extensive written report and give an oral presentation on their projects.

Students may work on their MQP for the entirety of their final year at WPI, and in most cases faculty advisorsmeet weekly with their students, Wobbe says, "hearing what they have done, making recommendations, holdingfeet to the fire as needed." Students are graded at the end of each term, so there is ample opportunity to give feedback. "There are checkpoints along the way, and thereshould be lots of interaction between faculty and studentsthroughout the MQP process," Wobbe continues, "early enough that if something was not going to be acceptable, the student found that out long before presentation time."

The priority given to process is also reflected in the final assessment of the MQP. While there is certainly a strong emphasis on solving the targeted problem, faculty also weigh how students followthe appropriate processes for their discipline as they engage with the problem. Engineering students,for example, strongly emphasize the design process. "You prototype, you test, you reimagine the design in light of any failures, and then you go back through the cycle," Wobbe says. "Students who do no assessment won't score very high; but some who go through and make improvements, even if they don't get a successful prototype, still would not be considered a failure, because the efforts and adjustments made would be considered successful."

In addition to writing a final report, all students present their MQP results at a campus-wide event at the end of the term to other students, faculty, invited community members, parents, and any other interested guests. Presentation formats vary, but "communication is a key skill that unifies them," Wobbe says.

In some ways, the MQP is not so different from the major capstones offered at many colleges and universities. It is the highly structured, deliberately scaffolded curriculum that is particular to WPI—and that may be hard to imitate at other institutions that have different curricular structures in place, that have higher student-faculty ratios, or that lack the funding to create opportunities like WPI's independent project sites, for example. But the most crucial element of the WPI Plan isthe repeated practice students get solving unstructured problems, and that can be done in many different settings, Wobbe says. "Projects can be done within any class…The more opportunities students have to engage with open-ended problems…the better they are going to be by their senior year at problem-solving as an independent process."

"I think the big takeaway is if you want students to engage in the world, you have to give them the opportunity to have authentic experiences—it's as simple as that," Vaz says. "That translates differently in different settings and disciplines, but I think it transcends all of higher education."

A Note to Readers

This Campus Profile represents one of many possible ways to make deep civic inquiry and engagement part of all postsecondary students' learning experiences.

The profile was adapted from a 2017 AAC&U publication related to AAC&U's initiative on preparing students to do significant "signature" projects on issues important to the students and to society.

The case shows how signature work can prepare students to apply their higher learning to public issues and challenges. It also shows how civic inquiry and action can become deeply embedded in an institution's degree requirements, institutional culture, and reciprocal relationships with community-based partners.

Source: Wilson Peden, Sally Reed, and Kathy Wolfe, *Rising to the LEAP: Case Studies of Integrative Pathways to Student Signature Work* (Washington: DC. Association of American Colleges and Universities, 2017).

To order copies of the complete report, which features thirteen case studies of integrative learning and signature work, please visit www,aacu.org.