Stanford Law School | Law and Policy Lab

Developing an Outcomes Framework for the Stanford Doerr School of Sustainability

June, 2022

Stanford Law School

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Report of the Spring 2022 Policy Lab:
Developing an Outcomes Framework for the Doerr School of Sustainability at Stanford
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Executive Summary

We propose a framework by which the Stanford Doerr School of Sustainability (the School) can track and improve its progress in achieving its stated goals of (1) advancing knowledge, (2) preparing students for leadership positions, and (3) linking research to action by engaging with partners— all toward solving sustainability problems.

The fundamental elements of the framework are theories of change encompassing the activities, intermediate outcomes, and ultimate outcome for the pathways to each of these goals. These theories of change enable the School to determine what activities are needed to achieve their desired outcomes, track progress as plans are implemented, get feedback to determine whether the plans are on course, and make necessary corrections to stay on course and achieve the intended outcomes.

The essence of the theory of change for advancing knowledge is familiar within any research university. It consists of the recruitment, hiring, and promotion of faculty and other researchers working on topics that have the short- or long-term potential to improve sustainability outcomes, recognizing that, while impact-driven research will be one major factor in recruitment, basic research has often resulted in practical applications that were not expected or even imagined.

(The two current cluster hire searches seem to reflect both of these considerations.) In addition, the School can promote sustainability outcomes through grants and assistance from the Accelerator (described below) and other programs, and by rewarding faculty's pursuit of the School's mission.

The essence of the theory of change for preparing students for leadership positions consists of developing and teaching a curriculum, including capstone projects and practicums, that imparts the core knowledge, skills, competencies, and leadership attributes deemed important for those positions. We propose two sorts of feedback for continuous improvement of the curriculum: (1) a performance assessment before graduation, and (2) feedback from the School's graduates about their needs and how the School could better prepare future graduates.

We identify three distinct pathways for linking research with action: (1) technology transfer, (2) translation into public policy, and (3) linking with practices by various communities and other actors. Each of these components has its own generalized theory of change, and we believe that a detailed theory of change should be developed, monitored, and modified as necessary for each individual project.

The report focuses on predicting, measuring, and achieving progress toward the intended outcomes of the various pathways with the goal of gaining feedback to enable the School to improve its performance. Whether the School has achieved "impact" by virtue of achieving a particular outcome depends on the extent to which its work contributed to the outcome compared to what would have happened without its activities (the counterfactual). Other than suggesting how impact might be assessed, we devote little time to this question, which must be answered separately for each component of each pathway.

Introduction

This coming September, the University will open the Stanford Doerr School of Sustainability (the School), a new school dedicated to "creating a future where humans and nature thrive in concert and in perpetuity."[1] The School intends to pursue this mission through three pathways:

1. Advancing knowledge critical to sustaining life on Earth and to ensuring the benefits of a healthy planet extend to all people
2. Preparing students as future sustainability leaders through rigorous, engaged education and research
3. Engaging with partners to generate and scale local, national, and global solutions to the defining challenge for humanity

The School is not being created from whole cloth. It "merges and expands on existing Stanford organizations, including the School of Earth, Energy and Environmental Sciences (Stanford Earth), Stanford Woods Institute for the Environment, and the Precourt Institute for Energy. The department of civil and environmental engineering will also join the Doerr School as a joint department with the School of Engineering. The Doerr School will include the facilities of Hopkins Marine Station, which had been administered by the School of Humanities and Sciences."[2] Our references to the School encompass existing as well as planned teaching and research programs.

[1] Stanford Doerr School of Sustainability, accessed July 8, 2022, https://sustainabilityinitiative.stanford.edu/.
[2] *Id.*

In the spring quarter of 2022, at the request of Kathryn (Kam) Moler and Stephan Graham, respectively transition dean and transition vice dean of the new School, Paul Brest conducted a Law School Policy Lab practicum[3] to help develop a framework by which the School could track its progress and estimate its impact in achieving its ambitious mission. Participants in the practicum are listed in Appendix 1, and experts we interviewed are listed in Appendix 2. This report is a joint work of the Policy Lab practicum members.

Core Concepts

An Outcomes Framework

What we call an outcomes framework has these core elements:

- The particular sustainability-related *outcomes* that the School and its faculty are seeking to achieve through research, education, and engaging with partners
- Plausible *theories of change* for achieving the outcomes
- *Assessment of progress* toward achieving the outcomes as the theory of change is implemented
- *Assessment of the School's contribution to achieving those outcomes*—that is, the extent to which the outcomes would not have occurred in the absence of the School's activities

"Sustainability" as an Outcome

"Sustainability" is a capacious term, which has typically been described as encompassing three dimensions: environmental, social, and economic.[4] The term is often used as a synonym for "sustainable development," which the UN World Commission on Environment and Development defines as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[5,6]

Sustainability is too vague a concept to provide an evaluable outcome for the School's impact. However, its broad umbrella encompasses many more specific outcomes, such as reducing greenhouse gas emissions, controlling wildfires, or protecting particular endangered species. The specific outcomes pursued by the School's faculty and other researchers aggregate to become the School's overall outcome.

The Theory of Change and Flowchart as Frameworks for Assessing Progress and Predicting Outcomes and Impact

It may take many years, even decades, to move from the School's research and educational activities to achieving tangible outcomes, and even longer to assess impact. The theory of change provides a framework for assessing progress along this path and for predicting the likelihood of

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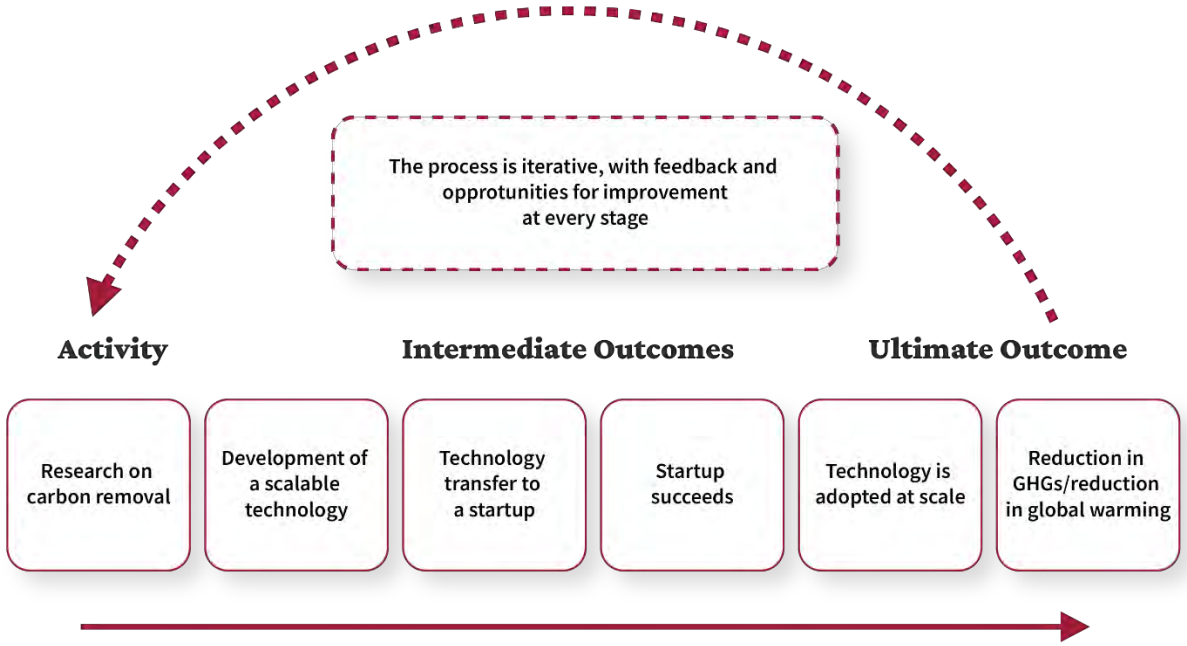
[3] See https://law.stanford.edu/education/only-at-sls/law-policy-lab/#slsnav-quoting-dean-jenny-martinez.
[4] "Sustainability," Wikipedia, accessed July 8, 2022, https://en.wikipedia.org/wiki/Sustainability#Dimensions_of_sustainability.
[5] "UN World Commission on Environment and Development, ed., *Report of the World Commission on Environment and Development: Our Common Future*," Environment and Society Portal, accessed July 8, 2022, https://www.environmentandsociety.org/mml/un-world-commission-environment-and-development-ed-report-world-commission-environment-and.
[6] See also the United Nations Sustainable Development Goals (SDGs), https://sdgs.un.org/goals.

achieving the outcome. The generalized form of a theory of change describes the School's *activities* leading to various *intermediate outcomes*, leading to the desired *ultimate outcome*.

For example, suppose that the ultimate outcome of a research project is a reduction in global warming through a reduction of atmospheric greenhouse gases, and that the activity is research on a carbon removal technology. Here is a simplified theory of change:



Success at each stage is necessary to achieve the ultimate outcome. As the project proceeds, the School will have updated information for predicting success in getting to the next stage, for predicting achievement of the ultimate outcome, and for predicting the impact of the project.

The theory of change, sometimes supplemented by a flowchart, creates a template for monitoring progress—e.g., to what extent have the activities been performed and to what extent have the necessary intermediate outcomes occurred? This feedback is essential for making course corrections when activities are not producing the necessary intermediate outcomes.

The Meaning of "Impact"

The Doerr School aspires to make an impact. Impact is not another step in the theory of change, but rather the extent to which the School's activities *contribute* to the outcome compared to what would have happened without those activities (the counterfactual).

Conventional methods for measuring impact—experimental (e.g., randomized controlled trials), quasi-experimental, and econometric techniques—can often determine whether a certain policy, technology, curriculum, or social or environmental practice made an impact. But this is a different question from whether the impact can be attributed to any particular researcher's work [7] or that of their institution. Sometimes, as exemplified by certain patents, an important result can

[7] These complexities, among others, are described in Professor George Triantis's August 2, 2021, memorandum to Vice Provost and Dean of Research Kathryn Ann (Kam) Moler on Research Impact Metrics, included as Appendix 3.

be traced to a single identifiable source. Often, however, as with the adoption of public policies, it is the product of many institutions' work.

The saying that victory has a thousand parents suggests modesty in the School's claiming credit for successful outcomes. In any event, one must generally use what is termed *contribution analysis*,[8] which relies heavily on critically evaluated anecdotal evidence, rather than on statistical evaluation techniques, to assess the impact of an institution's efforts.[9]

The Three Pathways

This section develops theories of change for each of the School's proposed pathways to impact. Because consideration of the "engaging with partners" pathway illuminates the "advancing knowledge" pathway, we discuss them in that order.

Advancing Knowledge

The School's mission encompasses "advancing knowledge critical to sustaining life on Earth and to ensuring the benefits of a healthy planet extend to all people."[10] Assessing progress and outcomes along this pathway poses a complicated question for a university that fosters a range of research from theoretical and basic to applied.

The proof of the pudding for applied research is in its link to action as described in a later section. However, basic research may advance knowledge without having foreseeable practical applications, and any practical application may be serendipitous and come decades later. The point is nicely captured by the title of a monograph by Abraham Flexner, the founding director of the Institute for Advanced Study at Princeton: *The Usefulness of Useless Knowledge*.[11]

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[8] John Mayne, Contribution Analysis: An approach to exploring cause and effect (2008) explains that under contribution analysis, causality is inferred from the following evidence: (1) The program is based on a reasoned theory of change: the assumptions behind why the program is expected to work are sound, are plausible, and are agreed upon by at least some of the key players; (2) The activities of the program were implemented; (3) The theory of change is verified by evidence: the chain of expected results occurred; (4) Other factors influencing the program were assessed and were shown not to have made a significant contribution or, if they did, the relative contribution was recognized. Mayne, John. "Contribution analysis: An approach to exploring cause and effect." ILAC brief (2008).

[9] The historian Benjamin Soskis has used this approach to assess the role of philanthropy in achieving marriage equality (see https://www.openphilanthropy.org/files/History_of_Philanthropy/Misc/Case_Study_Soskis_Marriage_Equality.pdf) and the passage of the Affordable Care Act (Obamacare); see https://www.openphilanthropy.org/blog/history-philanthropy-case-study-impact-philanthropy-passage-affordable-care-act.

[10] "Law 808N: Policy Practicum: Creating an Impact Framework for Stanford's School of Climate and Sustainability," Stanford Bulletin: Explore Courses, accessed July 8, 2022,, https://explorecourses.stanford.edu/search?view=catalog&filter-coursestatus-Active=on&page=0&catalog=&q=LAW+808N%3A+Policy+Practicum%3A+Creating+an+Impact+Framework+for+Stanford%27s+School+of+Climate+and+Sustainability&collapse=.

[11] Princeton University Press 2017 (including Flexner's 1939 essay with that title). For some examples, consider that I. Rabi's work at Columbia on the measurement of nuclear magnetic spin, for which he won the Nobel Prize in Physics in 1944, led to magnetic resonance imaging (MRI) and the atomic clock. Claude Shannon's research on information theory at Michigan and MIT in the years after World War II was critical to all modern electronic technology. Michael Gottlieb, as an immunologist at UCLA, was on the lookout for "interesting teaching cases," which eventually led to the identification of the human immunodeficiency virus (HIV) in the 1980s. Paul Brest and Hal Harvey, Money Well Spent: A Strategic Plan for Smart Philanthropy (2d ed. 2018) p. 220.

Mario Molina's and F. Sherwood Rowland's pathbreaking work in atmospheric chemistry provides an excellent example of advancing knowledge critical to sustaining life on Earth.[12] As a postdoctoral fellow at University of California, Irvine, Molino continued Rowland's study of the chemical properties of atoms with excess translational energy, which then led them to conduct research into chlorofluorocarbons (CFCs). Their research, begun in the early 1970s, provided the scientific basis for the 1987 Montreal Protocol on Substances That Deplete the Ozone Layer and led to their sharing the Nobel Prize in Chemistry in 1995 (with Paul Crutzen). We do not know whether a prediction of producing external impact, as distinguished from doing good science, led to Mario Molina's various faculty appointments. However, the pattern of faculty contributions to practical knowledge suggests modesty about such predictions, especially for junior faculty appointments.

In the course of our interviews, some stakeholders, noting the urgency of addressing the climate and other sustainability problems faced today, have argued that the School should emphasize hiring faculty who are prepared to address those problems. But history suggests that tomorrow's world will be faced with its own serious problems. Universities, as distinguished from some issue-specific research institutes, provide the foundations for addressing problems that cannot even be anticipated today.

How the Doerr School's faculty appointments process mediates between the short and the long term remains to be seen. In the 2021–22 academic year, the School announced searches for "cluster hires" for tenure or tenure-track faculty appointments in two areas: Climate Science, and Sustainable Development and Environmental Justice. The former seeks candidates with "a commitment to contributing to a strong university community in climate research, education and external impact."[13] The focus of the latter search is on:

> … risks from global environmental change to people and the planet, including adapting to, planning for, and reducing such risks, and in understanding how risks and impacts differ across populations. We are searching for creative and innovative scholars with an established record of high-impact research and a commitment to building a strong research, education, and impact community around the topics of sustainable development and environmental justice.[14]

In addition to continuing its catholic appointments process, the School can amplify today's practical contributions to sustainability without sacrificing tomorrow's in at least two ways.

First, which we believe is already on the School's agenda, is the hiring of professors of practice, senior fellows, and other non-tenure-line researchers, who typically have backgrounds in and maintain connections with particular fields of practice.

Second, the linking of research with action is facilitated to the extent that the work is *self-accelerated* by the researchers. Without suggesting any weakening of the University's criteria for scholarship or teaching as a basis for appointments and promotion,[15] we wonder whether the School might recognize the importance of engaging with external partners (described below) by

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[12] "Mario Molina," Wikipedia, accessed July 8, 2022, https://en.wikipedia.org/wiki/Mario_Molina.
[13] cluster_hire_Climate_Science_Ad_FINAL_121521, on file with Paul Brest.
[14] cluster_hire_SustDevEJ_ad_final, on file with Paul Brest.
[15] Service (including what might be called institutional citizenship), although relevant, is not a primary criterion for a tenured appointment. Service, however exemplary, cannot substitute for deficiencies in scholarship or teaching. See https://facultyaffairs-humsci.stanford.edu/handbook/chapter-5-tenured-appointment-tenure-line.

adding the third criterion akin to what some peer universities term public service,[16] but which might be more specifically linked to outreach beyond the university in service of the School's mission of "creating a future where humans and nature thrive in concert and in perpetuity."[17]

Along these lines, the planning document for the School's Accelerator suggests how the School might provide incentives for translating research into policy:[18]

> On the technology commercialization end of the Accelerator spectrum, Stanford faculty, researchers, post-docs, and grad students have career and financial incentives to scale their innovations for the private market. Those same incentives do not exist on the public policy side, where the end game is co-development and deployment of policy solutions that further sustainability but do not create financial rewards for participants. Even for the most altruistically minded members of the Stanford community, engagement work normally is on top of and juggled with an existing teaching and research load. The hope is that as the new school expands, incoming faculty will be interested in making community engagement a focal point of their research and teaching agenda, and the University will recognize that contribution in the promotion process. (The presence of a policy engagement hub within the Accelerator also may assist in recruiting the best graduate students interested in conducting policy-relevant research.) But until community engagement is rewarded on an equal footing with basic research, the policy side of the Accelerator must find ways to incentivize sustained participation by Stanford community members.

Summary Recommendations

American research universities have well-established yet still evolving criteria for recognizing and rewarding their faculties' advancement of knowledge. Especially, but not only, professional schools appreciate the value of applied as well as theoretical knowledge. With its outcome-oriented mission, the Doerr School incorporates some of the qualities of Stanford's other professional schools and may learn from their appointment and promotion practices as well as those at peer institutions. More generally, the School's mission calls for efforts to shift its ethos in this direction.

That said, we believe that it would be unfortunate, for several reasons, for the School to borrow from the efforts by Commonwealth countries to assess the impact of particular faculty members' research. First, the University is the home of a continuum of research ranging from applied work that has immediate results to basic research, whose contributions to knowledge, however significant, may not have foreseeable practical value. Impact assessments tend to skew toward the short term. Second, efforts to attribute impact to particular individuals face formidable methodological problems.[19] And finally, such metrics are poster children for Campbell's Law

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[16] For example, the University of California, Berkeley, Criteria for Appointment, Promotion, and Appraisal provide that: "Service by members of the faculty to the community, State, and nation, both in their special capacities as scholars and in areas beyond those special capacities when the work done is at a sufficiently high level and of sufficiently high quality, should … be recognized as evidence for promotion." Guidelines for Evaluation of Service in Faculty Performance Review, Berkeley Academic Senate, accessed July 8, 2022, https://academic-senate.berkeley.edu/sites/default/files/guidelines.pdf.

[17] Stanford Doerr School of Sustainability, accessed July 8, 2022, https://sustainabilityinitiative.stanford.edu/.

[18] Policy Engagement Lab in Sustainability Accelerator_QA_rev2 (1).pdf, on file with Paul Brest.

[19] See Appendix 3.

that "the more any quantitative social indicator is used for social decision-making, the more subject it will be to corruption pressures and the more apt it will be to distort and corrupt the social processes it is intended to monitor."[20] For example, efforts to attribute impact to individuals' research militates against collaboration and risk-taking at a time when aspirations for sustainability urgently need both.

Preparing Students

The School of Earth offers undergraduate degree programs in Earth Systems, Geological Sciences, Geophysics, and Energy Resources Engineering.[21] In addition to master's and PhD programs in Energy Resources Engineering, Earth Systems Science, Geological Science, and Geophysics,[22] the School offers three interdisciplinary graduate programs:

- Earth Systems Science, an interdisciplinary environmental science major and coterminal master's program
- The twenty-year-old Emmett Interdisciplinary Program in Environment and Resources (E-IPER), which offers both a PhD in Environment and Resources and joint and dual master's degrees with other schools in the University
- The relatively new SUST program in Change Leadership for Sustainability, which offers a coterminal master of arts and a master of science in Sustainability Science and Practice.

These programs will continue to be available to students as components of the new school's curriculum.

In addition to continuing to produce leaders in sustainability, the Doerr School aspires to make an ethos of sustainability pervasive throughout the University by attracting students to its courses, assisting other faculties in including issues of sustainability in their courses, and promoting extracurricular activities.

The School's tenure-line faculty as well as adjuncts and lecturers play key roles in preparing students as future sustainability leaders. We think the intended outcome of the School's teaching mission will be something along these lines:

> *Through their professional work and other activities, Stanford graduates contribute to a sustainable future.*

This outcome is considerably more difficult to specify and track than the School's research outcome because of the diverse careers and volunteer activities of the School's graduates, as well as the broad definition of sustainability. While any particular research project has knowable results, education has a virtually infinite range of possible outcomes related to sustainability.

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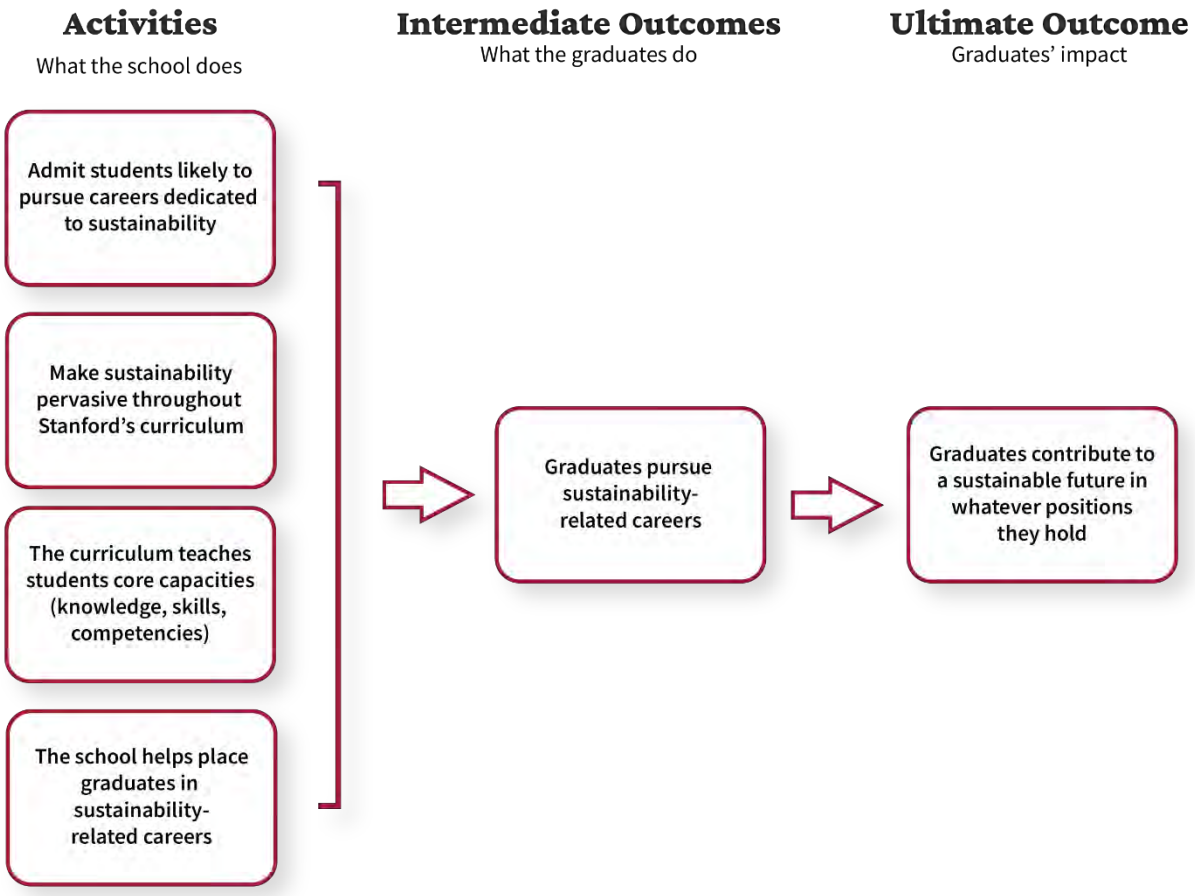
[20] "Campbell's Law," Wikipedia, accessed July 8, 2022, https://en.wikipedia.org/wiki/Campbell%27s_law.

[21] "Stanford Earth: Undergraduate Experience," Stanford University, accessed July 8, 2022, https://earth.stanford.edu/academics/undergraduates#gs.yb9gl3.

[22] "Stanford Earth: Graduate Programs," Stanford University, accessed July 8, 2022,, https://earth.stanford.edu/academics/graduate-programs#gs.yb9v9s.

A generalized pathway, or theory of change, for the School's core teaching mission might look like this:



- *Admissions*. Students' past activities and application statements provide some indication of the role of sustainability in their intended careers. From time to time, the School might reassess admissions criteria to improve prediction.
- *Teaching*. Much of our Policy Lab's work concerned ways that the School could get feedback to improve its already strong academic programs for preparing students as sustainability leaders. While the discussion below focuses on standard courses and programs, we should note that students' involvement in research while at the School also has significant educational benefits.[23]

- *Making sustainability education pervasive.*
    - *Within the Doerr School*. SUST and to some extent in E-IPER aim to provide students with the competencies and leadership attributes described below, as well as more conventional knowledge and skills. We wonder whether at least some of

[23] This is the rationale for the Law School's Policy Lab practicums, such as this one.

these might be offered to students in disciplinary programs, including PhD candidates, many of whom will hold leadership positions contributing to sustainability outcomes.

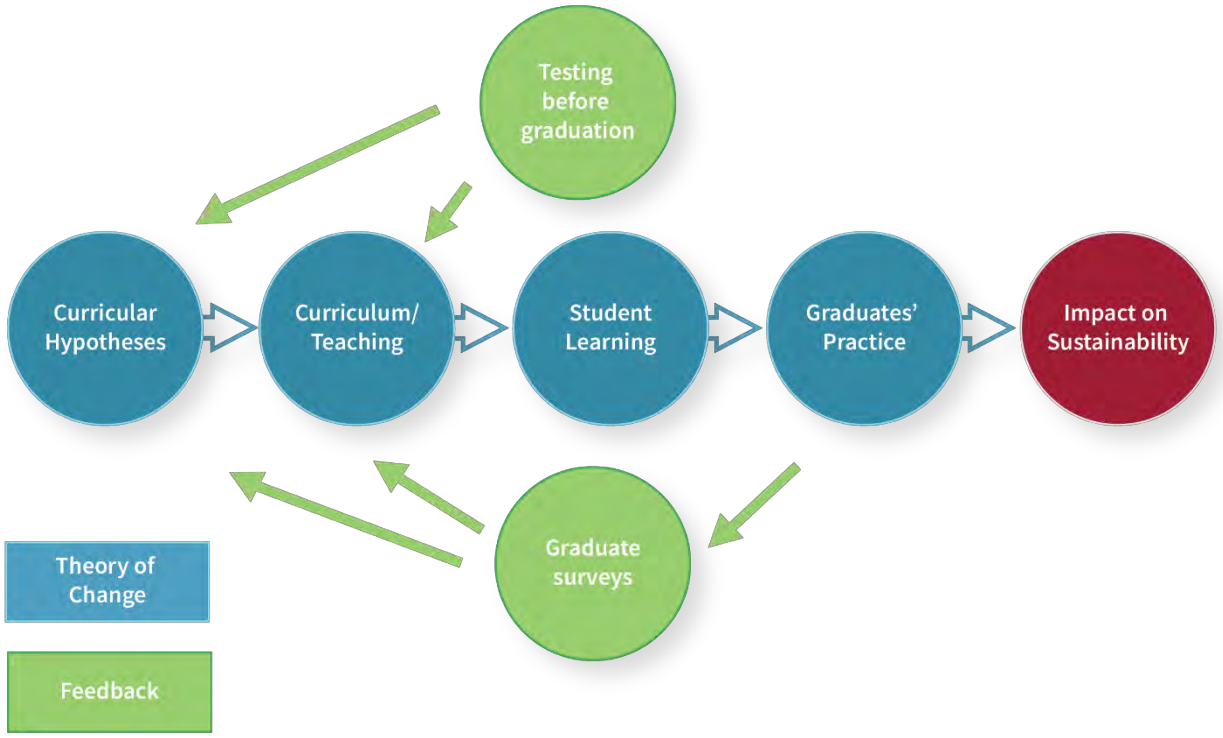
  - *Within the University*. Given our time constraints, we have not delved into the School's ambitious aspiration to make an ethos of sustainability pervasive throughout the University. This calls for a somewhat different theory of change from that described above, which would include attracting students from other schools in the University to the Doerr School's courses and activities, incorporating sustainability into orientation activities, and assisting faculty in other schools to incorporate issues of sustainability in their courses. Many students who do not self-select into the School's programs will have leadership roles in society, and it is likely that inculcating them with a sustainability ethos will have considerable impact.

- *Placement*. Professional schools devote considerable resources to helping their students find opportunities after graduation, and it might well be that the Doerr School's educational mission will be furthered through such services or by providing sustainability-specific resources to career offices at other Stanford schools.
- *Pursuit of careers related to sustainability*. This is the hoped-for result of the education plus placement framework. Even if graduates don't pursue such careers, however, they may contribute to sustainability in various ways as citizens, volunteers, and policy makers.
- *Contributions to sustainability*. This is the intended ultimate outcome of the educational process.

The theory of change described above indicates that the ultimate measure of the impact of the School's education programs depends on the impact that its graduates have in improving sustainability-related outcomes. Measuring this type of impact is largely impractical, however. More plausible measures are whether the graduates are pursuing careers where they are likely to contribute to sustainability in some way—granted that they may also do so as volunteers, citizens, or policy makers—and whether they possess the capability to achieve impact in those careers,

The discussion that follows focuses on the School's teaching mission in light of the many ways that its graduates can contribute to sustainability. We are keenly aware of the considerable thought that has gone into designing the existing curriculum, especially for the co-term SUST program.[24] Our goal is *not* to recommend improvements in the curriculum, but rather to propose methods by which the School can assess its outcomes and impact and get feedback for the continuous improvement of its teaching. Our explorations are premised on this diagram:

[24] See Novy, Julia W., Banny Banerjee, and Pamela Matson. 2021. "A Core Curriculum for Sustainability Leadership" Sustainability 13, no. 19: 10557. https://doi.org/10.3390/su131910557. https://www.mdpi.com/2071-1050/13/19/10557. See also Stephanie Rafanelli et al, "Stanford's New School Focused on Climate and Sustainability: Core Competencies" (2022), on file with Paul Brest.



- The School's curriculum and methods of teaching are based on deeply researched and well-developed hypotheses along the lines of Julia Novy, Banny Banerjee, and Pamela Matson in "A Core Curriculum for Sustainability Leadership," published in *Sustainability*.
- Students learn from this curriculum, and as graduates they have a positive impact on sustainability.
- Testing students before graduation provides feedback to allow the faculty to improve their teaching.
- Surveying graduates provides feedback to enable the faculty to revise curricular hypotheses and improve the curriculum.

Testing Students' Capabilities Through Practice-Related Exams, Portfolios, or Projects[25]

The School aims for its graduates to possess four sorts of capabilities:

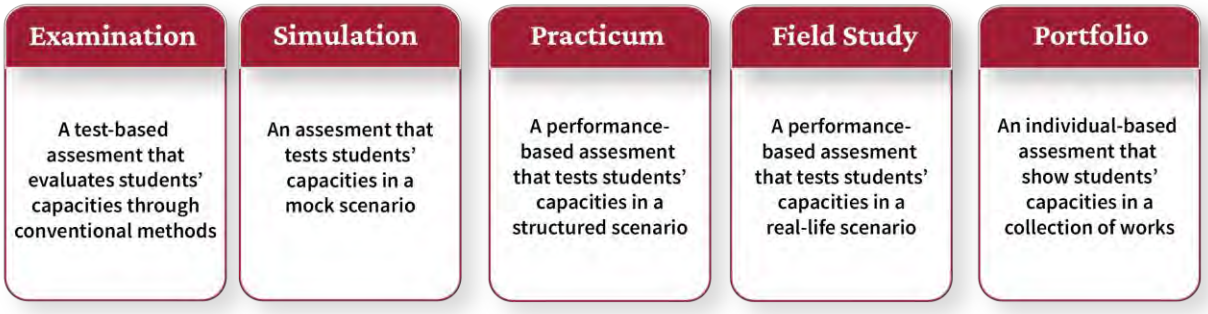
- Knowledge about concepts, facts, and processes—for example, the chemistry and physics of climate change.
- Skills, or the ability to do things—for example, being able to undertake an econometric analysis.

[25] A more detailed discussion of the issues in this section can be found in Appendix 5, Betsy Holland and Lily Liu, "The Doerr School: Testing Competencies."

- Competencies beyond knowledge and skills—for example, systems-thinking, strategic-thinking, interpersonal and intrapersonal capabilities, integrated problem solving, futures-thinking, and implementation capabilities.[26]
- Attributes of new leaders. The SUST program aspires to inculcate its graduates with the identity, perspective, and agency, as well as the capabilities, essential for change-making "New Leaders."[27]

While there are well-developed methods for testing for knowledge and skill, testing for competencies and leaders' attributes is more challenging. Competency testing is still the subject of much research, and testing for leaders' attributes presents the further challenge that these are mindsets or ways of being. Yet in addition to the importance of providing feedback on how to teach these capacities, the very process of designing testing instruments may also sharpen the faculty's definition of the various capabilities.

The following chart shows five distinct methods for evaluating whether students possess these capacities:



- *Examination*. Most exams test for knowledge and skills, but not for the third and fourth categories of competencies and new leaders' attributes, which the School's educational experts believe are crucial for careers in sustainability.

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[26] The competencies are described in detail in Rafanelli et al, *supra* note 24

[27] The New Leader's identity represents "their mental model of themself defined in terms of their values and special purpose in achieving intergenerational well-being. It includes an ability and desire to explore and understand their own identity, as well as the identities of others. The New Leader's identity shapes their mindset and *perspectives*. They see the world in holistic ways through a systems lens, recognizing coupled, integrated causal relationships. Their mindset of leading transformative change and innovating in the context of extreme complexity drives them to see problems as opportunities in disguise, and to continually seek ways to drive transformative action. The New Leader's *capabilities* represent their knowledge, skills, process sense, and ways of thinking that equip them to navigate the complexity and difficulty of sustainability challenges. They have the capability to build trust and work with diverse stakeholders in myriad contexts, bringing to bear distinctive ways of thinking and acting that result in transformative change. The New Leader's agency embodies their sense of possibility, ability to act, and their capacity to spur collaboration toward a shared goal. The directionality and nature of their actions, resulting from their identity, perspective, and capability, allows them to create enabling environments for others to contribute towards achieving intergenerational well-being. See Novy, Julia W., Banny Banerjee, and Pamela Matson. 2021. "A Core Curriculum for Sustainability Leadership" *Sustainability* 13, no. 19: 10557. https://doi.org/10.3390/su131910557. https://www.mdpi.com/2071-1050/13/19/10557. [minor omissions]

- *Simulation*. In a simulation, students are asked to assess and develop solutions for a mock scenario. The scenario typically takes the form of a "case study" that can be pursued individually or in a team. Simulations engaged in by teams of students can teach "many skills important in collaborative work on real-world problems including interpersonal communication, organization, planning, and delegation."[28] They are labor-intensive both for instructors and for students, however, and the difficulty of identifying the work of an individual student can make team simulations problematic evaluation tools.
- *Practicum.* Students typically improve their skills by working for an organization outside the School and are evaluated based on a final report or presentation. E-IPER students' Capstone Projects[29] and SUST students practicums[30,31] provide opportunities to apply various capabilities to particular projects but are not designed to provide comprehensive evaluations of students' capabilities.
- *Field study.* Field studies place students in real-life situations where they are observed solving problems for actual clients. Because the situations may call on different capacities, multiple field studies may be required to ensure testing for a range of capacities.
- *Portfolio.* Portfolios collect students' best works and reflections of their learning, to demonstrate mastery of knowledge, skills, and competencies.

Assessments may be done at three stages: (1) assessments of students' competencies and knowledge base when they enter the program, which help the School to develop an additive curriculum; (2) formative assessments, which provide feedback as a student progresses through the program; and (3) summative assessments, which "serve for overall evaluations…of whether competency standards and teaching-and-learning objectives defined have been met."[32] All three kinds of assessments can help the School improve its curriculum over time.

Designing assessment tools for the capacities the School wishes to instill in its graduates—especially for the competencies and attributes of leaders—is beyond our mandate and our capacity. In selecting which testing methods to adopt, however, we suggest that the School consider these criteria:

- Fairness, which assesses the extent to which the method can provide unbiased and fair results for students

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[28] Rafanelli, *supra* note 24.

[29] "Stanford Earth: Emmett Interdisciplinary Program in Environment and Resources: Capstone Project," Stanford University, accessed July 8, 2022, https://earth.stanford.edu/eiper/joint-ms-degree/capstone#gs.yc7d8t.

[30] "Stanford Earth: Practicum," Stanford University, accessed July 8, 2022, https://earth.stanford.edu/sust/graduate-programs/practicum#gs.yc7fq5.

[31] SUST describes its practicums as follows: "To integrate and internalize core lessons from the SUST curriculum, each student completes a 120-hour practicum project of their own design, collaborating on a complex sustainability challenge with an outside partner and working through the types of constraints often faced by decision makers and leaders" ("Sustainability Science and Practice: Overview," Stanford Bulletin: ExploreDegrees 2020-21, accessed July 8, 2022, https://archived-bulletin.stanford.mobi/schoolofearthsciences/sust/#:~:text=To%20integrate%20and%20internalize%20core,by%20decision%20makers%20and%20leader).

[32] Olga Zlatkin-Troitschanskaia, et al., *Modeling and Measuring Competencies in Higher Education: Approaches to Challenges in Higher Education Policy and Practice* (Wiesbaden: Springer VS, 2017), p. 13.

- Comprehensiveness, which evaluates the extent to which the method can provide high-quality assessments of all capacities required for the graduate
- Time commitment, which assesses the cost and time needed from students and evaluators
- Quality of testing, which determines how well the test can assess the capacities
- Adaptability, which assesses how well the method can adapt to different students' needs and changes in the curriculum

Because some of the test instruments are time- and labor-intensive for both students and faculty, it may be desirable to incorporate them into existing courses rather than to treat them as distinct from them.

Graduate Surveys and Focus Groups as a Method for Providing Curricular Feedback

Testing of the sort just mentioned can help inform the School's faculty whether students are acquiring the knowledge, skills, and competencies the faculty intend to teach, but these tests cannot inform the faculty whether those are the capacities that graduates *need* or actually *use* in order to make an impact in their various sustainability-related careers.

At our request, administrators of the E-IPER and SUST programs asked their graduates if we could interview them. We interviewed a total of fourteen graduates—three from E-IPER and eleven from SUST—with the goal of developing an interview protocol that could provide useful feedback to the School. (We also developed but did not have time to test a survey that could allow the School to obtain responses from many more graduates.) Our interviewees, a majority of who are in sustainability-related careers, are listed in Appendix 2.

Our goal was to elicit what capacities the interviewees believed they needed in their careers and the extent to which they acquired them through the School's programs or elsewhere. Although we focused particularly on what Novy, Banerjee, and Matson and Rafanelli describe as "competencies," we also elicited responses about knowledge and skills. (Future surveys should ask directly about these capacities and about the leadership attributes of identity, perspective, and agency emphasized by Novy et al.) We were also interested in ascertaining what methods of instruction, including practicums and externships, were useful in producing these educational outcomes.

Our goal was not to provide substantive feedback on the curriculum, but rather to investigate whether in the future the School could obtain useful feedback by surveying its graduates. In any event, given the small sample size (especially for graduates of E-IPER, whose programs are very different from SUST), we hesitate to make any generalizations based on our interview findings. That said, graduates were generally pleased with the curriculum, including various competencies. Areas mentioned for improvement included offering more "hard" skills and substantive knowledge, especially for graduates with jobs in business, and preparing those graduates to deal with pushback against sustainability. (More detailed substantive takeaways from the interviews are summarized in Appendix 5.)

The interview protocol, as it improved over the course of our interviews, is summarized in Appendix 7. Here we mention several challenges that we encountered.

- *Time constraints*.
    - Most interviews took thirty to sixty minutes to complete, not accounting for the time spent scheduling beforehand or the time spent compiling notes afterwards. Spending this much time per participant limits the scalability of the process and the range of graduates who can be interviewed.
    - This problem could be mitigated through an online survey. Without a live interviewer to clarify questions and follow up responses, however, we are less confident in the results.
- *Participants' reluctance to criticize the programs*.
    - Gratitude for the programs and their very flexibility seemed to make interviewees reluctant to identify their shortcomings. In several interviews, when participants were asked whether the SUST/E-IPER program had done a good job of helping them achieve specific competencies, some responded that any failures to achieve the competency reflected their own choices of classes rather than a programmatic failing. However, other respondents connected insufficient focus on a competency to the overall program, and a few suggested curricular or other changes to address the gap.
    - When faced with reluctance to criticize, the interviewers found it useful to acknowledge that flexibility in course choices could be beneficial as well as a drawback, and to remind interviewees that we indeed wanted candid comments about their experiences. This often led to more complete feedback.
- *Participants' misunderstanding of the competencies we inquired about.*
    - The definitions of some of the competencies that we explored through the interview protocol were quite vague. It was a challenge to elicit graduates' use of competencies while avoiding putting our own ideas in their minds. Although we were able to provide clarifications during the interviews, surveys would need to provide complete, unambiguous definitions of the competency and sustainability.
- *Eliciting trends from multiple anecdotes*.
    - It requires judgment, aided by a large sample size, to determine when and how to generalize from similar comments. (This challenge is familiar to instructors trying to learn from teaching evaluations.)

Interviews and surveys are only two possible ways to elicit information about how well the School's curriculum prepares its graduates for their varied careers. Other methods, such as focus groups, may be promising as well. We did not have time to explore them, however. Another unexplored possibility would involve asking current and potential employers what capabilities they would like the School's graduates to possess and to what extent the graduates possess them.

Embedding Sustainability in the Rest of the University's Curriculum

We have focused on the School's role in preparing its own graduates to be sustainability leaders. Although the School may not be able to assess particular graduates' contributions to sustainability outcomes, it can track the positions they hold and hence their potential to make such contributions.

Beyond this, the School could play a role in diffusing sustainability education to other schools and programs in the University. As mentioned above, this has the potential for considerable impact.

Summary Recommendation

We recommend that the School explore methods for ascertaining whether its graduates have acquired and are able to use the knowledge, skills, competencies, and other attributes that the faculty believe necessary for careers as sustainability leaders.

Engaging with Partners: Research to Action (R2A)

Faculty throughout Stanford University engage in a continuum of research ranging from basic to applied, much of which finds its way into practical applications. The Doerr School is particularly interested in linking the work of its faculty and other researchers with actions that promote sustainability by engaging with external partners. We call this pathway research to action (R2A). Most of the following discussion centers around the School's Accelerator, a nascent unit with the mission of linking research with action. The Accelerator bears considerable resemblance to the already-established Stanford Impact Labs,[33] and we believe that the two entities will benefit from cooperating with each other.

A generalized theory of change for the R2A pathway might look like this:

At the outset, we should recall the School's language describing this pathway: "Engaging with partners to generate and scale local, national, and global solutions to the defining challenge for humanity."[34] While research sometimes appropriately begins in isolation and only later finds its way into the outside world, much actionable research related to sustainability requires gaining

[33] Impact Labs recently hired a director of investments and accountability, whose mandate bears close resemblance to that of the Accelerator. See "Michael Eddy," Stanford Impact Labs, accessed July 8, 2022, https://impact.stanford.edu/people/michael-eddy.

34 "Law 808N: Policy Practicum: Creating an Impact Framework for Stanford's School of Climate and Sustainability," Stanford Bulletin: Explore Courses, accessed July 8, 2022, https://explorecourses.stanford.edu/search?view=catalog&filter-coursestatus-Active=on&page=0&catalog=&q=LAW+808N%3A+Policy+Practicum%3A+Creating+an+Impact+Framework+for+Stanford%27s+School+of+Climate+and+Sustainability&collapse=.

information from external partners from the outset and co-creating and collaborating with them.[35] This is an insight of transdisciplinary research (TDR), which, in Pamela Matson's words, "refers 1) to the integration of different ways of knowing (i.e., different kinds of knowledge emerging from different disciplinary and interdisciplinary scholarly efforts as well as from tradition and practice from non-academic sources, 2) for the solution of complex, societally-relevant problems related to sustainability, 3) generally through collaborative processes that engage diverse participants (including researchers and societal stakeholders) and seek to equalize power through multiple processes."[36]

Dean Matson goes on to write that "TDR can be framed conceptually as a three-step or three-phase research process: 1) collaborative problem framing, team building and goal setting; 2) analyzing the problem through co-production of knowledge in collaborative research; and 3) integrating knowledge, applying it in practice, assessing and communicating for solutions outcomes and impact. Not everyone in Stanford's sustainability research community will wish to engage in all of these phases. However, collaborating with decision makers in problem definition and research goal setting is often essential for producing knowledge that is trusted, useful, and used."[37]

We imagine that, among other things, the Accelerator will assist faculty in engaging in these collaborative processes.

There are three major R2A tracks by which academic research can contribute to sustainability outcomes:

- Public policy, typically promulgated by legislatures or agencies (e.g., mandating a carbon tax)
- Practice by communities, governments, nonprofit organizations, Native American tribes, or other practitioners (e.g., a university inducing faculty to reduce air travel)
- Technology transfer, typically to for-profit enterprises (e.g., decarbonization processes)

These three pathways involve the transfer of different sorts of knowledge by different means. The public policy and practice pathways involve nonexclusive, in effect "open source," sharing of knowledge. In the former case, knowledge makes its way into the public domain through legislative or administrative policy; in the latter, it does so through publicly available best practices and know-how. By contrast, technology transfer typically involves the exclusive licensing of intellectual property.

The planning document titled "Policy Work Within the New Stanford Sustainability Accelerator"[38] describes the first two tracks under the term "policy work." That document explains the rationale for the Accelerator:

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[35] See, for example, Peter Maldonado, Angie Peng, Derek Ouyang, Jenny Suckale, and Daniel Ho, "Science Translation During the COVID-19 Pandemic: An Academic-Public Health Partnership to Assess Capacity Limits in California," *American Journal of Public Health* 112 (Feb. 2022) 308–15. https://ajph.aphapublications.org/doi/full/10.2105/AJPH.2021.306576.

[36] Matson, P. A. "Transdisciplinary Research Brief: A Research Review for the NSF-Funded Transdisciplinary Training Collaborative Project." In prep.

[37] *Id.*

[38] Policy Engagement Lab in Sustainability Accelerator_QA_rev2.S, on file with Paul Brest.

> Although some faculty members and researchers have pre-existing relationships with external partners and may come forward with policy-relevant project ideas, community engagement is not the focus, or within the core competency, of many faculty. Nor is it explicitly rewarded in promotion and tenure decisions. For those reasons, we expect that the policy lab [i.e., Accelerator] staff will perform an essential function [of assisting faculty and other researchers[39]] in developing, maintaining, and strengthening Stanford's relationships with outside partners interested in applying Stanford expertise to pressing sustainability challenges. At the same time, policy staff will become deeply familiar with the sustainability-relevant domain expertise available across the campus and will develop and nurture relationships with members of the Stanford community who express interest in using their expertise to co-create solutions with outside partners. This systematic bridging work should be the central goal and focus of the policy engagement incubator.
>
> The policy team's role is not finished, however, when it has identified engagement opportunities between interested external partners and willing Stanford participants. Professional staff will continue to assist in designing, maintaining, and growing the proper vehicle(s) for the collaboration. This work may include, for instance, convening initial stakeholder meetings to launch the co-creation process; recruiting and funding grad student/RA/TA type-activities; helping craft and run experiential education opportunities (e.g., Law School-style policy practicum courses, Haas Center community service projects, etc.) which can serve as a hub for cross-disciplinary work; ensuring that ongoing projects remain on track to meet commitments with outside partners, etc. That is, policy lab staff must play an active role throughout the collaboration; without this scaffolding, faculty and student participants, who have many competing commitments and obligations, will likely find it challenging to drive a project at the pace desired by external partners.

Although the policy and practice tracks have much in common, the practice track sometimes involves distinctive features, such as data use agreements (DUAs), and we believe it is useful to treat them separately.

Research to Public Policy

The "Policy Work" document describes several examples of the School's possible contributions to public policy: "a new model that responds to the articulated needs of a government agency and can inform policy development, the collection and analysis of empirical data that could inform a new policy direction, [or] a legal analysis of available options for regulatory or legislative reform."[40]

Effective evidence-informed public policies often depend on the collaboration of academic researchers with:

- stakeholders, or "lived experts,"[41] affected by potential policies (e.g., local communities)

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[39] The authors of this report have added the bracketed text to emphasize that successful engagement requires the active participation of faculty and other researchers.

[40] "Policy Work Within the New Stanford Sustainability Accelerator: Basic Questions and Answers." On file with Paul Brest.

[41] See, for example, Anand Dholakia, "Community Engagement and the Expertise of Lived Experience," *Root Cause*, November 19, 2020, https://rootcause.org/field_notes/community-engagement-and-the-expertise-of-lived-experience/. Cf. Angela Jackson, John Kania, and Tulaine Montgomery, "Effective Change Requires Proximate

- policy advocates (e.g., nonprofit organizations)
- policy makers (e.g., legislators or administrative agency officials)

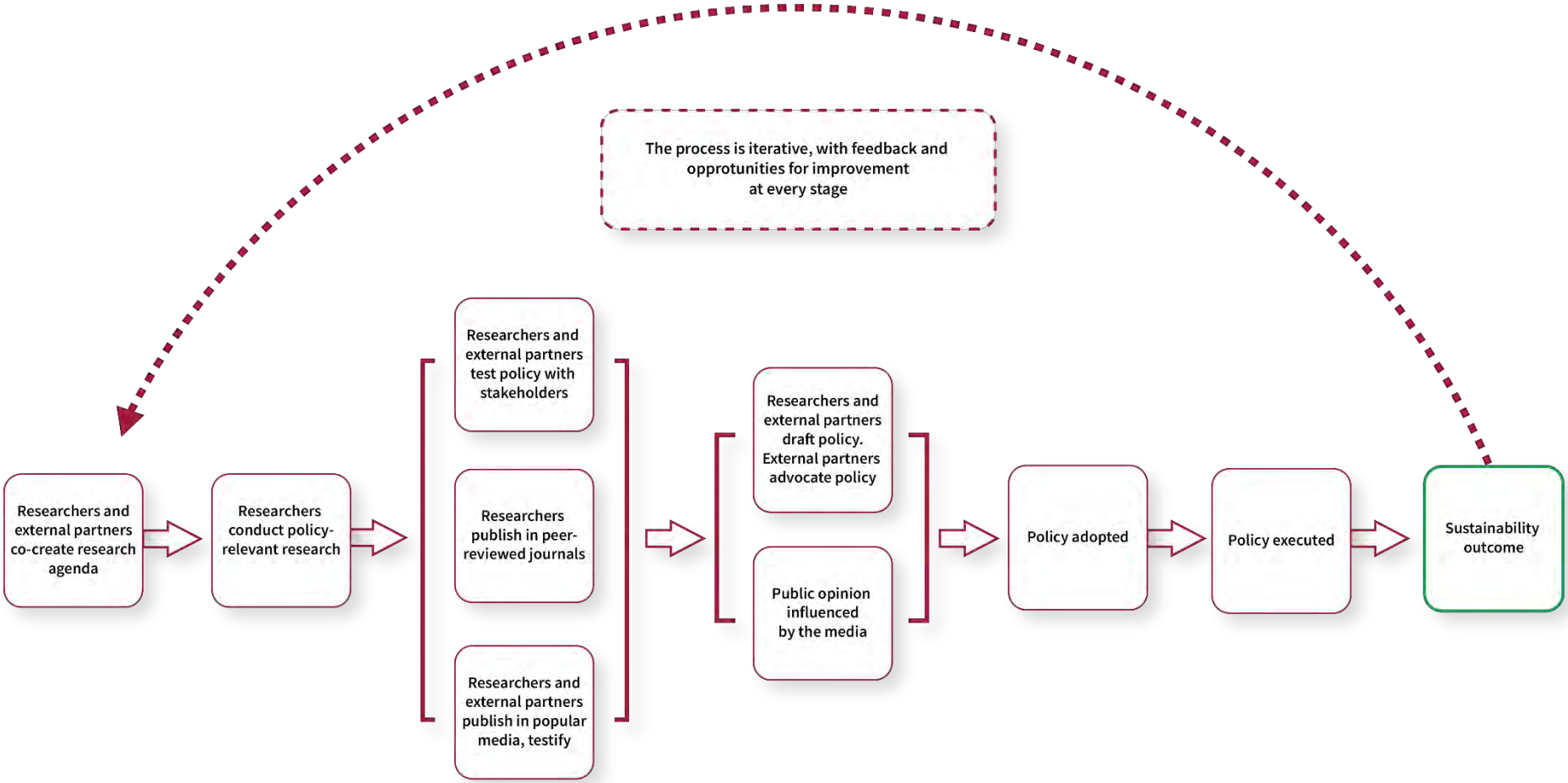
We refer to these three groups collectively as the School's *external partner*s.

This section first outlines the steps involved in the collaborative process and then briefly describes how the School can prime the pump for such collaborations.

The Research to Policy Process

The following figure sets out the research to policy process as a flowchart.

Leaders," *Stanford Social Innovation Review*, Oct. 2, 2020, https://ssir.org/articles/entry/effective_change_requires_proximate_leaders.


The process is iterative, with feedback and opprotunities for improvement at every stage
Researchers and external partners co-create research agenda
Researchers conduct policy-relevant research
Researchers and external partners test policy with stakeholders
Researchers publish in peer-reviewed journals
Researchers and external partners publish in popular media, testify
Researchers and external partners draft policy. External partners advocate policy
Public opinion influenced by the media
Policy adopted
Policy executed
Sustainability outcome

This is a generalized framework, not a recipe, and the process can begin at various stages. However, one starting point with promise of achieving an impactful policy outcome involves the co-creation of an agenda by researchers and external partners. External partners alert researchers to the problems they face, researchers engage in research aimed at solving those problems, and together they address the practical challenges in translating research into policy.[42]

The co-creation of public policy faces a number of barriers, which may require assistance and incentives to surmount:

- In some parts of the University, policy-oriented research is not valued by more theoretically oriented faculty. Hopefully, this will not be a problem in the Doerr School. In any event, ways to incentivize such research include valuing it in appointments, promotions, compensation, the recognition of achievements, and Accelerator grants.
- Even then, researchers may not have the time, inclination, knowledge, or skills to engage with external partners. Accelerator personnel, together with professors of the practice and other non-tenure-line personnel, could facilitate such engagement.
- Barriers exist on the external partners' sides as well, including lack of time,43 lack of knowledge of relevant research, inability to sift through academic texts, and in some unfortunate cases lack of interest in making policy informed by evidence. Accelerator personnel could help by identifying the needs of external partners, coordinating with researchers to develop research that speaks to these needs, and helping researchers to translate the research into digestible formats for external partners.
- We also should note the challenge to co-creation stemming from the different rhythms of the work streams of research and policy making. In contrast to the measured process of research, the policy-making process moves in spurts. Though policy professionals may spend many years laying foundations, they often must move quickly to meet political opportunities.

Measures of progress at the co-creation stage.

- On the assumption that co-creation plays an important role, the measures of progress center around (1) the coming together of researchers with subject-matter expertise in a field with external partners who have the knowledge, interest, power, and policy expertise to link the research to policy; (2) the ongoing relationships and trust built among the participants;[44] (3) researchers understanding the policy process; and (4) researchers and external partners assessing the pros and cons of alternative policy solutions. We believe that the Accelerator can facilitate these processes.

Measures of progress at the research stage. However the process begins, an essential step is conducting policy-relevant research, which in turn is subject to peer review that provides vital feedback to the researchers.

[42] Co-creation also may be inspired when researchers serve in policy roles and policy professionals take on fellowships in research institutions, as described in the conclusion to this section.
[43] Community members' involvement sometimes comes on top of their regular employment and may require compensation.
[44] These are described in more detail in the NatCap example in the next section.

- Measures of progress center around (1) the substantive quality of the research as manifested by conventional academic criteria, such as peer reviews;[45] and (2) the potential for the research to inform policies that have sustainability outcomes. In an ideal world, peer review would precede the stages that follow, but the extremely slow pace of the peer review process and the urgency of solving real-world problems often calls for acting in parallel.

Measures of progress at the iterative engagement phase. As researchers begin conducting policy-relevant research, they continue to engage external partners in an iterative process where external partners can help ensure that the research will be relevant.

- Measures of progress center around: (1) achieving a sufficient level of engagement with external partners; and (2) satisfaction that the direction of research continues to be policy relevant. The Accelerator may play a role in coordinating this engagement or even serve as an intermediary between researchers and external partners.

Measures of progress at the testing stage. Almost every public policy faces barriers to achieving its desired outcomes and has the potential for unanticipated consequences. Hence, an important step in the policy process is testing the proposed policy with stakeholders who will be affected by it.

- Measures of progress center around feedback from stakeholders to ensure that the policy, if implemented, is likely to succeed and that it does not have adverse, unintended consequences. This feedback may lead to further research, which is then subject to additional testing.

Measures of progress at the dissemination stage. Once researchers have reasonable confidence in the policy implications of their work, they may help spur its adoption by publishing articles in popular and policy-oriented media,[46] by giving talks to popular audiences and by testifying in legislative hearings. The Accelerator may play a role by assisting researchers in preparing and disseminating effective communications.

- Measures of progress center around the size and influence of the audiences reached, meetings with policy makers, and the policy makers' reception of the policy proposals.

Measures of progress at the drafting stage. Policy professionals, sometimes with the assistance of researchers, may draft legislation or administrative regulations.[47]

- The main measure of progress is well-drafted legislation or regulations.

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[45] It should be noted, however, that some peer-reviewed journals may have biases against policy-related articles of the sort mentioned above.

[46] *Behavioral Science and Policy* is an example of a journal that focuses on policy applications of research in behavioral science. Some institutions have their own house journals for promoting their researchers' work.

[47] The researchers' roles may be limited both by their competence at drafting and by laws and internal regulations constraining their advocacy activities. The "Policy Work Within the New Stanford Sustainability Accelerator" document notes: "To protect Stanford's non-profit status, such engagement would stop short of actual lobbying for specific legislation, but the underlying work could be packaged to provide the empirical data and analytical foundations needed."

Measures of progress at the adoption and implementation stage. The ensuing stages of the policy's being adopted and implemented are out of the researchers' hands. Of course, effective implementation does not inevitably follow adoption.

Measures of success. The ultimate success of the policy process is an outcome that improves some aspect of sustainability. The arrow indicating feedback to the research phase reflects the fact that the actual outcome may not be what was predicted or desired, thus calling for additional research.[48]

Achieving the ultimate outcome of an impactful policy requires positive outcomes at many of the stages described above. Measuring the progress of research's impact on policy is difficult because policy change happens slowly and the road to policy outcomes is full of detours and hazards. Estimates of achieving the ultimate outcome come with a large margin of error.[49]

The Intermingling of Academic Researchers with External Partners

In addition to the systematic pathway from research to policy just discussed, researchers may learn about policy opportunities from external partners through informal means. For example:

- External partners bring their expertise to Stanford as visiting fellows or lecturers or through other non-tenure-line appointments. Many schools and programs at Stanford have appointments. For example, this very quarter, the community organizing scholar Marshall Ganz has been on the campus as the Haas Center Distinguished Visitor.
- Researchers bring their expertise and know-how to bear on sustainability problems through advising and consulting with organizations.
- Faculty move between academia and government—a mutually beneficial "revolving door." Examples include the late George Shultz, William J. Perry, Condoleezza Rice, Steven Chu, Michael McFaul, and Jeremy Weinstein, the last of whom returned from a stint in the Obama White House to establish Stanford Impact Labs.
- While the focus of this section of the memo is directed toward researchers and external partners, it should be noted that the capacity of the Doerr School to engage with a wide variety of such partners provides pathways for current students to network and find career paths in sustainability as a result of those relationships. This, in turn, provides opportunity for the extended Doerr School alumni network to engage in the co-creative processes described in this section and in the Research to Practice section below to further the School's sustainability outcomes.

Research to Practice

The policy pathway involves the use of research to shape legislative policies. By contrast, the practice pathway emphasizes incorporating the research into the work of external partners: civil society organizations and government entities acting operationally rather than in their legislative or policymaking roles. By civil society we mean the network of organizations, communities

[48] It may take a long time to witness the sustainability outcome of a policy's implementation. It is often possible to identify shorter-term, intermediate outcomes, which can inform research and policy responses.

[49] It is worth noting that even if the path does not lead to the expected policy success, the research may produce knowledge of intrinsic value and of value to future policy making.

(rural, urban, tribal, etc.), self-organizing professionals, and individual citizens that operate outside the realm of business and government and that shape much of how we live.

A variety of means are available for linking research with action in this pathway, including:

- *Co-creating*: working collaboratively with civil society leaders, communities, and organizations to create and deploy scientific knowledge
- *Advising*: providing analytic, problem-solving, and change management support for communities and organizations addressing sustainability
- *Educating*: teaching, training, skill building, and certification for people outside the university
- *Facilitating, convening, organizing, and advocating*: catalyzing communities of practice in support of sustainability

These are not mutually exclusive and may come into play at many points in the linking process. To illustrate, consider the case of the Water for Life and Sustainability Fund, in Cali, Columbia. The Fund is a collaboration between the local environmental authority, sugarcane growers, The Nature Conservancy, and a local peace and justice organization. Stanford's Natural Capital Project (NatCap) was engaged by the Fund to apply its scientific methods of evaluating biodiversity and environmental services (BES) to guide investment decisions for the watershed. In the course of this engagement, NatCap and its external partners defined scenarios (facilitation), used NatCap's InVEST models to estimate possible benefits (co-creation), supported the development of investment portfolios, developed RFPs for targeted investment projects (advisory services), and trained local experts to use the InVEST platform themselves to continue to improve and revise their program (education).[50] The analytic work was performed iteratively with constant feedback between scientists and stakeholders.

The case of Water for Life and Sustainability can also serve to illustrate more generally how research can be linked with practice, as described below.

[50] Mary Ruckelshaus et al., "Notes from the Field: Lessons Learned from Using Ecosystem Service Approaches to Inform Real-World Decisions," *Ecological Economics,* 115 (Jul. 2015) 11–21. https://www.sciencedirect.com/science/article/pii/S0921800913002498.

Engage and build trust. The starting point for linking research with practice is a trusting relationship with external partners. Such a relationship is generally built over time through focused effort. In the case of the NatCap engagement described above, the relationship among the stakeholders was decades in the making before NatCap arrived on the scene, invited by one of the trusted members of the local coalition.

- *Skills needed:* listening, empathy, humility, collaboration, convening
- *Progress indicators:* involvement of appropriate stakeholders, trusting relationships, agreement to work together

Agree on the problem and outcome and co-develop strategies. Effective linking requires external partners to be actively engaged in defining the problems to be addressed as well as the potential solution set. For NatCap this meant leading broad discussions among stakeholders about potential watershed investments and developing with stakeholders rough scenarios to explore potential alternatives. To its surprise, NatCap found that economic return was not the only, nor necessarily the primary, criterion for evaluating the success of investments. Sometimes stakeholders were interested in cultural values or in maintaining biodiversity for its own sake. Developing effective strategies also requires understanding the motives and behaviors of actors who are essential to the solution and understanding the dynamics of the systems in which they operate. For example, NatCap needed to adapt its initial biophysical models to the fact that some of the most promising areas for investment were under the control of guerilla groups.

- *Skills and knowledge needed:* problem solving, behavioral economics and other social sciences, and systems thinking, as well as information about the local environment
- *Progress indicators:* agreement on the problem and strategies to solve it, identification of strategies to overcome barriers to implementation

Deploy strategies. The deployment of strategies is an iterative process. Solutions are tried and revised based on feedback from the field. For example, NatCap had to adapt its analysis when it learned that key data for its sophisticated optimization models were unavailable.

- *Skills needed:* Implementation science, quality improvement, program management, social marketing, communications, organization
- *Progress indicators:* implementation plan, pilot projects, stakeholder engagement

Sustain and scale. A key factor in sustaining and scaling a successful strategy involves local experts and other stakeholders taking over the provision of needed technical assistance and other services. NatCap has explored this strategy by training local experts to use its open-source InVEST platform, which helps ensure that the resulting analyses are "relevant and sensitive to local issues."

- *Skills needed:* technical training, skill building
- *Progress indicators:* Pilot programs scaled and replicated in new sites

Improve multigenerational welfare. This is the ultimate outcome of the strategy. The NatCap example involved a one-off project with civil society organizations. An alternative model involves an ongoing strategic relationship between a university and an external partner. For example, Arizona State University (ASU) and Conservation International (CI) have created a valuable relationship with the following elements:[51]

- *Professors of Practice:* funding new Professors of Practice aligned with ASU's Global Future Laboratory to hasten research to practice
- *Sharing researchers:* putting CI scientists on the ASU faculty to build effective research collaborations
- *Field-driven research:* building on CI's established relationships with organizations and communities in many countries
- *Other partnerships:* building on CI's existing relationships with technology firms, the financial community, and other stakeholders on a project-by-project basis

The partnership is illustrated by ASU's and CI's efforts to reduce human rights abuses in global fisheries—an outcome expected to benefit both people and natural systems. Based on a successful project in Costa Rica, the CI Professor of Practice teamed with ASU's Human Rights Hub to identify legal and corporate leverage points. CI then drew on its relationships with government agencies in Peru and Ecuador and the technology needed to track and monitor abuses.[52] The data collected is being used to inform policy discussions and to support additional fieldwork. Meanwhile, a path to scale has been identified through initial discussions with Pacific Island nations, the Gulf of Guinea, Liberia, and Sierra Leone.

Stanford has considerable experience with partnerships in addition to NatCap. The Stanford Future Bay Initiative's work with local Bay Area communities[53] and the RegLab's collaboration with federal and state environmental protection agencies on clean water are examples of successful partnerships forged and sustained over a number of years.[54] The Doerr School can draw on these as well as other universities' experiences to continue to develop programs that put research into action for civil society organizations and governments.

Technology Transfer

The Doerr School's technology transfer pathway will be served largely by the Office of Technology Licensing and supported by Industrial Affiliate Programs and other programs focused on sustainability.

The Office of Technology Licensing

Stanford's fifty-year-old Office of Technology Licensing (OTL) seeks to facilitate "the transfer of technology in ways that benefit society for generations."[55] OTL has deep expertise in

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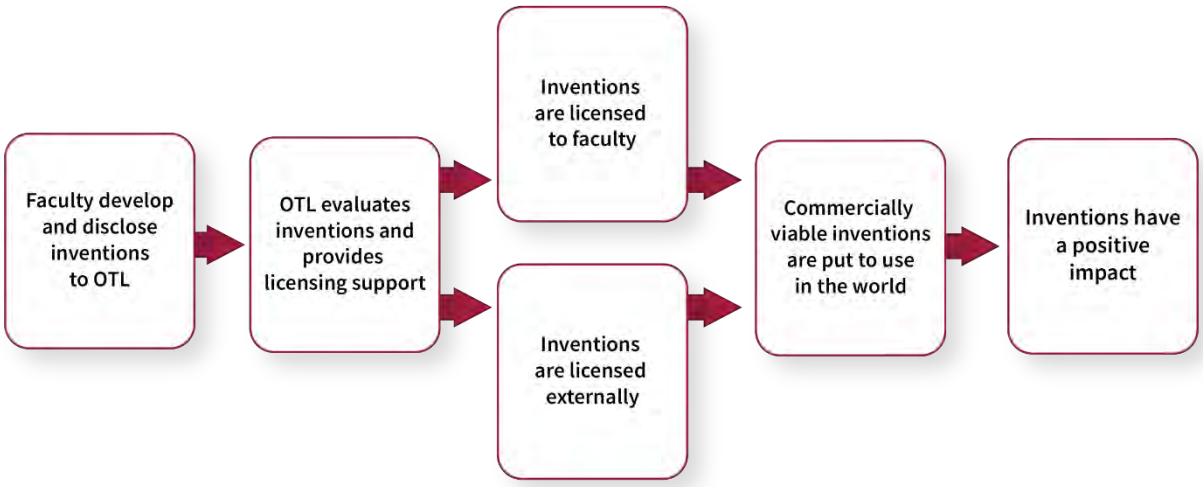
[51] "ASU and Conservation International," Arizona State University, accessed July 8, 2022, https://gfl.wp.rtd.asu.edu/asu-ci/.
[52] See Alejandro García-Lozano et al., "Decent Work in Fisheries: Future Trends and Key Considerations for Future Research and Policy," *Marine Policy* 136 (Feb. 2022) 104922. https://www.sciencedirect.com/science/article/pii/S0308597X21005339.
[53] "Stanford Future Bay Initiative," Stanford University, accessed July 8, 2022, http://bay.stanford.edu/.
[54] "Environmental Protection for All," Stanford University, accessed July 8, 2022, https://impact.stanford.edu/environmental-protection-all.
[55] "Why We Do It," Stanford Office of Technology and Licensing, accessed July 8, 2022, https://otl.stanford.edu/about/about-us/why-we-do-it./

licensing technologies developed by its faculty and other University researchers for commercialization. OTL is a centralized resource that will serve the Doerr School as it does the rest of the University.

OTL's involvement spans the lifecycle of a project, from receiving invention disclosures, to ensuring there is a market for the invention, to developing patents and facilitating commercial relationships.[56] OTL's key intermediate outcomes on the path to commercialization include inventors disclosing their inventions, inventions having commercial viability, and these inventions being licensed to external entities or to the faculty inventors themselves. OTL's theory of change can be depicted as follows:



Although it has also licensed technology for noncommercial use, OTL has historically focused on generating revenues from commercialization. However, the High-potential Innovation Translation (HIT) Fund, which assists faculty in developing promising projects, also considers the projects' social impact. Under the direction of Nitin Parekh, the HIT Fund is exploring additional intermediate outcome indicators for projects whose ultimate outcome includes social or environmental impact as well as financial viability.[57] This presents an opportunity for the HIT Fund and the Doerr School to collaborate to create measures of social, environmental, community, and health outcomes of the technology transfer process. In any event, while safeguarding and promoting the University's intellectual property, OTL must also take into account the potential social and environmental value of open-source licensing.

Entrepreneur-in-Residence

The Doerr School might further facilitate technology transfer through an "entrepreneur-in-residence" (EIR) program within the Sustainability Accelerator to help sustainability projects cross common "valleys of death" on the way to commercialization. The EIR would be an accomplished entrepreneurial leader with experience in sustainable technologies, who would

[56] "A History of OTL," Stanford Office of Technology and Licensing, accessed July 8, 2022, https://otl.stanford.edu/history-otl.

[57] The "Policy Work Within the New Stanford Sustainability Accelerator" planning document for the School suggests that measures of progress in technology transfer "might be a pilot-scale proof of concept demonstration, the formation of a new start-up, venture funding for a technology innovation, or a similar measurable result."

provide guidance to researchers focused on technological solutions and connect them to the University's broader entrepreneurial ecosystem.[58]

Informal Technology Transfer Through Industrial Affiliate Programs

The University's Industrial Affiliate Programs provide an informal means of technology transfer. As described in the Stanford Research Policy Handbook:

> Industrial Affiliate Programs offer companies an opportunity to engage with University faculty, researchers, students, and industry peers in an open environment to discuss pre-competitive research and teaching activities in a field of mutual interest. In parallel, Industrial Affiliate Programs provide faculty and students with insight into the challenges and opportunities that face industry. The membership fees paid by members provide unrestricted financial support for the Affiliate Program's research, teaching and administrative activities.[59]

Through these means, the Industrial Affiliate Programs can serve as starting points for specific technological developments, which can be facilitated through industry-sponsored research, and subsequent development of that technology through OTL. Although most affiliates are industrial, a small number hail from nonprofit and government sectors. The School of Earth's current affiliate programs are described in Appendix 4.

The implicit theory of change for the Doerr School's affiliate programs having environmental impact is that the contact between faculty and affiliates will produce some adventitious valuable outcomes—not a process susceptible to linear progress indicators.

Assistance Provided by the Accelerator

Our discussion of the three pathways—technology transfer, public policy, and practice—suggest that the Accelerator must bring skills and capabilities to bear that lie beyond the core University missions of research and education. These include expertise in data science, systems thinking, outcomes measurement, communications, policy making, program management, and other skills necessary to link research with action.

Some of these skills and capabilities are already present in the University in centralized functions, such as the OTL with its deep expertise in the commercialization of research. Others exist in schools and departments like the Graduate School of Business, the Hasso Plattner Institute of Design, and the Psychology Department's SPARQlab. The Accelerator can draw on those resources as well as develop its own.[60]

The preceding discussion emphasizes the importance of Stanford faculty and other researchers engaging with external partners. While the Accelerator cannot substitute for their engagement, it can play a facilitative role. One area where such facilitation is likely to become increasingly important involves the process of contracting with external parties for data use and collaboration

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[58] Alternatively, the School may consider an advisory board composed of multiple entrepreneurial leaders with experience across many different types of sustainable technologies at various stages of development.

[59] "Section 13.4: Establishment of Industrial Affiliates and Related Membership-Supported Programs," *Research Policy Handbook*, accessed July 8, 2022, https://doresearch.stanford.edu/policies/research-policy-handbook/definitions-and-types-agreements/establishment-industrial-affiliates-and-related-membership-supported-programs.

[60] Hopefully, the availability of professional Accelerator staff will significantly reduce, if not obviate, the need for individual research projects to hire staff members performing similar functions.

agreements. For example, early in the COVID-19 pandemic, the Stanford Future Bay Initiative (led by Jenny Suckale from the School of Earth) and the Regulation, Evaluation, and Governance Lab (led by Dan Ho from the Law School) began collaborating with the Santa Clara County Emergency Operations Center and Public Health Department to deploy Stanford's expertise in data science, machine learning, and social science to address the County's challenges involving public health surveillance and contact tracing. To enable this work, the County needed to share important case data with Stanford, much of which had already been shared with a different Stanford research team. Even in this emergency situation, it took Professors Suckale and Ho months of bureaucratic review to get permission from the University's Information Security Office, the Office of Sponsored Research, and the Office of General Counsel. Though in this instance one of the principal investigators was able to draw on his legal expertise, many other Stanford faculty and researchers might just give up.[61] Other faculty members have faced similar internal bureaucratic challenges to externally engaged work. The Accelerator could play an important role in reducing the internal barriers to such engagements.

The Accelerator also can mitigate the confusion that sometimes results when a number of different research projects engage independently with the same external organization. Short of playing the role of traffic cop, the Accelerator can inform the projects of each other's work and encourage them to coordinate.

Finally, the Accelerator can make grants to support the Doerr School's research projects. While this year's one-year grants were designed to pilot test the process, the Accelerator's designers well understand the importance of structuring grants to fit the differing needs of different projects.

Summary Recommendation

We recommend that, with the assistance of the Accelerator, each R2A proposal be accompanied by a written theory of change showing its planned path to technology transfer, policy, or practice. Almost inevitably, the theory of change will need to be modified in light of changing circumstances. But at each stage, it will allow the School to chart progress and predict likely outcomes and impact as things move along the path (or don't).

We also recommend that the Accelerator assess its own effectiveness, both through feedback from the researchers it serves and from the outcomes it achieves. The Accelerator should be willing to support risky projects that have the potential for great social returns, which entails a nontrivial failure rate.

At least annually, the Accelerator should report to the dean and faculty on the progress of specific projects and its effectiveness overall.

[61] As County Health Officer Sara Cody and Daniel Ho describe, the collaboration was critical, particularly for equitable COVID-19 response for testing, contact tracing, social distancing, and vaccine policy in the county. Sara H. Cody and Daniel E. Ho, "How to Build Academic-Public Health Partnerships: The Stanford - Santa Clara County Experience with COVID-19 Response," in *Build Me the Evidence*, ed. Tamar Bauer (forthcoming).

Conclusion

The Stanford Doerr School of Sustainability is the first school created at Stanford in seventy years.[62] The design of the School's research and educational programs is the purview of its faculty and administration and is well underway. With these programs in mind, we were asked to help develop frameworks for assessing the School's progress, outcomes, and impact, with the goal of helping the School get feedback to improve the performance of these programs.

The core of our recommendations is what we term an "outcome framework"; that is, sets of theories of change for the School's three stated goals: (1) advancing knowledge, (2) preparing students for leadership positions, and (3) linking research with action by engaging with partners to solve sustainability problems. Above, we set out theories of change for each of these goals, with the suggestion that every project that seeks to link research to action should have its own specific theory of change.

A theory of change describes the path from the School's activities through various intermediate outcomes to its intended ultimate outcome. Although the planned path will inevitably be modified as a project gets underway, articulating the outcome and a theory of change for achieving it from the start both guides the work and provides a framework for assessing progress and making the necessary corrections.

We think of the contribution of the Policy Lab reflected in this report in similar terms. We hope that we will have provided a good starting point for the Doerr School to assess progress along its three major pathways. However, it would be not only a surprise but a disappointment if the outlines of the framework presented here were not significantly modified as the School continues to move along those pathways.

Another word about impact: There is no formulaic way to assess the impact of the School's teaching and research—that is, to show that some desirable change in the outside world would not have occurred (or would not have occurred to the same extent) but for the School's work. In the extremely complex and ramified systems in which it participates, it will be the rare case in which the School can fairly claim responsibility. But we believe a strong record of achieving sustainability outcomes will be a solid demonstration of its value.

Finally, although our mandate was to propose an outcomes framework for the Doerr School, we inevitably have touched on substantive aspects of the School's programs as well the staffing of the Accelerator. One recurring theme in our interviews with the faculty and other important stakeholders is the centrality of the School's internal culture, or ethos. While faculty members understandably have diverse interests and not everyone will be involved in co-creating sustainability policies and practices, the faculty as a whole must support colleagues who are engaged in this work—through appointments and promotions, funding, and other means. This is the key to achieving the School's mission of "creating a future where humans and nature thrive in concert and in perpetuity."

[62] Michael Nietzel, "Stanford University Creates New School for Study of Climate and Sustainability," *Forbes,* Aug. 1, 2021, https://www.forbes.com/sites/michaeltnietzel/2021/08/01/stanford-university-creates-new-school-for-study-of-climate-and-sustainability/?sh=13c7c5e3357f.

Appendix 1: Policy Lab Participants

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Appendix 2: Experts and Graduates Interviewed and Commentators on Drafts

We gratefully acknowledge the assistance of the following people in preparing this report.

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Piyush Tantia, Chief Innovation Officer at ideas42.

Michael Wara, Director of the Climate and Energy Policy Program, Senior Research Scholar at the Stanford Woods Institute for the Environment.

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SUST and E-IPER Graduates

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Ryan Calvert, Director of Strategy and Analytics at Kairos Aerospace.

Amanda Cravens, Research Social Scientist at the U.S. Geological Survey.

Michaela Crunkleton-Wilson, Consultant at Camber Collective.

Ahmi Dhuma, Strategy and Innovation Manager at East Bay Community Foundation.

Boomer Fleming, Associate at Killian-Pacific.

Jackie Huddle, Responsible Sourcing Senior Project Manager at Tesla.

Eunice Jung, Head of Partnerships at Future.

Caroline Ling, Current E-IPER and Graduate School of Business student, considering full-time opportunities in corporate sustainability.

Maggie McGraw, Legislative Correspondent and Legislative Assistant at the U.S. House of Representatives.

Laura Mediorreal, Product Manager at Microsoft.

Clay Meyer, Manager of Business Strategy in the Americas at Smart Wires Inc.

Kelsi Okun, Associate Consultant at Bain & Company.

Jack Richardson, Head of Business Development at GrowthPoint Technology Partners.

Appendix 3: George Triantis Memo on Research Impact Metrics

MEMORANDUM
To: Kam Moler
From: George Triantis
Date: August 2, 2021
Re: Research Impact Metrics

Further to our conversation a few months ago and with the help of a law-student research assistant, I have summarized below my impressions of the state-of-the-art in research impact metrics and its challenges. The literature on the topic over the past decade is voluminous and foreign government agencies have designed and tested a range of quantitative and qualitative metrics. For the purposes of this introductory memo, I have omitted references but would be happy to supply them as needed. But, as I explain below, there are many challenges to assessing the policy and social impact of research, particularly outside of scientific fields, and corresponding hazards in using the assessments. So, it is fair to say that the exercise is very much in early stages and there is much work to do. There has been significantly less interest in this topic in the U.S. than in Europe, Australia and Canada, and the open question is whether Stanford should encourage more discussion in the U.S.

1. **University's interest in impactful research.** Across the research ecosystem, there is a growing appetite for promoting and assessing the contributions of academic research to human welfare. Universities seek to incentivize interdisciplinary and applied research, and to build relationships with organizations outside the academy, particularly with government, industry and NGOs. While this emphasis has much support, there are detractors who argue that it embraces an unduly short-term horizon and neglects the longer-term gains from fundamental research and the humanities.
2. **Various purposes of measuring research impact.** The choice among different methods of measurement is partly determined by how the goal is framed. There are several purposes for which a measurement of research impact may be sought: 1) to support advocacy, generally, for greater research funding from government, industry and foundations, 2) to provide analysis and information that help researchers and others to enhance the impact of research outside academic circles, (3) to evaluate the social contributions of research projects and programs, and promote accountability ex post, (4) to inform the allocation of funding and other resources among research projects and programs, and (5) to encourage policy making informed by research.[1]
3. **Social and Political Impact.** The paths from research to improvements in the human condition often run through actions of government policy, such as legislation, regulation or judicial adjudication. So, the impact on policy can provide indirect measures of social impact. However, assessing policy- or political-impact is not only complicated, as explained below, but also raises the question of whether it should matter that the policy change is deemed to be socially beneficial (and how much so). Indeed, a potentially hazardous bias

[1] There are other objectives of less significance to us: for example, the American Recovery and Reinvestment Act (2009) directed agencies to collect indicators (known as Star Metrics) of the effect of funded research activity on employment and economic growth in the U.S.

may cycle from funding source to research to policy making and back to enriching the funders.

4. **Attribution and evaluation are difficult because impact paths are varied and complex.** The paths to policy impact are varied and very unlikely to be direct, because (a) research contributions are typically incremental and (b) research outcomes interact with political, economic, cultural and social factors before they influence policy. Policy changes are accordingly difficult to attribute to individual research projects or programs. Even setting aside the attribution challenge, research impact takes more or less time and often travels through feedback loops before resulting in policy outcomes. The short-termism mentioned in the first paragraph may distort priorities by giving primacy to quick impact over more significant, longer term influence that might take 5, 10 or even 20 years.

   Consider, for example, a research project that is conducted in collaboration with a government agency (perhaps using its data) and with post-docs and graduate students who subsequently conduct follow-on research projects in another organization. The media may report on both stages of research, while the researchers give various public lectures, write blogs and tweet. Along with others, they contribute testimony before the legislature and, when for-profit companies launch a lobbying effort that cites the related research, new legislation is passed. Even if all factors are important, it is difficult to assess their relative impact. However, a case study tracing the paths may reveal potentially contributing factors and strategies, thereby providing lessons to future researchers.

5. **Market-mediated (commercialized) paths**. Some nodes in the impact paths are commercial, market-mediated. Universities recognize the importance of licensing patented technologies in disseminating new technical knowledge for social benefit. Although social science and humanities research is less likely to give rise to intellectual property, there are other market mechanisms by which knowledge can be transferred: researchers may be paid, expert consultants to companies, their lobbyists and litigators, or government regulators. While promoting policy impact, these interactions give rise to conflict of interests concerns.

6. **Non-market paths.** A large number of other potential paths between research and policy impact are not commercialized. Researchers communicate results publicly through various media beyond academic publications, including newsletters, websites, blogs, YouTube videos, podcasts, tweets, public lectures and events, newspaper op-eds. In addition, researchers communicate directly with lawmakers through testimony to legislative, regulatory or judicial bodies, as well as webinars, boot camps and other collaborative events. There are many non-university, non-profit research organizations (such as Brookings, the Heritage Foundation, American Enterprise Institute) who target impact even more explicitly than University and who use these various paths to do so. They often bring in university researchers as well.

7. **Measurement choices.** As observed above, there are various impact paths and along each one, numerous nodes between research and policy action (and then, farther along, to social impact). It is helpful to describe these paths using case studies, narratives or representations by logic models [or theories of change].[2] And, measurement can be taken at almost any of the

[2] Logic models are graphic representations of the paths, networks and processes by which research affects policy (or the economy or society), including complex interactions between researchers and policy makers and feedback loops

nodes: e.g., how many collaborators on a project, how many viewers of the slides on the project's website, how many tweets or YouTube videos, how many followers (likes or shares), how many citations in policy documents, how closely does the language of the legislation/regulation track that of the researchers? In the case of policy documents and new laws, the measures can be forward- or backward-looking: starting with a research project and mining for references to that project, or starting with the policy outcome - a piece of regulation or legislation - to see what research informed it.

8. **Government interest in metrics.** A number of government agencies have designed frameworks for measuring impact, especially in Australia,[3] the U.K.[4] and the European Union.[5] These frameworks vary considerably, at least partly because they have different goals (analysis, evaluation, allocation, advocacy), focus on different disciplines (health research, physical and life sciences, and more recently, social sciences and humanities) and begin with different units of research (project, program or university).

9. **Quantitative measures.** As observed above, there are many paths to impact, they are typically complex and there are many nodes along any given path at which measurement can occur. The more quantitative measures tend to bibliometric (number of publications, citations in other academic works, references in policy documents such as white papers and committee reports), and extend to references in social media (including blogs, tweets, downloads, clicks, likes, shares). Indicators of commercialization, such as patents or other IP, technology licenses, entrepreneurship, are also used. The principal advantage of quantitative measures is that they tend to be standardized, transparent and scalable, sometimes automated. Therefore, they can be used to compare impact across researchers and programs within a given discipline, for the purpose of evaluation and allocation of resources. They should not be used to compare across scientific fields because the use of any one or set of impact mediators varies greatly. Where quantitative metrics have been introduced, acceptance among researchers and universities has varied: for example, they have been more acceptable in Australia than in the U.K., where they are viewed as too noisy and distorting incentives.

10. **Qualitative/experiential measures.** The more qualitative approaches involve human narrative and judgment: they include case studies, surveys and interviews, logic models, and expert panel reviews. These methods are more contextualized and adaptable to the different impact paths across research fields than the standardized, quantitative methods. It appears that interviews, surveys and case study narratives are the more common methods for assessing impact of social science and humanities. To address reporting and assessment

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across stages. Canadian Academy of Health Sciences Payback and the UK National Institute of Health Research Dashboard frameworks are often discussed as examples.

[3] The Excellence for Research in Australia (under auspices of Australian Research Council) includes an Engagement and Impact Assessment, periodically measuring the engagements between researchers and end-users, and the extent of translation of research into verifiable economic, social, environmental, and cultural impacts.

[4] Research Excellence Framework (REF) conducts a periodic assessment of the research quality (including impact) of universities, where the expert review panels include academics and "research users" from policy circles. https://www.ref.ac.uk/

[5] For example, there have been several iterations of the European Framework Programme that monitor and evaluate the impact of social sciences and humanities research in the European Union. Impact is broken into categories of scientific, political and social impact. One of the recent iterations introduced the SIAMPI (Social Impact Assessment Methods) to evaluate impact of research projects, programs and funding instruments. http://www.siampi.eu/

biases within universities, impact assessment reviews often include end-users or experts from outside the academy.

11. **Incentive effects of measures.** In selecting across standardized and qualitative methods, one must be aware of incentive effects, particularly if the measures will be used for comparative, evaluative or allocative purposes. To illustrate, consider that if a researcher's future funding depends on quantitative measures such as op-eds and the number of citations in policy documents, this would have two potentially adverse incentive effects: (a) to distort the choice among research topics in favor of one that is eye-catching to newspaper editors, congenial to strong lobbying interests, and likely to have a quick path through regulatory, legislative or judicial process, and (b) to potentially lead to excessive investment of time and effort to currying favor with media outlets and lobbying interests.
12. **Use of multiple/hybrid methods**. Most approaches use multiple sources and methods in order to address some of the challenges described above. Indeed, some methods inform others: For example, case studies illuminate the paths to impact and the indicators that might be used within a given research field. The challenges above also explain the reticence to use metrics for evaluative or allocative purposes, at least until more analysis is completed.

Appendix 4: Stanford Affiliate Programs

Betsy Holland

Stanford's affiliate programs are faculty-driven research projects that bring together external organizations to facilitate the transfer of knowledge on a particular problem or problem area.[1] They are designed to facilitate the transfer of knowledge to the public and to further dialogue between academia and industry.[2] While most affiliates are industrial, a small number hail from nonprofit and government sectors. Affiliate programs fulfill a number of goals: (1) funding academic research; (2) bringing together faculty and companies to discuss and explore broad research topics in a precompetitive environment; and (3) opening the door for future collaboration between university research and the outside world, including opportunities for future, more specified sponsored research.[3]

Currently, Stanford has a number of affiliate programs that touch on sustainability, including Stanford Energy Corporate Affiliates (SECA), Stanford Center for Carbon Storage (SCCS), and Stanford Center for Earth Resources Forecasting (SCERF).

Stanford Energy Corporate Affiliates

SECA is a corporate affiliate program within the Precourt Institute for Energy.[4] Its mission is to promote interaction between companies and Stanford's faculty and graduate students across a full range of energy-related topics, including carbon capture and storage, data analytics, energy efficiency, nanotechnology, and sensors.[5]

SECA has the following tiers of annual membership:[6]

- Foundational Member: at the US $250,000 level, up to three funding allocations may be distributed at this annual membership fee.
- Regular Member: at the US $100,000 level, one funding allocation is offered, and includes all other membership program benefits.
- Small Business or Nonprofit Member: at the US $25,000 level, this tier is reserved for small businesses or nonprofits with fewer than or equal to 100 employees. These SECA members receive invitations to all SECA and Precourt Institute for Energy events.

Membership benefits include: (1) invitations to Stanford, Precourt Institute, and SECA events; (2) participation in its Fellow-Mentor-Advisor Program, Visiting Scholars Program, and Focus Group Program; and (3) opportunities for student recruitment.[7]

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[1] "Industrial Affiliates Program," Stanford Industrial Contracts Office, accessed July 8, 2022, https://ico.stanford.edu/industrial-affiliate-programs.
[2] *Id*.
[3] *Id*.
[4] "Membership Overview," Stanford Energy Corporate Affiliates, accessed July 8, 2022, https://seca.stanford.edu/membership-overview.
[5] "Welcome to SECA," Stanford Energy Corporate Affiliates, accessed July 8, 2022, https://seca.stanford.edu.
[6] "Membership Overview," Stanford Energy Corporate Affiliates, accessed July 8, 2022, https://seca.stanford.edu/membership-overview.
[7] *Id.*

Stanford Center for Carbon Storage

SCCS "uses a multidisciplinary approach to address critical questions related to flow physics, monitoring, geochemistry, geomechanics and simulation of the transport and fate of CO_2 stored in partially- to fully-depleted oil & gas fields and saline reservoirs."[8] Its focus areas include regional analysis, pore to score scale analysis, modeling and simulation, and technoeconomics and policy analysis.

SCCS has two tiers of membership:[9]

- Tier 1: $100,000 per year
- Tier 2: $50,000 per year

While membership in SCCS is open to everyone, Tier 2 membership is open only to NGOs, nonprofits, foundations, and startups.[10] The membership fee is principally "used for graduate student support, laboratory, computer and analytical facilities and administrative costs."[11] Membership benefits include "[a]ccess to cutting edge research conducted by Stanford faculty, post-docs, and Ph.D. students," invitations to events hosted by the Precourt Institute for Energy and Stanford University events, annual Affiliates meetings and workshops, and monthly speaker series.[12]

Stanford Center for Earth Resources Forecasting

SCERF outlines its motivation as "[t]he challenge of living on a planet with a growing population requiring an increasing need for such resources."[13] Accordingly, the program believes that, "[a]ny exploration, evaluation [and] development will have to rely on smart decision-making processes that address properly large uncertainties due to limited observations, whether from drilling, geophysical or flow dynamic data, and to mitigate environmental impact."[14] With this motivation in mind, its mission is to provide solutions for problems stemming from this challenge.[15] In doing so, it focuses on "developing state-of-the-art data scientific methods for the integration of spatial data over many scales, the quantification of uncertainty of subsurface systems, and the value of information of data sources in the context of decision making purposes."[16]

SCERF has one tier of membership with a fee of $60,000 per year; however, members may provide additional funds above the annual fees.[17] Membership benefits include:[18]

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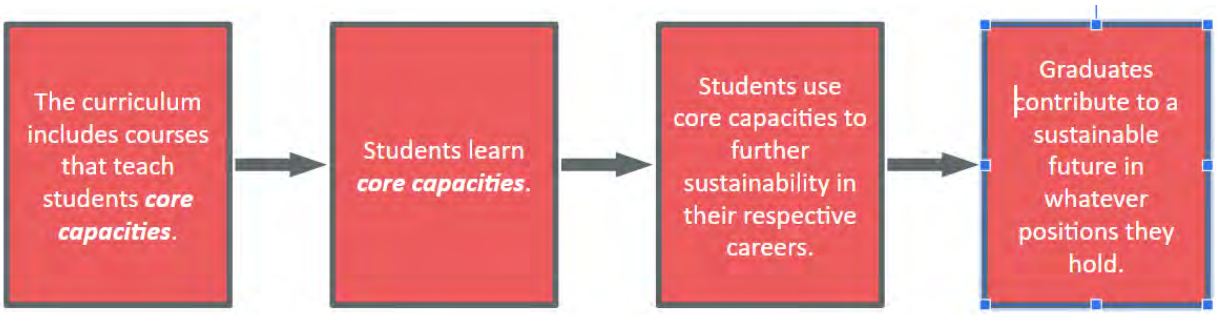
[8] "Welcome," Stanford Center for Carbon Storage, accessed July 8, 2022, https://sccs.stanford.edu.
[9] "Affiliates," Stanford Center for Carbon Storage, accessed July 8, 2022, https://sccs.stanford.edu/affiliates.
[10] *Id.*
[11] *Id.*
[12] *Id.*
[13] "Welcome," Stanford Center for Earth Resources Forecasting, accessed July 8, 2022, https://scerf.stanford.edu.
[14] *Id.*
[15] *Id.*
[16] *Id.*
[17] "Affiliates," Stanford Center for Earth Resources Forecasting, accessed July 8, 2022, https://scerf.stanford.edu/affiliates.
[18] *Id.*

- Engagement with top students for possible recruitment for work in the area of geomodeling, data science, uncertainty quantification and geophysics.
- Facilitated access to research results (publications, reports, software, etc.).
- Annual meeting to review and discuss research.
- Visits by Stanford faculty to member companies' sites to make technical presentations of the Program's research results. The site presentations and all information, data and results arising from such visitation interactions will be shared with all members and the public.
- Opportunities to engage in sponsored projects on topics of interest.
- Opportunities for members to share information and data in an open environment. Members are highly encouraged to make suggestions on research areas and topics of mutual interest."

Appendix 5: The Doerr School: Testing Competencies

Betsy Holland and Lily Liu

The outcome of the Doerr School's teaching mission is: graduates contribute to a sustainable future in whatever positions they hold. To achieve this ultimate outcome, the theory of change could be as follows:



For the Doerr School to achieve this ultimate outcome, it must have a curriculum that includes courses that teach students certain core capacities (further defined in the section below). As an intermediate outcome, students must learn these core capacities. As a secondary intermediate outcome, students must use these core capacities to further sustainability in their respective careers.

This research memo seeks to answer how the Doerr School can measure the first intermediate outcome: whether students are actually learning the defined core capacities. In doing so, this memo starts by defining the core capacities that students are expected to have upon graduation. Next, it explores the criteria that the Doerr School could use to select one or more testing methods. Then, it dives into when assessments should be given. Finally, this memo provides options for testing methods, their pros and cons based on the defined criteria, and how these testing methods may be used to ensure the Doerr School is adequately teaching its students the defined core capacity. The hope is that by implementing an appropriate system of measurement, the Doerr School will be able to test students' capacities such that it may inform its curriculum and bolster the above theory of change.

I. Core Capacities

Defining the capacities Doerr School graduates are expected to have is important not only as it informs the Doerr School's curriculum but also insofar as these definitions may form "as a basis for the development of testing methods."[1] The Doerr School aims for its graduates to possess three sorts of capacities:

- *Knowledge* about concepts, facts, and process (e.g., the chemistry and physics of climate change)
- *Skills*, or the ability to do things (e.g., being able to undertake an econometric analysis)

[1] Olga Zlatkin-Troitschanskaia, et al., *Modeling and Measuring Competencies in Higher Education: Approaches to Challenges in Higher Education Policy and Practice* (Wiesbaden: Springer VS, 2017).

- *Competencies* beyond knowledge and skill (e.g., as described by Novy et al., systems-thinking, strategic-thinking, interpersonal, and intrapersonal capabilities, integrated problem solving, futures-thinking, and implementation capabilities).

II. Criteria for Selecting Testing Methods

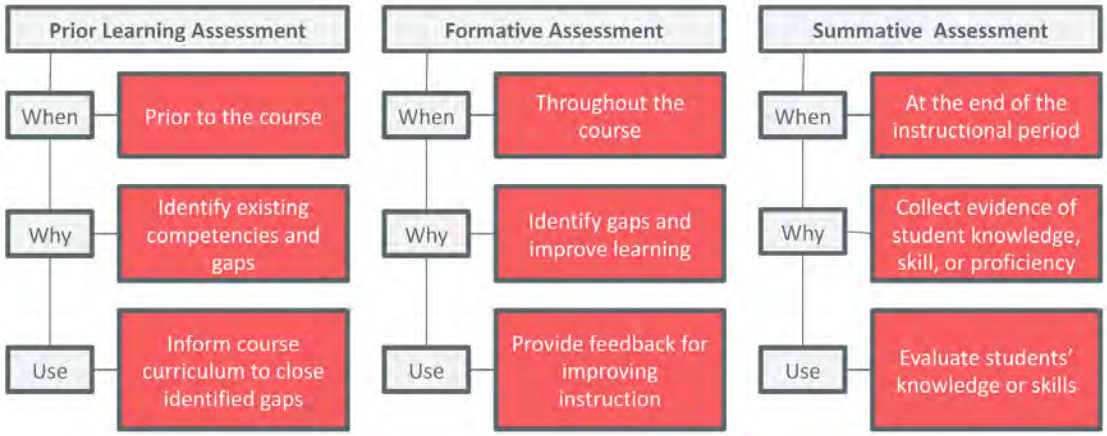
To select which testing methods to adopt for the Doerr School, we recommend the committee consider five main criteria:

- *Fairness*, which assesses the extent to which the method can provide unbiased and fair results for students
- *Comprehensiveness*, which evaluates the extent to which the method can provide high-quality assessments of all capacities required for the graduate
- *Time commitment*, which assesses the cost and time needed from students and evaluators
- *Quality of testing*, which determines how well the test can assess the capacities
- *Adaptability*, which evaluates how well the method can adapt to different students' needs, change in curriculum, and different interpretation of capacities

Comprehensiveness and quality of testing are especially important to assess the validity of the testing method, while time commitment and adaptability are valid logistical considerations. Fairness of the testing method, finally, addresses the School's key priority in promoting equitable education among its students.

III. Timing

One key factor for the Doerr School's consideration is at what point assessments should be given. As it pertains to this timing, there are generally three types of assessments: (1) prior learning assessments; (2) formative assessments; and (3) summative assessments.[2]



[2] Cathy Anderson, "Competency-Based Eduation & Assessments," Skilled-Up, accessed Apr. 23, 2022, https://commission.fiu.edu/helpful-documents/competency-based-courses-degrees/competency-based-education-assessments-skilledup.pdf.

A. Prior Learning Assessments

Prior learning assessments, or diagnostic assessments,[3] occur before any instruction and are used to test what students have learned before and outside of the classroom.[4] More specifically, they may "examine on the job training and skills, previous college experience, military training, volunteer service and independent study."[5] In administering prior learning assessments, the Doerr School would be able to identify the existing capacities students already have and what capacities they lack. In doing so, the Doerr School would be able to use that information to adequately close gaps instead of simply reinforcing preexisting capacities. Moreover, in addition to informing curricular development, the benefit of prior learning assessments may be better realized by the Doerr School as a benchmarking tool. Setting a benchmark followed by a summative assessment (described below) would allow the Doerr School to measure students' improvement of existing capacities and development of new capacities and accordingly attribute any improvements and/or developments to its curriculum.

B. Formative Assessments

Formative assessments are used as a more iterative tool to evaluate students at different points in time.[6] In contrast to summative assessments, formative assessments are continuous and "are used to assist students in finding the correct path of study and to adjust the curriculum to meet the student's needs."[7] Although formative assessments can be a crucial tool for the Doerr School to develop and iterate its curriculum, this assessment type may not be the best way to directly evaluate students' mastery of the defined core capacities.

C. Summative Assessments

Summative assignments are used to test what students have learned over a given time period.[8] They are typically performed using traditional testing methods and are most akin to the final exam, project, or paper used to grade students after they have taken a course.[9] While these assignments are helpful in evaluating students, they do not typically offer students guidance for future learning.[10] Accordingly, they "serve for overall evaluations…of whether competency standards and teaching-and-learning objectives defined have been met."[11] It is within this category that the Doerr School may best achieve its objective of testing students' core capacities. And, as mentioned above, the Doerr School can use a summative assessment to compare students' improvements in existing capacities and developments of new capacities.

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[3] "Formative and Summative Assessment," Northern Illinois University Center for Innovative Teaching and Learning, accessed April 26, 2022, https://www.niu.edu/citl/resources/guides/instructional-guide/formative-and-summative-assessment.shtml.

[4] Anderson, *supra* note 3.

[5] Bonnie Ordonez, "Competency-Based Education: Changing the Traditional College Degree Power, Policy, and Practice," *New Horizons in Adult Education & Human Resource Development* 26, no. 4 (Winter 2014): 47–53. https://doi.org/10.1002/nha3.20085.

[6] Anderson, *supra* note 3.

[7] Ordonez, *supra* note 6, at 50.

[8] Anderson, *supra* note 3.

[9] *Id*.

[10] *Id*.

[11] Zlatkin-Troitschanskaia, *supra* note 12, at 13.

IV. Testing Methods

In providing a preliminary learning assessment and/or summative assessment, the Doerr School could employ one of the following testing methods: (1) examination; (2) simulation; (3) practicum; (4) field study; or (5) portfolio.

Examination	Simulation	Practicum	Field Study	Portfolio
A test-based assessment that tests students' capacities through MCQ	A team-based assessment that tests students' capacities in a mock scenario	A performance-based assessment that tests students' capacities in a structured scenario	A performance-based assessment that tests students' capacities in a real-life scenario	An individual-based assessment that shows students' capacities in a collection of work

These testing methods assess students' capacities in the following four areas: (1) "knows," which assesses students' "knowledge of basic facts"; (2) "knows how," which assesses how students "apply their knowledge to analyze and solve problems presented in case-based scenarios"; (3) "shows how," which assesses how "students demonstrate the application of skills in authentic conditions that allow for supervised interactions"; and (4) "does," which assesses students' performance of "core competencies and responsibilities."[12] Furthermore, in deciding what type of testing method the Doerr School should employ, the School should keep in mind that it may use multiple methods at multiple points during a student's time at the School. In their report "Creating Systems of Assessment for Deeper Learning," David T. Conley and Linda Darling-Hammond assert that "[a] benefit of this approach is that different types of information can be used for different purposes, instead of trying to have one assessment address all needs."[13]

A. Examination

Examinations are test-based assessments that are best used to test what students "know."[14] They represent the traditional method of testing competencies and are typically multiple-choice and close-ended items.[15] To measure knowledge and skill, examinations present a time-convenient and easily administrable option. And while examinations are a useful tool to test knowledge (primarily through multiple-choice questions) and skills (through more open-ended questions), they mostly "require students to recall or recognize fragmented and isolated bits of information."[16] This result may be exacerbated for exams that are exclusively multiple choice, as "the level of cognitive demand [can be] severely constrained by the extent of multiple-choice questions, which were unable to assess these higher-order skills."[17] Accordingly, one downside of examinations is that they "rarely require students to apply their learning and almost never

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[12] Teresa La Chimea, et al., "Assessment of Clinical Competence in Competency-Based Education," *Canadian Journal of Dental Hygiene* 54, no. 2 (June 1, 2020): 83–91. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7668267/pdf/CanJDentHyg-54-2-83.pdf.

[13] David T. Conley & Linda Darling-Hammond, "Creating Systems of Assessment for Deeper Learning," Stanford Center for Opportunity Policy in Education (2013) https://edpolicy.stanford.edu/sites/default/files/publications/creating-systems-assessment-deeper-learning_0.pdf.

[14] La Chimea, *supra* note 13.

[15] Conley & Darling-Hammond, *supra* note14, at 21.

[16] *Id.* at 3.

[17] *Id.*

require students to exhibit proficiency in higher-order skills" (i.e., competencies beyond knowledge and skill).[18]

The bar examination that law school graduates must pass before practicing law provides an example of a summative examination. The American Bar Association claims that the bar exam "tests minimum competence by testing for baseline knowledge of substantive law."[19] One limitation of the bar examination, and examinations in general, is that "[t]here is little to no credible evidence that the bar exam is an adequate measure of lawyer competency."[20] While there may be other ways to test "knows how," "shows how," and "does" competencies in the legal profession, the bar examination, by virtue of its nature as a one-time test, often fails to measure evidence of these additional capacities. Therefore, while examinations may be a good way for the Doerr School to test knowledge and skills, competencies may be better tested using the methods described below.

B. Simulation

In a simulation, students are asked to assess and develop solutions for a mock scenario. These scenarios typically take the form of a "case study" that can be taken individually, by a team, or a combination of the two. "[C]ase studies provide a limited form of interaction between students and the societal context on which a case study is based, as students usually have no direct contact with stakeholders outside of the university."[21] Unlike examinations that are limited in their ability to test competencies, simulations—and team-based simulations in particular—present a unique opportunity to test competencies in situations more akin to the real world. Indeed, "[a]ssignments and projects that require students to work in groups have become more common in higher education in general and increasingly called in sustainability education in particular."[22] On one hand, "group work fosters many skills important in collaborative work on real-world problems including interpersonal communication, organization, planning, and delegation."[23] However, team-based simulations are not without their challenges, as "group processes are difficult, delicate, complex, sometimes thrilling, exhausting, and last but not least, they do need time and attention."[24] In addition to these challenges, there may be questions of fairness, as students can "often become frustrated with group work due to poor guidance by faculty and dependence on other group members for their grade."[25]

One example of a simulation is offered by a research study published in the *International Journal of Sustainability in Higher Education*. In this study, sustainability-focused faculty at various universities constructed "a classroom assessment aimed at determining the extent to

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[18] *Id*.

[19] Steven Foster, "Does the Multistate Bar Exam Validly Measure Attorney Competence?" *Ohio State Law Journal Online* 82 (Mar. 24, 2021): 31–42. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3759924.

[20] Donna Saadati-Soto, et al., "Does the Bar Exam Measure Competence? The Answer: We Have No Idea," Jurist, Apr. 21, 2020. https://www.jurist.org/commentary/2020/04/saadati-soto-escontrias-sarkar-bar-exam/.

[21] Sonya M. Remington-Doucette, et al., "Assessing Sustainability Education in a Transdisciplinary Undergraduate Course Focused on Real-World Problem Solving: A Case for Disciplinary Grounding," *International Journal of Sustainability in Higher Education* 14 no. 4 (Sept. 13, 2013): 405–433.

[22] *Id*. at 415.

[23] *Id*. at 415.

[24] *Id*. at 415.

[25] *Id*. at 412 (internal citations and quotation marks omitted).

which key sustainability competencies develop in students during an introductory transdisciplinary sustainability course."[26] The assessment was given twice, at the beginning of the course (as a prior learning assessment) and at the end of the course (as a summative assessment).[27] The assessment involved a simulation through a case study that asked students to respond to the following prompts:[28]

- identify all possible social, environmental, and economic challenges presented in the case study;
- prioritize the challenges in terms of the ones they believe most important to achieving sustainability;
- identify and critique the values that underline the non-profit's strategies;
- identify the conflicts between the social, environmental, and economic priorities;
- identify where the non-profit might have to compromise on values and make a trade-off in order to achieve their goal; and
- make recommendations for the non-profit about how the conflicts between the social, environmental, and economic priorities could be resolved while still supporting sustainability.

"To guide the analysis of the participants' responses to the case studies' questions and the assessment of key competencies, the researchers developed a rubric."[29] This rubric identified various elements of higher thinking and conflict resolution that incorporated identified competencies that students were expected to have (in this case it was systems thinking, normative, and strategic competencies), and students were graded on a scale of zero to five (0 - no skill; 5 - exceptional skill).[30] As offered by this example, a benefit of this testing method may be that the instructor can design the simulation to test for particular competencies.

C. Practicum

While very similar to a simulation, a practicum offers a more theoretical framework for students to apply learned competencies to a real-life scenario under faculty supervision.[31] In this assessment method, students are typically evaluated on their final report and/or presentation. And unlike a simulation, where the instructor can design a case study to test for particular competencies, practicums simply ask students to use competencies, which may result in their application at random. This differentiation may lead to inconsistencies in evaluation that may be difficult for the Doerr School to standardize.

This testing method is the one currently used by the SUST program. As stated, "to integrate and internalize core lessons from the SUST curriculum, each student completes a 120-hour practicum project of their own design, collaborating on a complex sustainability challenge with an outside

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[26] *Id*. at 404.
[27] *Id*. at 415.
[28] *Id.*
[29] *Id*.
[30] *Id*. at 416.
[31] "Handbook: Practicum in Human Development & Family Studies (HDFS 44092/54092) and Practicum in Gerontology (GERO 44092)," Kent State University School of Lifespan Development & Educational Sciences, accessed July 8, 2022, https://www-s3-live.kent.edu/s3fs-root/s3fs-public/file/Handbook%20Practicum.pdf.

partner and working through the types of constraints often faced by decision makers and leaders."[32] One interesting aspect of the practicum requirement is the requirement for reflection. In addition to writing an analytical paper and presenting their findings, students must also reflect on how they have used key competencies from the program, such as the Capital-Asset framework and Connect-Adapt-Innovate framework, and how they have grown throughout the practicum. Students are also evaluated on the quality of presentation and paper and how well they have used the degree's core competencies to engage with the external partner. While the practicum offers a hands-on opportunity to culminate the students' learning in SUST, the purpose of the current practicum tends to be more educational than evaluative. Given the flexibility and diversity of student projects in the past, some students have reported to struggle with fitting their projects neatly under the practicum's rubric and required components.

D. Field Study

A field study is a performance-based test administered through direct observation in authentic situations.[33] In layman's terms, field studies, when used for an assessment, place students in real-life situations where they are tasked to solve a problem faced by a real client. While these clinical assessments are particularly useful to assess students' capacities, they are limited in that the real-world aspect of these field studies means there is wide-ranging variability.[34] In particular, "direct observation necessitates multiple observations to provide reliable data, as well as faculty training to ensure reliability."[35] Moreover, there may be additional difficulties in administering field studies because of the "need for substantial planning," "adequate physical space in which to conduct the assessment," "lack of appropriate clients," and, most importantly, "a lack of standardized test conditions."[36]

To better understand the benefits of field studies as an assessment method, objective-structured clinical examinations (OSCEs) used in healthcare education provide an illustrative example. "In an OSCE, students move through a series of stations where they have to perform specific clinical tasks within a time limit."[37] A benefit of OSCEs is that they are valuable in testing "shows how" and "does" competencies and, accordingly, have become "one of the most widely used methods of assessing aspects of clinical competency in healthcare education."[38] Moreover, studies suggest that "[w]hen preparing for OSCEs students focus on the acquisition of clinical skills and need less studying time to achieve the expected level of competency/performance, as compared to [multiple-choice question] tests."[39] However, because of variability of real-world situations, to "increase validity and accuracy of assessment practices, and mitigate the challenges associated

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[32] "Sustainability Science and Practice: Overview," Stanford Bulletin: ExploreDegrees 2020-21, accessed July 8, 2022, https://archived-bulletin.stanford.mobi/schoolofearthsciences/sust/#:~:text=To%20integrate%20and%20internalize%20core,by%20decision%20makers%20and%20leader.

[33] La Chimea, *supra* note 1.

[34] *Id*.

[35] *Id*.

[36] *Id*.

[37] Stefan Müller, et al., "How the Introduction of OSCEs Has Affected the Time Students Spend Studying: Results of a Nationwide Study," *BMC Medical Education* 19 (2019). https://doi.org/10.1186/s12909-019-1570-6.

[38] Gerry Gormley, "Summative OSCEs in Undergraduate Medical Education," *Uslter Med. J.,* 80 no. 3 (Sept. 2011): 127–132. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3605523/.

[39] Müller, *supra* note 38, at 1.

with [OSCEs], experts have advocated for a continuous assessment approach in which the triangulation of data from multisource feedback, multiple methods, and a variety of assessments over time provides a multifaceted and accurate representation of student competence."[40] Therefore, while helpful in assessing how students would perform in the "real world," field studies are limited by their variability and time-intensity.

E. Portfolio

A portfolio can be the collection of the student's best work, a reflection of their learning, or the documentation of the student's learning journey. In other words, the collection of work can be a reflection of the struggles of learning, not necessarily a polished product.[41] Portfolios are typically more formal presentations that demonstrate mastery of knowledge and skills for a degree. Although assessment portfolios are great for assessing teaching outcomes, they may not adapt well to diverse student needs and development.

Columbia School of Nursing's master's portfolio requirement exemplifies how a portfolio can combine summative and formative assessments together.[42] While demonstration of the mastery of key competencies and skills is needed, the portfolio also contains intermediate works by the student throughout the student's completion of the program, some of which could inform the student's future professional development. By having the portfolio include the student's learning journey, unfinished work, and reflections on learning, this assessment can also serve as a lower-stress, learning-driven metric. Similarly, the New York Performance Standards Consortium allows students to complete graduation requirements through a portfolio combining literary analysis, a research paper, mathematical modeling, and community service or internship experience.[43] This portfolio is graded on a common scoring rubric to ensure consistency.[44] While a portfolio helps assess a student's ability to coordinate a long-term and complex project, this assessment method presents the challenges of standardizing evaluation metrics and accommodating the diversity of acceptable final products that the student could present.

V. Other Comments and Concerns

A. Teacher Involvement

Research has found that "when teachers become experienced in developing and evaluating high-quality performance assessments, they are more able to design and deliver high-quality learning experiences because they have a stronger understanding of what kinds of tasks elicit thoughtful work, how students think as they complete such tasks, and what a quality standard looks like."[45]

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[40] La Chimea, *supra* note13.

[41] Greg Port, "Types of Portfolios," All Saints' College, Mar. 26, 2021, https://portfolio.ascollege.wa.edu.au/blog/2021/03/26/types-of-portfolios/.

[42] "Master's Portfolio," Columbia School of Nursing, updated Mar. 25, 2022, https://www.nursing.columbia.edu/courses/masters-portfolio-nurs7020n.

[43] Conley & Darling-Hammond, *supra* note 14, at 8.

[44] "Rubric for Portfolio-Based Assessment," Stark State College, accessed July 8, 2022, https://www.starkstate.edu/wp-content/uploads/2016/02/REVISED-MASTER-RUBRIC.pdf.

[45] Conley & Darling-Hammond, *supra* note 14, at 14.

B. Separate Certification

Rather than tie competency assessment to graduation, the Doerr School could provide a competency certificate that is separate from a student's degree.

Appendix 6: Substantive Takeaways from the Graduate Interviews

This summarizes the substantive findings from interviews with SUST and E-IPER graduates.
Practical courses and experiences were very helpful.

- For many students, their practicum experience helped them find their passion or gave them the experience needed to land their job. SUST grads in particular cited it as how they "stumbled upon" their future area of focus.
- Case-study classes were excellent for strategic-planning competency. But many noted that the examples were outdated and overly focused on NGO or other nonprivate sector roles.
- E-IPER grads lauded the opportunities to fund opportunities not covered in Stanford's curriculum (such as Environmental Indigenous Law courses offered at Vermont Law's summer session).
- Practical courses such as SUST 220 felt like business classes that taught necessary skills.

- Small courses/discussion-based courses were stellar.
  - Particularly helpful for the teamwork and values core competencies.
  - Some students, however, mentioned that "group project" experiences weren't enough to fully develop teamwork competencies, which might need to include more structured skill building.
- Diversity of student backgrounds helped forge new ideas.
  - In the SUST program, this led to students feeling that they gained collaboration skills that they carry with them into various roles.
- Mentorship, formal and informal, was crucial for success.
  - Mentors taught skills that weren't always emphasized in classrooms: storytelling, understanding stakeholders, and other more ambiguous skills.
  - Desire for mentors to help students in SUST program define possible focus areas prior to enrolling in courses. Some felt that those who came into the program with direction got more out of it.
- SUST alums may not be working in "obviously" sustainability-oriented roles.
  - Some participants from the SUST program were working in social-impact careers at foundations and in politics that weren't directly involved with sustainability. Attitude toward this differed: some wanted to mold their career into something more environmentally related while others appreciated how the social impact they were making did in fact contribute to "sustainability."
  - Divide between E-IPER and SUST grads.
  - E-IPER grads, who come into the PhD with generally more experiences, enjoy the lack of structure and the freedom to specialize.

    - SUST grads, who complete a one-year degree, often felt that they were not adequately exposed to the range of sustainability careers and cited "stumbling" into their area of interest. They often recommended a broader base of core curriculum and a better understanding of earth systems.
- Course offerings should increase in breadth and especially depth.
    - Graduates felt they lacked subject-matter knowledge of earth systems beyond the introductory course.
    - Offerings in business models/ESG and sustainability would be welcome.
    - Offerings in sustainability psychology and organizational psychology would be helpful in turning values into action, strategic planning, and other competencies.
    - Offerings that simulate experiences/situations in the private sector, especially those that emphasize pushback, would be helpful for the advocacy competency.
    - SUST program should offer more specialized courses across different interest areas (for example, supply chain, carbon emissions tracking model, corporate finance, circular economy, energy infrastructure, etc.).
    - These specialized offerings should replace or merge with the electives portion of the course requirements.
- Competencies where Stanford needs to improve:
    - Self-awareness: students felt that, at times, Stanford curricula put its own ideas on a pedestal.
    - Advocacy: not adequately prepared for "pushback" in companies.
    - Thinking about future consequences and scenarios.
    - Putting values into action.
    - Subject-matter knowledge of earth systems and sustainability.
    - Global/indigenous perspectives in climate.
- Areas where Stanford excels:
    - Teamwork and collaboration.
    - Strategic planning.
    - Understanding systems (at a baseline level, needs more depth).
- Summary of competency rankings (mean of 10 maximum):
    - Understanding systems
        - Extent to which Stanford contributed to competency: 8.9
        - Importance of competency to current work: 9.5
    - Thinking about future scenarios and consequences
        - Extent to which Stanford contributed to competency: 6.8
        - Importance of competency to current work: 8.5

- Putting values into action
    - Extent to which Stanford contributed to competency: 8
    - Importance of competency to current work: 10
- Strategic planning
    - Extent to which Stanford contributed to competency: 5.7
    - Importance of competency to current work: 9.3
- Teamwork and collaboration
    - Extent to which Stanford contributed to competency: 7.3
    - Importance of competency to current work: 9
- Advocacy
    - Extent to which Stanford contributed to competency: 5.8
    - Importance of competency to current work: 7
- Self-awareness
    - Extent to which Stanford contributed to competency: 5.1
    - Importance of competency to current work: 6.5
- Effective problem solving
    - Extent to which Stanford contributed to competency: 6.5
    - Importance of competency to current work: 8.5

Appendix 7: Graduate Interview Protocol

The typical interview ranged from thirty minutes to one hour. Google form surveys were sent to interested graduates whom we did not have time to interview. Below is the question portion of the interview protocol, which was used as a script. Before launching into the questions, the interviewers introduced themselves and explained the purpose of the interview.

Background:

- Did you complete any sustainability-related degrees or work experience before entering your SUST or E-IPER degree? If so, please describe those experiences.
- What is your current position, and does it relate to sustainability?
- Have you held any other sustainability-related jobs since graduating from Stanford?
- Specifically, what do you do in your current work (e.g., draft public reports, meet with stakeholders, run or participate in certain programs, invest in new technologies, etc.)?
- How did your Stanford program prepare you for this work?
- What skills or knowledge do you wish you had before entering this job?

Assessing Core Competencies:

- Understanding Systems
    - Understanding systems is the ability to recognize and understand relationships, to analyze complex systems, to think of how systems are embedded within different domains and different scales, and to deal with uncertainty.
    - To what extent is this competency relevant to your current job?
    - How well did Stanford's curriculum meet this competency?
    - Anything you'd like to add about the "understanding systems" competency?
- Thinking of Future Scenarios
    - Thinking about future scenarios and consequences encompasses the abilities to understand and evaluate multiple futures—possible, probable, and desirable; to create one's own visions for the future; to apply the precautionary principle; to assess the consequences of actions; and to deal with risks and changes.
    - To what extent is this competency relevant to your current job?
    - How well did Stanford's curriculum meet this competency?
    - Anything you'd like to add about the "thinking about future scenarios and consequences" competency?
- Strategic Planning
    - Strategic planning encompasses the abilities to collectively develop and implement innovative actions that further sustainability at the local level and further afield.
    - To what extent is this competency relevant to your current job?

    - How well did Stanford's curriculum meet this competency?
    - Anything you'd like to add on the "strategic planning" competency?
- Putting Values into Action
    - Putting values into action describes the ability to understand and reflect on the norms and values that underlie one's actions; and to negotiate sustainability values, principles, goals, and targets, in a context of conflicts of interests and tradeoffs, uncertain knowledge, and contradictions.
    - To what extent is this competency relevant to your current job?
    - How well did Stanford's curriculum meet this competency?
    - Anything you'd like to add on the "putting values into action" competency?
- Teamwork and Collaboration
    - Teamwork and collaboration encompass the abilities to learn from others; to understand and respect the needs, perspectives, and actions of others (empathy); to understand, relate to, and be sensitive to others (empathic leadership); to deal with conflicts in a group; and to facilitate collaborative and participatory problem solving.
    - To what extent is this competency relevant to your current job?
    - How well did Stanford's curriculum meet this competency?
    - Anything you'd like to add on the "teamwork and collaboration" competency?
- Advocacy
    - Advocacy encompasses the ability to question norms, practices, and opinions; to reflect on one's values, perceptions, and actions; and to take a position in the sustainability discourse.
    - To what extent is this competency relevant to your current job?
    - How well did Stanford's curriculum meet this competency?
    - Anything you'd like to add to the "advocacy" competency?
- Self-Awareness
    - Self-awareness is the ability to reflect on one's own role in the local community and (global) society, to continually evaluate and further motivate one's actions, and to deal with one's feelings and desires.
    - To what extent is this competency relevant to your current job?
    - How well did Stanford's curriculum meet this competency?
    - Anything you'd like to add on the "self-awareness" competency?
- Effective Problem Solving

    - Effective problem solving describes the overarching ability to apply different problem-solving frameworks to complex sustainability problems and develop viable, inclusive, and equitable solution options that promote sustainability.
    - To what extent is this competency relevant to your current job?
    - How well did Stanford's curriculum meet this competency?
    - Anything you'd like to add on the "effective problem solving" competency?

Programmatic Changes:

- Did you come into your program with a strong idea of an area of sustainability or a career path you intended to pursue?
- What programmatic changes would improve instructional quality, increase student success, and build needed skill sets (for program completion, for job success, etc.)?
- Was your education here appropriately focused? Where do you wish you had more coursework or preparation?
- Were there job opportunities you would have wanted to pursue but did not feel equipped to do so?
- Any other thoughts?