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# A Core Curriculum for Sustainability Leadership

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**Abstract:** In response to the scale, complexity, and urgency of the sustainability challenges societies face, there has been both rapid growth in the broad field of sustainability science and technology, as well as sustainability education globally. Yet, demand for sustainability education still far outstrips supply, and the gap between current reality and achieving the goal of intergenerational well-being is widening. There is a need for greater understanding, innovation, and alignment in sustainability education to ensure programs are effective in cultivating agents of change with capabilities pertinent to and commensurate with the nature of the challenge. Through a highly consultative, multi-year process, we used systems design, combining a systems perspective with the iterative design and inquiry process from design thinking, as well as grounded theory to develop a model of a "New Leader", and an associated curriculum and pedagogy to cultivate these change agents. The resulting Change Leadership for Sustainability Program at Stanford University offers a set of perspectives, frameworks, and tools and a pedagogical approach that prepares students to study and lead change effectively in any social-environmental system, no matter the sector or topic of interest, with an explicit normative goal of intergenerational well-being. After testing and evaluating the Program's curriculum and pedagogy over the past five years through both master's and executive programs, we have found that the development of specific competencies is an essential element of sustainability education, yet it is also crucial to focus on cultivating the identity, perspectives, and agency of these New Leaders in order to prepare them for maximum impact.

**Keywords:** sustainability; curriculum; education; innovative pedagogy; intergenerational well-being; systems thinking; design thinking; transformative leadership; social-environmental systems; systems change; collaborative leadership; multi-stakeholder partnership; transdisciplinary research

## 1. Introduction

An increasing demand for sustainability education has coincided with the emerging academic field of sustainability, focused on understanding and addressing the complex challenge of securing the well-being of all people, now and in the future, and the increasing engagement of individuals, corporations, governments, and non-governmental organizations in pursuing sustainable development goals and corporate goals related to environmental, social, and governance (ESG) concerns [1,2]. Today, there is an emerging recognition of the need for intentional and comprehensive sustainability curricula focused on inclusive social and environmental well-being, for graduates of all kinds, and indeed, for all citizens.

Students are increasingly demanding curricula to prepare them to engage in sustainability challenges. The vast majority of students surveyed in 2012, and then later in 2019, as part of Stanford University's environment and sustainability initiative requested that the university offer more sustainability courses overall, add sustainability topics to courses that did not address sustainability, require sustainability courses in programs that did not require them, and require all undergraduates to complete at least one sustainability

course before graduating [3,4]. Students from all over the world have expressed similar priorities [5–8].

The need for purposeful sustainability education is coming likewise from other quarters. A 2012 GreenBiz survey of sustainability leaders from the world's largest companies found that 80% believed that sustainability education would help their careers, and 76% said that universities could help corporate and non-profit organizations achieve sustainability goals [9]. The rapid rise over the past decade in educational offerings for corporate audiences from membership organizations such as the Corporate EcoForum and GreenBiz, as well as academic executive education offerings is one response to this demand. Accenture's 2021 report calls for dramatic engagement of the corporate sector in sustainability challenges [10]. Governments, likewise, require sustainability education. A 2013 report of the National Academies highlighted the need for sustainability education in public agencies, including training in systems thinking, interdisciplinarity, and collaborative partnerships to improve national effectiveness in addressing complex sustainability challenges [11].

Despite the growing demand and critical need, there is still a paucity of supply and a general lack of alignment in curriculum and pedagogy across programs. While some academic researchers have noted progress in implementing education for sustainable development via campus greening and research initiatives, pedagogical and curricular innovation in support of sustainability, particularly at the graduate level, has meanwhile been slow to develop [12]. The 2008 report by the International Commission on Education for Sustainable Development Practice called for new graduate and professional programs in sustainability and identified a dearth of programs that integrate natural, social, and health sciences with management training for the purposes of preparing practitioners to address the full range of sustainability challenges [13]. The report noted that graduate programs around the world offering degrees associated with sustainable development "typically focus on either social sciences or environmental sciences, and offer few opportunities for systematic, cross-disciplinary education or management training" [13] (p. 4). Since then, additional studies have identified a lack of consistency across sustainability programs and the need for greater clarity regarding the key competencies critical for graduate students of sustainability to possess [14–16].

In response to this global need and demand, as well as a call from Stanford students and the university administration, we (the authors of this paper) embarked on a multi-year process to explore the question: "if we were to prepare leaders to radically accelerate the transition to a sustainable society, what curriculum and encompassing program would be required"? Our effort built upon earlier academic education and research efforts focused on interdisciplinary problem solving in environment and natural resource issues, and the growing emphasis on sustainability and management of complex social-environmental systems at Stanford's School of Earth, Energy, and Environmental Sciences led by then-dean Pamela Matson. Our aim was to take a fresh look at sustainability education and innovate a new curriculum and way of teaching that would develop transformative leaders capable of breaking down established norms and structures and building a society aligned with the goal of intergenerational well-being.

In developing Stanford's Change Leadership for Sustainability Program to serve master's students and professionals, we drew upon our diverse disciplinary backgrounds and professional experience. Pamela Matson has been a key contributor to the development of the field of sustainability science in the United States and brings research-based expertise in the social-environmental systems analysis, global environmental change, and knowledge–action linkages. Julia Novy has been a leader of non-profit and philanthropic organizations and brings expertise in multi-stakeholder collaborations, market-based approaches to sustainability, resilience, and international development. Banny Banerjee is one of the pioneers of design thinking methodology and brings expertise in large-scale systems innovation and transformation.

In this paper, we share the intensive process we undertook, which included first establishing a common goal for our effort and an initial theoretical model of the change agent we sought to cultivate; then engaging leaders from business, government, and civil society to explore their perspectives on the knowledge, mindsets, and skills required of leaders capable of advancing transformative change for sustainability; and then vetting insights from this global consultation through a collaborative process with faculty from Stanford's seven schools and other academic colleagues around the world. After distilling our findings and conclusions into a core curriculum and program for sustainability leadership, we compared our results with lessons from other programs and the academic literature. Finally, in 2016, we launched our program. Now, after five years of program experience and much learning from academic and practice-based communities, we are able to reflect on the relevance of our program and curriculum and make recommendations on future directions for sustainability education.

## 2. The Curriculum Design Process

We began exploring the possibility of developing a new program and curriculum in sustainability leadership in 2013. Given that development of sustainability curricula was a relatively new undertaking and the nature of sustainability programs in higher education quite varied, we chose to adopt a highly consultative process rather than relying strictly on a literature review or advice from other programs. Our process involved taking a broad and inclusive systems perspective and harnessing insight from people with diverse experiences and forms of knowledge. Typical academic paradigms are often based on cultivating expertise in a singular area, which is antithetical to systems transformation. Our task was different, so we used "systems design" as our primary methodology, which combines a systems perspective with the iterative design and inquiry process from design thinking, in addition to drawing on grounded theory to develop and synthesize insights. The open-ended nature of the inquiry coupled with cycles of systems-based design activity ensured that the definition of the problem (the challenge of securing intergenerational well-being) and the framing of solution criteria (the profile of the transformative change agent) advanced in lockstep as new and surprising insights emerged. We believed this approach would enable us to generate new ideas for a sustainability leadership program and curriculum that would be highly responsive to the needs identified by stakeholders deeply engaged in complex sustainability challenges.

### 2.1. Theoretical Model Development

We began by meeting weekly over a period of several months to build common understanding and define a vision for our collaboration by sharing ideas in live brainstorms, refining concepts in writing, exchanging ideas over email, and iterating extensively. Through our discussions and communications, it became clear that our vision was not simply to create a curriculum and educate students, but more significantly, to transform people. We sought to cultivate leaders capable of driving radical change at a societal scale. We believed that in order to tackle 21st-century challenges, we needed a special kind of leader, one quite distinct from past and current leaders. Consequently, our initial focus involved considerable critical thinking to define the attributes of this "New Leader". The theoretical model for the agent of change that emerged from this exercise served to underpin the subsequent design process. We challenged ourselves to think beyond competencies to consider the identity, perspective, and agency of this change-maker, all of which would be essential to their ability to spur the paradigm shifts needed to achieve collective and inclusive thriving on Earth.

The theoretical model we developed of the New Leader is depicted below (see Figure 1). It places the New Leader in the context of complex social-environmental sustainability challenges, spanning both the constraints of our current reality and the fertile space for intervention, where the New Leader takes action to drive society toward the outcome space where pathways toward sustainability are realized. The New Leader is represented

by four concentric circles, each of which describes an element of their persona essential to their capacity to lead transformative change, and all of which are mutually reinforcing and synergistic:

1.  Identity: At the center is the New Leader's identity, representing their mental model of themselves 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.

2.  Perspective: 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.

3.  Capability: 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.

4.  Agency: 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.
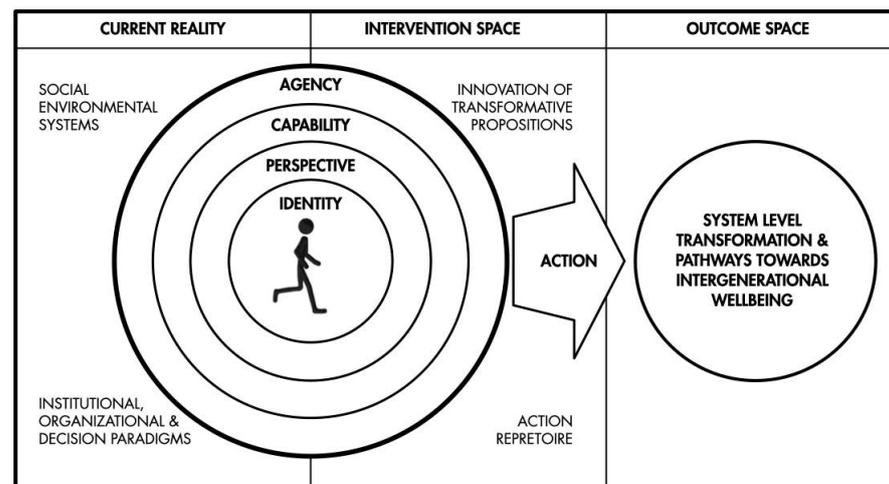


**Figure 1.** A Theoretical Model depicting the 'New Leader', and the structure of their attributes to enable pathways toward intergenerational well-being.

With an initial version of our theoretical model defined, we began an iterative process of characterizing the challenges and opportunities associated with achieving sustainability, seeking insights and perspectives from a wide array of people, synthesizing the information, and refining our theoretical model of the New Leader and the essential elements of a curriculum and program that would achieve our goals.

## 2.2. Design Journey

We launched the consultation and design phase in late 2013. We used the open-ended inquiry approach of "empathy interviews" to engage over 100 leaders from transnational corporations, smaller companies and benefit corporations, social enterprises, management and social sector consulting firms, impact investment firms, international and local NGOs, philanthropic foundations, think-tanks, municipal, state, and national governments, and academics and students from universities around the world. We gathered their perspectives

on: (1) opportunities and obstacles to advancing sustainability; (2) the knowledge, mindsets, and skills required of New Leaders; and (3) curricular and teaching considerations.

We used design thinking and grounded theory methodology to synthesize the information we gathered from the interviews [17,18]. For example, we documented the most significant stories we heard, including those that surprised or inspired us, and those that verified or challenged our assumptions. We added substance to our theoretical model of the New Leader, highlighting mindsets, knowledge, and capabilities that emerged consistently from the interviews.

We then conducted a series of working sessions at Stanford University to explore themes, stories, and scenarios from the interviews, consider Stanford assets that could contribute to our curriculum, and develop additional ideas. This group comprised faculty, professors of practice, lecturers, academic staff, and practitioners possessing expertise in theory and practice and drawing from diverse disciplinary backgrounds and forms of knowledge, including from the natural and social sciences, humanities, engineering, design, business, and law, as well as experiential, traditional, indigenous, and scientific knowledge bases. We also solicited input and feedback from Stanford undergraduate and graduate students from diverse disciplinary backgrounds, engaging both prospective students as well as students who had designed their own education pathways in the absence of a formal sustainability curriculum. Integrating student perspectives was essential to ensuring that we were user-driven in our design. Several students engaged with us over a few years to catalog relevant courses and identify gaps in university offerings.

In March 2014, we hosted a faculty-CEO Roundtable at Stanford University in partnership with the World Environment Center to revisit the core questions from the empathy research and working sessions in live-time with a primarily external audience of sustainability practitioners. We sought to determine if their recommendations reinforced, conflicted with, or altered our emerging conclusions on the most important perspectives and capabilities of New Leaders and the nature of the curriculum and program required to develop them.

The thirty global participants represented product and service industries, including oil and gas, clean energy, transportation, information technology, logistics, investment, consulting, beverage, and retail, as well as academics, thought leaders, and practitioners from non-profit organizations, think-tanks, and universities, some of whom had been interviewed during the research phase. Given our combined professional experience with multi-stakeholder processes and design thinking methodology, two of us facilitated the Roundtable and organized it around collaborative design thinking sessions to achieve the following objectives: (1) develop a vision of a transformed future where sustainability and resilience are the natural outcomes of business as usual; (2) map radical opportunities and identify constraints to achieving this vision; and (3) develop a detailed profile of the New Leader, including their core mindsets, knowledge, and capabilities. Breakout groups reported their findings to the broader group for feedback. We then distilled the Roundtable outcomes and evaluated them in the context of our empathy and grounded theory research to identify commonalities as well as new perspectives.

## 3. Outcomes of the Design Process

The key stakeholder input from the design journey informed the creation of the Change Leadership for Sustainability Program, including its core curriculum, pedagogy, program principles and values, target audiences, and degree requirements for the new Master's Program in Sustainability Science and Practice.

### 3.1. Key Stakeholder Input

We compiled the most salient recommendations from the interviews, Stanford working sessions, and the faculty-CEO Roundtable into four emergent categories described below: (1) New Leader purpose, knowledge, mindsets, and capabilities; (2) curriculum and teaching methodology; (3) audience; and (4) program structure, strategy, and management.

Category 1: New Leader Purpose, Knowledge, Mindsets, and Capabilities

- Committed to sustainability and intergenerational well-being.
- Grounded in ethics and possessing humility.
- Highly collaborative and inclusive.
- Builds bridges and spans siloes to partner with diverse stakeholders.
- Deep listening, empathy, and inquiry capability.
- Identity and capacity as radical change-maker, driving evolutionary and revolutionary change.
- Systems perspective and systems thinking capability.
- Understands life support systems of the planet.
- Capacity to understand change, be adaptable, embrace ambiguity and uncertainty.
- Personal resilience and capacity to build resilience across scales.
- Thinks beyond narrow roles and sees new perspectives and possibilities that others do not.
- Possesses drive and capacity for vision and innovation, rather than compliance.
- Creative confidence in face of daunting challenges, risk-taking, bias for action.
- Capacity for complex problem solving with mindset to look for root causes.
- Effective decision making, drawing on foresight and pattern recognition.

Category 2: Curriculum and Teaching Methodology

- Derive curriculum from complex sustainability challenges and effective approaches rather than from theory or discipline.
- Integrate theoretical frameworks with deep knowledge of practice.
- Develop and teach case studies that show *why* certain approaches work.
- Integrate natural and social sciences, and experiential and indigenous knowledge.
- Teach "how" to think, not "what" to think.
- Change hearts and minds through curriculum; go beyond rational learning.
- Create opportunity for global exposure to understand poverty and environmental degradation first-hand.
- Integrate hands-on, applied learning in class.
- Use project-based learning and offer opportunity to "shadow" mentors.

Category 3: Audience

- Go beyond "converted" to reach broad array of people.
- Undergraduate students from various disciplines.
- Graduate students from diverse undergraduate degrees.
- Professionals from multiple sectors.
- Mid-career leaders (perhaps more open to personal transformation).
- Later career leaders (moving from executive and management roles to board roles or shifting careers to a sustainability focus).
- Professionals who want to collaborate with university to drive change.

Category 4: Program Structure, Strategy, and Management

- Address structural barriers that impede transdisciplinary research and collaboration at the university to provide more supportive environment for program.
- Incentivize faculty and practitioners to participate, teach, and advise.
- Transcend disciplines through program structure and delivery.
- Attract new faculty and practitioners to fill teaching gaps and fulfill learning objectives.
- Use innovative classroom teaching approaches to drive a new educational model that can have broader impact on changing norms and increasing impact of the university.
- Create a platform that supports learning and experimentation through collaboration across diverse audiences inside and outside of the university.
- Strive for continual learning: set clear goals, evaluate program, and apply learnings.

### 3.2. Change Leadership for Sustainability Curriculum

We synthesized the key stakeholder input and insights from the design journey, considered the unique assets of Stanford University, and integrated perspectives and experience developed through our careers working in sustainability as we returned to our theoretical model. Just as we decided to go beyond competencies to develop change-makers holistically, we purposefully chose not to focus on sector-based issues, but instead developed a curriculum and program that would offer a set of perspectives, frameworks, and tools to help students study and lead change effectively in any social-environmental system, no matter the sector of interest, with an explicit normative goal of intergenerational well-being.

The resulting Change Leadership for Sustainability curriculum is defined by three core elements: (1) Understanding Complex Social-Environmental Systems; (2) Understanding Decision Making and Strategies for Leading Change; and (3) Innovating System Transformations for Sustainable Futures (see Figure 2).
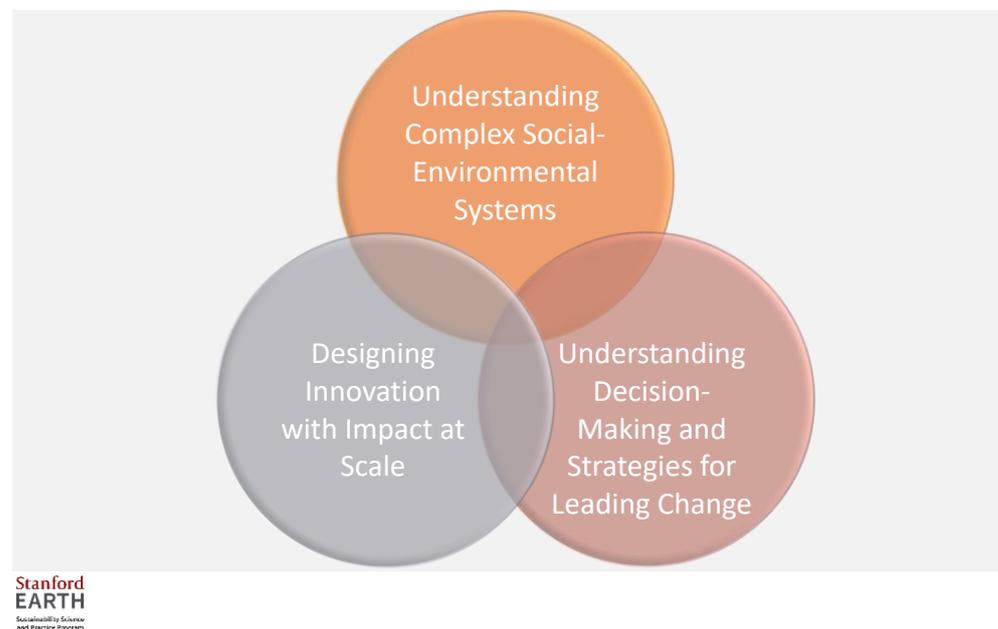


**Figure 2.** Change Leadership for Sustainability curriculum core elements.

### 3.2.1. Curriculum Core Element 1

The first curricular element, "Understanding complex social-environmental systems", cultivates a systems perspective, deepening awareness of the dynamic and interrelated nature of social-environmental systems. This element prepares systems thinkers who investigate complex interactions between human beings and their social and technological constructs and the natural world, including potential feedbacks, thresholds, and unintended consequences. Students explore global environmental change and the biophysical sciences as well as social, economic, political, cultural, and governance forces that influence the management of social-environmental systems. They develop proficiency in measuring, mapping, and modeling five assets or resources—social, natural, human, manufactured, and knowledge capital—that underpin the pursuit of sustainability, and learn to understand and manage them as integrated systems.

Courses in this element develop students' ability to understand, assess, monitor, and evaluate complex system dynamics, the state of social-environmental systems regionally and globally, and current and future human needs. Beyond required courses that examine separately the biophysical and social aspects of social-environmental systems and a core course that focuses on systems dynamics, students broaden knowledge through additional course topics, including ecosystem services models and management; life cycle assessment;

vulnerability, risk, and resilience analysis; policy analysis; sustainability accounting, metrics and indicator systems; climate and Earth system monitoring; econometrics and cost–benefit analysis; common goods management and community-based management; and environmental law and policy.

### 3.2.2. Curriculum Core Element 2

The second curricular element, "Understanding decision making and strategies for leading change" cultivates an understanding of collaborative leadership, decision making, and change. It builds competency in strategy, partnership building, and approaches for aligning teams and organizations with the goal of sustainability. This element develops transformative leaders, who practice decision making in complex, uncertain contexts and investigate holistic and effective approaches to advancing sustainability. Core courses in this element use case studies to examine the roles of diverse actors in social-environmental systems and to explore strategies and approaches for advancing sustainability, equity, and justice. Examples include corporate partnerships with indigenous communities; circular economy; benefit corporations; pre-competitive problem solving; multi-stakeholder collaborations; and integrated goals, metrics, and evaluation approaches, including the U.N. Sustainable Development Goals, national goals and metrics beyond GDP, and environment, social, and governance (ESG) criteria in investment strategy.

Courses in this element develop students' ability to understand the psychological, social, and contextual underpinnings of decision making, including power structures. Beyond required courses that delve into psychology, sociology, decision making, and behavioral economics and a core course that focuses on sustainability strategy and the connect, adapt, and innovate mindsets of transformative leaders, students broaden knowledge through particular topic areas. These include cognitive bias; growth mindset; appreciative inquiry, active listening, and empathy; organizational theory and change; negotiation; decision analysis; power and ethics; scenario planning; participatory planning; social movement building; and strategic communications and storytelling.

### 3.2.3. Curriculum Core Element 3

The third curricular element, "Designing Innovation with Impact at Scale" cultivates the ability to probe and innovate in the context of complex systemic social-environmental challenges. This element exposes students to the type of critical thinking, mindsets, creativity, and agency that is required to understand and intervene in large-scale systems challenges. This element uses project-based learning, case studies, hands-on co-creation with real-world stakeholders, and decision making in complex scenarios. Students develop creative confidence and skills in multi-criteria assessment and evaluation to enable them to identify optimal solutions in contexts with competing objectives.

Courses in this element draw heavily on systems thinking; systems innovation methodology; resilience theory; organizational change theory; social cognitive theory; human-centered design; iterative rapid prototyping and conceptualization; multi-stakeholder partnership strategy; platform design; diffusion of innovation; foresight; and storytelling techniques. Beyond required courses that delve into design thinking and social change, and a core course that focuses on system transformation, students broaden knowledge through additional course topics. These include value chain and supply chain analysis; entrepreneurship and distributed economic models; international and cross-cultural collaboration; and behavior change and theory.

### 3.3. *Change Leadership for Sustainability Program Principles, Values, and Audience*

Because the program vision is to develop the identity, perspective, capability, and agency of the New Leader, it was essential to go beyond articulating curricular content to express the foundational principles and values of the program that would enable it to accomplish transformational goals. Framing the program's principles provided a compass to maintain alignment with the vision as the program was implemented, grew, and

inevitably faced challenges. It allowed us to test whether the curriculum and principles accomplished the goal of preparing transformative change agents. If not, we could evaluate the shortcomings and determine how to evolve and improve the program. If so, the program could contribute a meaningful perspective to Stanford's new school focused on tackling sustainability and climate challenges at scale, as well as the university's intention to become a more impactful university.

### 3.3.1. Principles and Values

By reflecting on key findings from the research process and the authors' professional experience, we defined the following program principles and values:

- Values and Ethics: Explicitly articulate the core values and ethics of the program. Emphasize humility, curiosity, the importance of intergenerational well-being, the value of diverse forms of knowledge and experience, and the fundamental importance of ethics, social justice, equity, and environmental justice. Ensure that these values are reflected by the faculty, practitioners, and staff associated with the program, in all program events, interactions, communications, and materials, and integrated into the program's required courses.
- Theory and Practice: Integrate theory and practice to ensure the relevance of the curriculum and the preparedness of students to lead transformational change in society. Combine theoretical frameworks with case studies to teach students ways of thinking and working that enable them to be effective in complex, dynamic settings. Ensure students have sufficient practice applying the frameworks, so they go beyond the theoretical to the applied.
- Knowledge, Mindsets, and Skills: Teach core knowledge that is essential for understanding the complex, interactive nature of social-environmental systems and the strategies that are effective in advancing sustainability. Develop mindsets that enable students to navigate uncertainty and thrive in volatile, complex settings, and cultivate skills that strengthen their capacity to lead change through collaboration and across disciplinary and cultural boundaries.
- Applied Learning: Use teaching methodologies that enable students to practice being change-makers, systems thinkers, and collaborative leaders. Strengthen student confidence and identity as visionaries and sustainability leaders through hands-on exercises in core classes, project-based learning, and a required practicum (for master's students).
- Trans-disciplinarity: Integrate insights and approaches from multiple disciplines; and recognize and explore disciplinary biases.
- Diverse Knowledge: Integrate diverse forms of knowledge—indigenous, experiential, scientific—into the curriculum through case studies, guest speakers, and project-based learning. Actively teach about the importance of all forms of knowledge and demonstrate how inclusive problem solving contributes to holistic and sustainable solutions.
- Innovative Teaching Methods: Use innovative teaching methods to help students develop visioning skills, strengthen their creative confidence, develop their identity as sustainability leaders, and practice effecting change. Include methods such as design thinking and systems thinking workshops, reflection exercises, mindfulness practice, scenario planning, role play, collaborative projects, and interactive exercises.

### 3.3.2. Audience

We sought to develop a curriculum that would be relevant to all learners, accessible through a variety of modalities and timeframes, depending on the audience. Feedback from our consultations aligned with our intention to focus on both emerging and existing leaders—those who could exert influence now, given the scale and urgency of the challenges, as well as emerging leaders who possessed perhaps greater capacity for mindset change and would dedicate their entire careers to advancing intergenerational well-being.

For the "existing leaders", we decided to focus first on mid-career professionals, because of their greater openness to sustainability and the network connections we had already established with that audience. For the "emerging leaders", we decided to begin by developing a coterminal master's program, because it would be a relatively smaller-scale experiment that could later be expanded upon to become a stand-alone master's or include joint master's degrees, dual master's degrees, and perhaps an undergraduate degree and minor.

### 3.4. Required Courses for the Sustainability Science and Practice Master's Program

After clarifying target audiences, program principles and values, and learning objectives, we set out to create a new Master's Program in Sustainability Science and Practice, referred to as "SUST". We designed new courses, identified existing offerings across the university, and developed a pedagogy to support the program's goal of cultivating New Leaders. The comprehensive list of required courses and course options for the master's program is published in the Stanford Bulletin [19]. The authors created the courses listed as "SUST Core" specifically for the degree program, with the intention to build a solid and shared foundation for all students and address the key learning objectives of the core curriculum [20–23]. Other required courses are offered by schools and departments. In addition to the required courses, students must complete several electives from a pre-approved list of offerings. The program is highly interdisciplinary, requiring students to learn both natural science, technology, and social science concepts and practices; however, the program provides latitude for students to build a predominance of one or the other; thus, we award the degree as either M.S or M.A., the distinction (as required by the academic council of the university) being based on the weighting of coursework in the masters toward natural sciences and engineering, or social sciences.

The course content and pedagogy emphasize case study analysis, self-reflection, project-based work, and visioning in order to develop all facets of the New Leader. The program authored a series of case studies and created companion videos for the core courses to illuminate complex, systems change efforts and provide an inclusive and interactive view of actors and forces involved in driving transformative change [24–30].

The required sustainability leadership practicum is a culminating course through which students leverage their new knowledge, mindsets, and skills to address complex sustainability challenges with a partner organization. Students identify their own partner organizations, which may be corporations, start-ups, non-profits, philanthropies, or government agencies. They work with mentors on collaborative teams and apply the frameworks they have learned to make a tangible impact. They share analysis and recommendations with their partners and present their work to a faculty review committee and student peers. The practicum serves as a key indicator of how well our students are achieving the program's learning objectives. We partner with Stanford's Haas Center for Public Service to provide students with training and resources on ethical and effective community-engaged learning so that they are better equipped to design practicum experiences that integrate and balance their own educational goals with the needs of their partners [31].

### 3.5. Program Implementation, Learning, and Outcomes

Stanford's Master of Science and Master of Arts in Sustainability Science and Practice ("SUST") was approved by the university's academic council in February 2017 and began admitting its first students immediately. The Executive Program was launched the year prior, in partnership with Stanford's Graduate School of Business, to implement a custom program for a cohort of Young Global Leaders from the World Economic Forum [32] and now includes custom programs, open-enrolment programs, and an online course.

SUST has grown rapidly, increasing from 7 student matriculations in the first year to 61 new matriculations four years later, for a total of 128 students enrolling between 2017 and 2021. As expected, this program and associated curriculum has been relevant and appealing to a broad range of students, not just those who come from an environmentally

focused undergraduate degree program (as many had predicted). Thus far, students have come in with BS or BA degrees from over 30 undergraduate majors (see Figure 3), including mathematics, computer science, product design, engineering, economics, political science, international relations, English, comparative literature, history, urban studies, art history, biology, sociology, psychology, and Earth systems, among many others. The diversity of practicum projects SUST students have pursued speaks to the broad relevance of the curriculum (see Appendix A) [33].
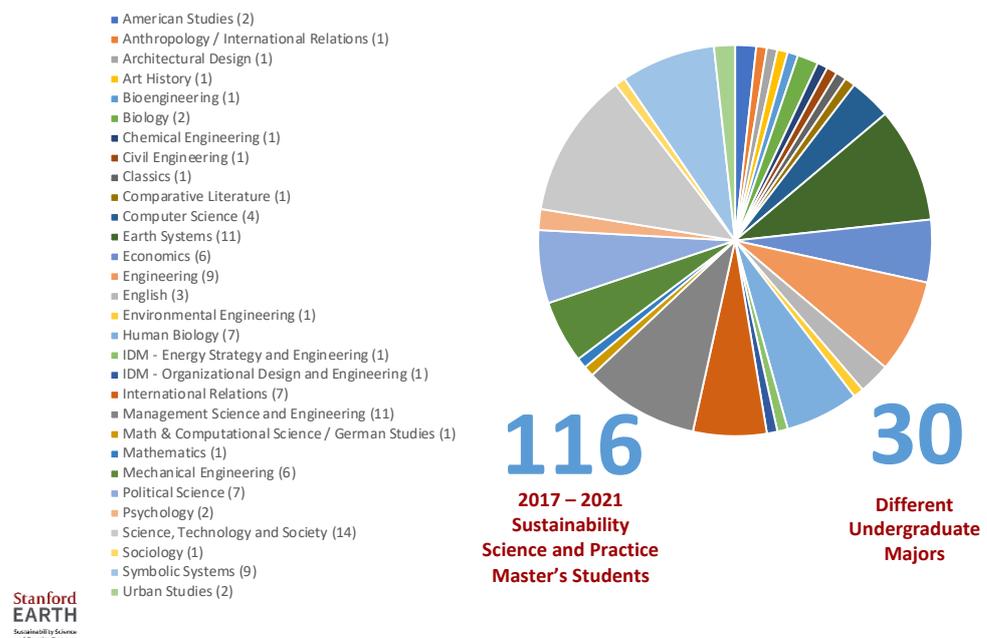


- American Studies (2)
- Anthropology / International Relations (1)
- Architectural Design (1)
- Art History (1)
- Bioengineering (1)
- Biology (2)
- Chemical Engineering (1)
- Civil Engineering (1)
- Classics (1)
- Comparative Literature (1)
- Computer Science (4)
- Earth Systems (11)
- Economics (6)
- Engineering (9)
- English (3)
- Environmental Engineering (1)
- Human Biology (7)
- IDM - Energy Strategy and Engineering (1)
- IDM - Organizational Design and Engineering (1)
- International Relations (7)
- Management Science and Engineering (11)
- Math & Computational Science / German Studies (1)
- Mathematics (1)
- Mechanical Engineering (6)
- Political Science (7)
- Psychology (2)
- Science, Technology and Society (14)
- Sociology (1)
- Symbolic Systems (9)
- Urban Studies (2)

**116** 2017 – 2021 Sustainability Science and Practice Master's Students

**30** Different Undergraduate Majors

Stanford EARTH
Sustainability Science and Practice Program

**Figure 3.** Undergraduate Majors of Sustainability Science and Practice Master's students.

The Change Leadership for Sustainability program has instituted processes to learn continually from the experiences of faculty, staff, and students during and following their time in the master's and executive programs and seeks to serve as a model for the kind of education that drives the transition to sustainability. Evaluation is an ongoing part of the program, drawing on formal and informal student feedback over the short and long terms, student career trajectories and success, and internal and external reviewer analyses to help the program continuously improve.

Executive learners complete comprehensive evaluations at the end of each program, including upon completion of the online course. The master's program conducts student entry and exit surveys annually, evaluates anonymous feedback from course evaluations, hosts informal conversations with students, and reaches out to alumni every few years to gather data. To gain faculty input, SUST convenes a bi-annual Advisory Committee meeting and gathers feedback and suggestions for program improvements from faculty advisors quarterly. SUST alumni are employed and hold positions of significant responsibility in corporations, non-governmental organizations, start-ups, and philanthropic institutions in a range of fields, including agriculture, technology, clean energy, education, social sector consulting, and investment management [34].

In 2020, SUST completed a comprehensive self-study and external review as part of the reauthorization process required of all new Interdisciplinary Programs (IDPs). In the extensive student, alumni, and faculty surveys that were included in this process, key areas of challenge, as well as feedback on the strengths of the program were identified. Students requested improvement in three areas: (1) increased access to key courses and more options for required courses; (2) reduction in redundancy in some of the core courses; and (3) greater financial support. To address the first challenge, the program identified a general earth systems course and several biophysical sciences courses to offer students

additional options for meeting their "understanding earth systems" requirement. SUST also engaged new lecturers to expand its offerings in systems science and decision making and continues to identify additional design thinking courses that meet the innovation requirement. Matson and Novy expanded the capacity of their courses to accommodate the larger student body. Yet, it is still a challenge to provide sufficient course offerings, and SUST is working with the nascent school of sustainability and climate with the hope that additional faculty will be hired who can teach courses relevant to the master's program.

Regarding the second challenge, SUST convened faculty of core courses to identify and reduce redundancy, as well as to think about how different courses can provide unique perspectives on common case studies. Finally, SUST collaborated with the School of Earth, Energy, and Environmental Sciences to launch a Coterminal Fellowship Program to provide financial support to master's students. In addition, the master's program is working with the fundraising teams for the new school of sustainability and climate to ensure that student financial aid is a priority.

The review committee that oversaw the evaluation stated that: "SUST has proven itself to be a remarkably successful program in a short amount of time, with high levels of student satisfaction and demonstrated success in attracting and training students in the advancement of sustainability around the world. We believe SUST fulfills a critical outward-facing role within Stanford's broader sustainability efforts, preparing students to become leaders in moving the world towards sustainability across a range of public and private organizations" [35] (p. 5). The review committee also noted that: "Students reported that 'SUST has fundamentally changed the way I view social and environmental challenges', and that 'the content is illuminating and applicable for any profession'" [35] (p. 6). Students cite three primary reasons why they join the program: (1) to gain an understanding of complex challenges; (2) to develop systems thinking and practical skills to create systems change at scale; and (3) to engage in a highly interdisciplinary and integrated approach to learning.

The most common strengths of the program cited in the 2020 student survey include: (1) community and collaborative spirit of the program; (2) faculty and guest speakers who have "walked the talk" by advancing sustainability in their careers; (3) range of interdisciplinary classes; (4) hands-on, practice-based learning of classes and practicum "to bridge academia to application in the real world"; (5) passionate and supportive student cohort; (6) open environment "accepting of all ideas"; (7) passion, supportiveness, and accessibility of faculty; and (8) systems change approach and problem-solving tools [35] (pp. 37–42).

In summary, after four years' experience implementing the Sustainability Science and Practice Master's Program and five years' experience implementing the Executive Education Program, the Change Leadership for Sustainability program has identified areas that require attention as well as indicators of success. The program seeks to continuously refine its evaluation efforts to better understand the extent to which the curriculum, pedagogy, and program structure are effective in developing the identity, perspective, competency, and agency of New Leaders.

## 4. Discussion

In this section, we consider curriculum functioning and options for improvement in three ways. First, from the lens of sustainability competencies as noted in the literature, particularly by the most cited competency reference framework, how does the Sustainability Science and Practice Master's Program compare [15]? Second, what approaches allow the program to cultivate student identity, perspective, and agency to prepare leaders capable of driving radical change? Third, what avenues exist for spurring broader change at Stanford University and in the Academy more generally to better prepare 21st-century citizens to lead change, as well as to increase the positive impact of higher education institutions in society overall?

### 4.1. Competencies

Regarding competencies, the Sustainability Science and Practice Master's Program aligns with the most cited reference frameworks [14,15]. For example, the systems-thinking and strategic-thinking competencies are introduced and practiced heavily in Element 1 courses; the strategic-thinking, interpersonal, and intrapersonal competencies are especially developed through Element 2; and the integrated problem solving, futures-thinking, and implementation competencies are particularly tested through Element 3. Moreover, each element touches upon all competencies to foster synergy and deepen learning from all elements of the curriculum.

The values-thinking competency is developed through each of the core and required courses, including through the integration of the Haas Center principles for ethical and effective service in student practicum proposals and projects as noted earlier [31]. The values-thinking competency goes beyond the curriculum itself to permeate the way the program interacts and communicates with students, faculty, staff, and professionals engaged in the program. The core values and social norms of the program, which emphasize dedication to intergenerational well-being, interdependence, diversity, humility, curiosity, engagement, responsibility, agency, and collaboration are shared during SUST information sessions and in program materials. These values and norms are reinforced through discussions with students about the program's vision and expectations of them, as well as through email correspondence, social events, wellness liaisons, graduate student advisory committee representatives, and communications among students, alumni, and practicum partners. The program hosts a range of events such as practicum dinners at the faculty co-director's home to foster the personal, collaborative, and supportive nature of the program.

### 4.2. A Holistic Approach to Developing Change Agents: Identity, Perspective, Competency, and Agency

The program seeks to broaden the discussion of competencies and curriculum to include *how* to develop other essential facets of emerging sustainability leaders. We know that identity is one of the most powerful forces influencing human behavior. Having certain sustainability competencies is unlikely to be as powerful as having those competencies *combined with* an identity as a capable and effective sustainability leader. In the book *Atomic Habits*, James Clear notes that the greatest predictor of behavior change is identity formation, rather than the more often cited approaches of gaining knowledge of why a particular behavior change is important, setting a goal, making a commitment to change, having a support network to aid in the change, or removing obstacles [36]. This can be seen in an example he provides that contrasts the responses of two people trying to quit smoking and relates that to the likelihood that they stop smoking. When offered a cigarette, Person A, who responds, "No thanks, I'm trying to quit", is much less likely to stop smoking than Person B who responds, "No thanks, I'm not a smoker". Person B has evolved to identify herself as a non-smoker, while Person A is working toward a goal but has not experienced a personal identity transformation.

SUST has experimented with the following approaches to encourage personal transformation and cultivate students' identity as sustainability leaders. The program directly communicates its transformative objectives through the application process, in core courses, and through reflection exercises in SUST 220 in which students articulate their life stories, core motivations, personal purpose statements, career goals, and visions for a sustainable society. The program also engages effective sustainability leaders from diverse sectors, racial backgrounds, and regions of the world to join class sessions, participate in its sustainability leadership speaker series, and serve as mentors and examples of the diverse pathways for sustainability leadership.

Similarly, SUST helps students develop perspectives aligned with their growing identities as sustainability leaders. Through an iterative process of both teaching and asking students to explore and reflect on what it means to act from a center grounded in

values, purpose, partnership, equity, and humility, the program has observed students deepening their commitment to intergenerational well-being, clarifying their personal purpose, and approaching questions and challenges with a systems perspective, examining first the relationships and interdependencies that are present, and then asking how to change the nature of those relationships in order to improve the system. As students deepen these perspectives and clarify their values, identity, and sense of purpose, SUST offers students opportunities to develop and test their capabilities in order to reinforce their identities and perspectives as sustainability leaders, and to enhance their sense of agency and confidence in driving significant change, even as young people early in their careers.

The program takes a progressive approach, beginning by providing low-stakes opportunities for students to practice acting as agents of change and then introduces more significant, real-world opportunities to develop and recognize their ability to understand complex systems dynamics and intervene strategically. Initially, in many of the required courses, students analyze and evaluate the role of different actors in complex systems case studies, requiring them to discern which strategies are most effective in advancing systems change, and articulate why. Some courses ask students to take on the roles of different stakeholders and practice what it is like to represent different perspectives within a complex problem. Students are asked to envision and "play out" future phases of case studies, practicing how their actions and decisions can lead to different outcomes and learning how outcomes can change when they engage in collaborative problem solving with other stakeholders.

Later in the program, students take on higher-stakes opportunities, developing their experience, confidence, and sense of agency through project-based work. For example, through their design thinking course requirements, they learn and practice applying design thinking and systems thinking methodologies as they conduct empathy interviews, map and analyze relationships between stakeholders, test and evaluate different intervention strategies, and present recommendations to and obtain feedback from expert practitioners who review their work. They then design and implement collaborative class projects in several required courses (see Box 1), as well as engage in extended complex problem solving and multi-stakeholder change efforts through their practicum projects [33].

*4.3. Future Directions*

An exploration of the importance of identity, perspective, and agency invites exciting questions about the nuances of *how* to nurture students in such a way that they experience internal transformation. It asks us to integrate insights from theory and practice related to transformative leadership, personal change, perspective-taking, and identity formation. It takes us outside of the comfort zone of academic conversations about curriculum, learning outcomes, and standard evaluation processes and asks us to consider values, culture, and non-traditional pedagogy that will allow us to accomplish our goal of preparing leaders to drive tangible and scaled sustainability impact in the world.

The many university programs in sustainability around the world are leading the way and should support one another in adopting best practices and continuing to innovate. Similar to many institutions of higher education, Stanford has committed to becoming a more impactful university and is in the process of designing a new school of sustainability and climate focused on sustainability challenges and solutions, which will, by definition, be concerned with the normative goal of securing intergenerational well-being. The Change Leadership for Sustainability Program has contributed learnings from its five years of implementation to many of the visioning exercises, white papers, curriculum committees, and school design teams related to Stanford's evolution. The Program will continue to encourage the university to place greater value on all forms of knowledge, increase the hiring of diverse faculty in the domains of sustainability science and practice, including professors of practice and lecturers, and create financial and other incentives for faculty from distinct disciplines to engage deeply in Stanford's interdisciplinary programs. We see great opportunity to spur broader change at Stanford University and in the Academy more

generally to better prepare 21st-century citizens to lead change, as well as to increase the positive impact of higher education institutions in society overall.

**Box 1.** Project-based Learning: Horseshoe Crabs and Ocean Plastics.

> Project-based Learning: Horseshoe Crabs and Ocean Plastics
>
> In one course, "Case Studies in Leading Change for Sustainability", students form collaborative teams and identify a sustainability challenge to work on. They are required to create tangible sustainability impact within the quarter and must describe a pathway to scaled impact if they were able to continue their efforts beyond the timeframe of the course. One team in 2021 sought to reduce the threat to horseshoe crab populations. Horseshoe crabs are harvested because their blood contains a unique compound that is used to test for endotoxins in vaccines. Inspired to spur a change amidst a massive increase in global vaccine production due to COVID-19, the team wrote a white paper outlining the threat to horseshoe crabs and the rationale for alternatives, presented a letter to CEOs of pharmaceutical companies, and launched a social media campaign and accompanying petition to encourage pharma companies to switch to the synthetic alternative.
>
> In another course, "Collaborating with the Future: Innovating Large Scale Sustainable Transformations", a student team worked with strategists from the United Nations Development Program (UNDP) and the Philippine government to address the massive challenge of ocean plastics pollution. Mid-way through the course, some of the team members had an opportunity to participate in a global summit with 170 stakeholders across the plastics value chain. Having been equipped with new skills in systems analysis and innovation from their course, the students found themselves unexpectedly leading and facilitating group discussions with senior executives, including major plastics companies (e.g., DOW) retailers (e.g., Hasbro) and management consulting companies (e.g., BCG). Using systems analysis tools, the students helped the executives look at the problem in new ways and see perspectives and opportunities that, despite their experience, they had not been able to see prior.
>
> The students returned with stronger identities as sustainability leaders and a new belief in their leadership capabilities, because they could practice and demonstrate how to take a systems approach in a real-world context, and gain genuine acknowledgement for their contributions from executives twice their age and experience. Their values and perspectives as systems thinkers dedicated to intergenerational well-being combined with their competencies to strengthen both their identity and sense of agency as sustainability leaders capable of making meaningful impact on an unwieldy challenge with diverse actors. Both have continued their collaborations with industry and NGO stakeholders from the Summit, and one went on to participate in the U.N. negotiations for a global treaty on ocean plastics in 2021.

## 5. Conclusions

By emphasizing personal reflection, interdisciplinary training, and the practice of sustainability leadership with partner organizations, the Change Leadership for Sustainability Program has been successful thus far in cultivating the identity, perspective, competency, and agency of future sustainability leaders. The program continues to test, iterate, and evaluate its approach, which represents a departure from purely content-based pedagogical models, recognizing there is much to learn as it seeks to develop New Leaders capable of taking on challenges of unprecedented magnitude, complexity, urgency, and difficulty. We believe that there is a case to be made not only for the evolution of more holistic curricula and pedagogy in sustainability programs, but for the Academy more broadly, to consider adapting and reframing educational programs across disciplines to shift norms and help forge new pathways towards intergenerational well-being.

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**Appendix A. Examples of Master's Student Practicum Projects**

Below is a summary of several practicum projects students have completed, illustrating broad applicability of the curriculum:

- Fervo Energy—Ryan Sheppard worked with a geothermal energy company, Fervo Energy, analyzing the role of geothermal in larger renewable energy systems and working with stakeholders to help decarbonize the energy sector through partnerships with governments and companies.
- NewDay Impact Investing—Laura Jacobsen and Taylor Hendrickson worked with NewDay Impact Investing, a start-up focused on enhancing corporate performance across environmental, social, and governance (ESG) criteria. Laura conducted research on ESG investment portfolio standards and Taylor launched NewDay's blog and the NewDay Impact Community, a social platform for impact events and shared experiences.
- Rebuilding Together Peninsula—Ricardo Sanchez Romero partnered with Rebuilding Together Peninsula, an organization looking to increase the development of accessory dwelling units (ADUs) in the Bay Area. He created a bilingual survey for residents to communicate their needs and his final analysis engaged local stakeholders to better understand their capabilities to support affordable housing and well-being.
- Microsoft AI for Good—Laura Mediorreal assisted the AI for Good Team at Microsoft in building and training data systems to better identify types of ocean plastic pollution, and she proposed how AI technology can be democratized by communities outside of technology companies in order to scale their sustainability projects.
- Stanford University—Land, Building, and Real Estate—Abby Bauer worked with Stanford's Office of Sustainability to measure university aviation emissions and develop strategies to reduce the university's carbon footprint. She created a final proposal with actionable strategies for air travel emission reductions and appropriate carbon offset options to be considered by the Board and administration.

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