

Developing Change Agents

DEVELOPING CHANGE AGENTS

Innovative Practices for Sustainability Leadership

EDITED BY KRISTI L. KREMERS, ALEXANDER S. LIEPINS, AND
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SUSTAINABILITY LEADERSHIP

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ANGLES: A Network for Graduate Leadership in Sustainability

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INTRODUCTION

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Today we face rapidly changing environments that increasingly require us to reinvent ourselves. The more dramatic the changes in our environment, the less we can rely on past patterns, and the more we need to learn to pay attention and tune in to emerging future opportunities.

—OTTO SCHARMER

Given the grand environmental and societal changes we face, graduate student leadership development is an area of great opportunity that allows for the cultivation of the next generation of sustainability leaders. This important leadership development work is often seen as either a natural byproduct of higher education or a non-essential add-on. Furthermore, whereas leadership development for undergraduates, or within the realm of organizational development, is nothing new, leadership development for graduate students remains underexplored, especially when coupled with the goals and impacts of scientists and sustainability.

As colleges and universities develop the scientist-leaders of the future, an awareness of how to navigate the complex social and environmental challenges that require transdisciplinary knowledge and creativity is needed. In the scientific disciplines, there is acknowledgement that leadership training is needed to ensure the success of research projects, but training must also evolve to lead to outcomes that enhance career advancement and collective action (Kvaskoff & McKay, 2014; Meyer et al., 2016). However, there are few programs that offer scientists leadership training and fewer designed to help scientists-in-training develop the capacity to address wicked problems; communicate with different audiences; and co-create the future with communities, businesses, and legal structures that can have the most sustainable impact.

In response, this book seeks to provide a context for the need for leadership programs within graduate education and the specific practices that can address the gaps between transforming knowledge into action and action into impact. In addition to chapters that address research and theory, this book specifically focuses on innovative practices and models that can be replicated by organizations and institutions.

Part One highlights program models that provide inspiring best practices and lessons learned along the way of developing graduate leadership sustainability programs. Part Two emphasizes transdisciplinary and interdisciplinary approaches to graduate leadership programs with a sustainability focus. Finally, Part Three examines how to move forward with new constructs to co-create a sustainable future through the development

of change agents. In the concluding chapter, a number of competencies that are endorsed as essential to this work are set forth.

While the focus of this book is on graduate-level leadership development, the lessons contained within can also apply to both undergraduate and faculty leadership development. We hope that whether you are a faculty member, administrator, student, or practitioner who is committed to a more sustainable and just world that you will find insights and concrete action steps on how we can move forward together.

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1.

EMPOWERING SUSTAINABILITY LEADERS: VARIATIONS ON A LEARNING-BY-DOING THEME

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The complex character of sustainability problems calls for new forms of leadership. Traditional academic training—with its emphasis on the accomplishments of independent scholars, the advancement of individual disciplines, and the production of new knowledge—is ill-suited for addressing emerging sustainability problems that require interdisciplinary collaboration, engagement with diverse stakeholders, and an integrated focus that combines problem characterization with the development of adaptable solutions (Irwin et al., 2018). As a result, traditionally trained academics often lack the necessary skills and practical experience needed for tackling wicked problems (Kreuter, De Rosa, Howze & Baldwin, 2004; Rittel & Webber, 1973).

The Senator George J. Mitchell Center for Sustainability Solutions (at the University of Maine (UMaine)), together with partners in academia, government, the private sector, and civil society, aspires to address this leadership challenge by providing graduate students with opportunities to conduct team-based, solutions-oriented research, thereby preparing them to act as change agents in our increasingly complex world. The Mitchell Center's approach recognizes that one's ability to lead in these multifaceted partnerships depends on one's competencies (e.g., thoughtful listening, reflexive communication, boundary spanning) and state of

mind (e.g., desire to learn, willingness to take risks, tolerance for ambiguity). While the authors see leadership as an individual competency that can be nurtured, we also see leadership as a condition of the organization itself, and we work to create leadership-rich organizational environments (Crona & Bodin, 2012; Marion & Uhl-Bien, 2001).

This understanding of sustainability leadership guides the Mitchell Center's graduate training approach. Graduate students are first embedded in interdisciplinary, stakeholder-engaged teams to conduct their research. Each team is part of a broader network of teams that is addressing a variety of sustainability challenges in Maine and beyond. In some ways, being embedded in a team and partnership is a more important part of training than the specific challenge being addressed. Concurrently, graduate students take part in coursework along with formal and informal training that strengthens their leadership capacity and enhances student learning in their research teams. This is accomplished by 1) providing theoretical and practice-based information on collaboration, shared decision-making, and science communication, among other topics; 2) promoting reflection and a critical analysis of one's experiences with both interdisciplinary and transdisciplinary research (Lang et al., 2012), and 3) developing specific skills such as mixed-methods research, facilitation, communication, and participatory approaches to enhance real-world decision-making. In our experience, these are crucial skills for sustainability scientists. Further, these skills are often not taught in traditional disciplines, thus other ways to facilitate this learning are needed.

In collaboration with faculty, staff, community partners, and program alumni the Mitchell Center has developed and refined this training approach over the last decade, helping train more than 200 graduate students. The authorship team of this chapter reflects our approach to leadership development. For example, Karen Bieluch and Bridie McGreavy entered the Sustainability Solutions Initiative (SSI), a program run through what is now the Mitchell Center for Sustainability Solutions and made possible through a Track 1 grant supported by the National Science Foundation, as students and are now leading the development of a chapter that reflects our approach to leadership training. This is just one example of the synergy between the training approach and the organizational culture and how it strengthens our ability to evaluate and refine our leadership development practices. We emphasize, however, that the Mitchell Center's approach should not be viewed as a model for graduate sustainability leadership development that can be strictly replicated (i.e., applied in exactly the same form in any university setting). Instead of *adopting* the described approach as a fixed strategy, the focus should be on *adapting* the approach: taking the overarching strategies we have described and adapting the approaches to your context, your situation, your students, and your system. Although it is a complex and often ambiguous journey, doing this builds the individual and organizational attributes needed for sustainability.

At every stage of our journey, we have drawn insight and inspiration from the wisdom of visionary systems thinkers (e.g., Meadows, 2001, 2008). In that spirit, we offer an introspective and adaptive set of reflections about the Mitchell Center's journey in hope that we can help others grow their capacity to train the next generation of sustainability leaders.

Background

Developing sustainability leaders is a core component of numerous sustainability science programs across the United States, yet, definitions of what leadership looks like in sustainability science remain relatively undeveloped (Shriberg & MacDonald, 2013). Unlike traditional notions of leadership, leadership in sustainability does not mean that one individual dictates the direction of the group by using single-person decision-making models, for example. In fact, it is nearly impossible for a traditional model of leadership to work to advance sustainability because the systems involved in the problems are so deeply intertwined and involve groups with diverse interests, knowledge, values, capacities, and power. One person trying to lead a knowledge-to-action process would likely fail because sustainability issues can only be addressed long-term through collaborative decision-making. Further, the inherent complexity of the systems in which sustainability scientists work and the problems of focus indicate that any sense of control, especially attempts to control decisions on a project, will be limited at best. Thus, effective sustainability leaders are characterized by their ability to work in teams and to value diverse forms of knowledge; by their willingness to cede control so others can take charge of various aspects of the work, such as solutions development, rather than having central control; and by their interest in learning from and listening to others. Given these essential skills and approaches, aspiring sustainability science leaders must not only learn how to collaborate but also how to advance the group, a project, or a solution.

Although focusing on leadership development in individuals is critically important – history demonstrates that individuals can have a dramatic impact across group, organizational, and geographic scales – a focus on the individual does not mean there is one right way to lead. In contrast, effective leadership training seeks to help people identify how they can hone their unique interests and skills – and those of others – and promotes a sense of agency in applying the skills to a group or to solving sustainability problems. For example, empirical research on leadership in complex organizations shows that diverse forms of leadership are essential for understanding and advancing solutions to vexing problems (Folke et al., 2002; Gunderson, Peterson, & Holling, 2008), a process that can complement and extend individual visionary leaders (McGreavy, Calhoun, Jansujwicz, & Levesque, 2016). People who are able to identify and craft workable solutions to a myriad of problems; those who can easily connect across differences in perspective, institutions, and other social constructs; those who are media savvy and effective communicators; and those who attend to intuition, emotion, and artistic expression all have vital roles to play and may all be considered leaders.

In addition to being a skill or attribute ascribed to an individual, leadership is also a condition of existence in any place, organization, institution, or culture (Marion & Uhl-Bien, 2001). For example, the work at the Mitchell Center is, in part, made possible because of the leadership culture of Maine (see Maine Policy Review *Special Issue on Leadership*, 2018). Leadership constructs are prominently exemplified in the narrative of the state, including in the state motto, *Dirigo* (“I guide”), and in the actions of key political leaders (e.g., Senators Margaret Chase Smith, Edmund Muskie, George Mitchell) who used their skills to advance policies for equity and environmental protection. Further, the culture of home-rule, in which Maine municipalities are able to

self-govern, helps foster leadership-rich communities in which citizens become actively involved in town and state government. Finally, as the only doctoral degree-granting institution, UMaine is the flagship institution for the state. As a public university and a Land and Sea Grant college, UMaine has a unique status since many citizens either graduated from UMaine, know alumni, or have benefitted from the services that the institution provides.

In an effort to align our leadership development activities with these cultural contexts, we conducted research to identify leadership characteristics that enhance the problem-solving capacity of sustainability science teams. Our organizational research revealed that teams who use a collaborative decision-making model realize outcomes such as continued progress towards identified goals and satisfaction with the collaboration, whereas teams that use a single decision-making model do not (McGreavy et al., 2015). Thus, to make sure students were ready to work in communities with strong principles of local control and in research teams with shared decision-making models, we provided communication training that focused on interactional competencies such as group decision-making. We also emphasized how our work is connected to and engages with the community, rather than solely viewing it for its scientific enterprise. This perspective was necessary for working within a land-grant institution, but it also aligned with our approach to sustainability science (Hart et al., 2015; McGreavy & Hart, 2017).

The Mitchell Center Approach and Outcomes

So, what leadership training approaches and organizational development have worked at UMaine and how are they sustained? There were several influential choices made during the early development of the Mitchell Center that created a sense of mission, especially as it relates to transforming the traditional academic culture at UMaine and beyond. These structural, programmatic, and pedagogical choices led us down a path to securing a large National Science Foundation grant which helped us build capacity for advancing and innovating graduate training in sustainability. While we have experienced setbacks and tried things we may not try again, we have learned and adapted along the way, leading to numerous successes. In this section, we discuss some of the choices, strategies, and outcomes of the Center's approach.

Structural, Programmatic, and Pedagogical Choices

Addressing sustainability problems and developing solutions requires that academics work across disciplines and with community stakeholders and partners at the local, state, national, and international levels to ensure that the strategies developed are viable for understanding complex problems and identifying usable solutions (Clark, van Kerkhoff, Lebel, & Gallopin, 2016; Whitmer et al., 2010). The barriers that stand in the way of such an approach and the need for focused planning are significant (McCoy & Gardner, 2012). Some of these barriers include working to address issues regarding who controls which courses are offered, what courses graduate students are allowed to take, how faculty are rewarded or “punished” if they work with others

outside their fields, and what happens if faculty engage in teamwork where individual responsibility is not easily discerned (McCoy & Gardner, 2012).

Many academic programs, including interdisciplinary ones, have trouble crossing such divides. Recognizing these barriers, the Mitchell Center took a different approach to mobilize broad-based institutional change in our graduate student training. Together, with a diverse array of faculty and key leaders in UMaine's senior administration, we developed a shared vision that stated that our efforts could not be successful without the participation of faculty and students from many different schools and departments in an interdisciplinary research center, rather than through individual departments or by way of an administrative edict. Nationally, research centers are exploring the role of becoming agents of institutional and academic change (Silka, 2001). Several factors contributed to the success of our center-focused strategy: 1) interdisciplinary collaboration is more common in UMaine research centers than in traditional departments; 2) UMaine centers are less likely to be viewed as competitors with academic departments, especially if departments benefit from increased recognition and expanded funding made possible by a center; 3) centers can provide significant support to faculty and students at low or no cost, including the development of major research proposals, administrative support for major grants, etc.; 4) centers can promote a risk-tolerant culture that allows for trial-and-error and learning-by-doing; and 5) centers can help raise university-wide awareness of and support for stakeholder-engaged, solutions-driven, interdisciplinary research, thereby enhancing the professional success of faculty and students.

Senior leadership at the Mitchell Center launched the program via a faculty-led, 'grassroots' initiative in which students and faculty sought to hone their skills in researcher-practitioner collaboration and interdisciplinary teamwork. Senior leadership at the Mitchell Center and other key campus leaders supported the initiative via advocacy, convening, team building, facilitating, and grant writing roles. An interdisciplinary team of interested scholars (senior leaders, faculty, staff, and students) involved with the Mitchell Center identified and embraced a set of core values that helped shape the Mitchell Center's distinctive organizational culture (Hart, 2018). Beginning in 2007, the Mitchell Center used a peer-review process to fund small-scale, pilot projects that helped interdisciplinary research teams gain experience working with stakeholders. Some reviewers were experts in researcher-practitioner collaboration, which helped strengthen alignment between researcher interests and stakeholder needs. In 2009, we received a major grant from the National Science Foundation that helped support 20 interdisciplinary teams of students and faculty working in a wide range of sustainability partnerships including projects focused on municipal planning, forest management, climate adaptation, and renewable energy (e.g., Hart et al. 2015). The initiative was named the Sustainability Solutions Initiative (SSI) and it led to the creation of the Mitchell Center for Sustainability Solutions in 2014. This large-scale grant provided opportunities for faculty and graduate students from more than 20 different academic disciplines to become acquainted and bring their areas of expertise together to address sustainability problems.

One of the cornerstones of our approach was a 'learning-by-doing' mindset, which reflected the idea that we would be blazing new trails and that we were sure to get disoriented or completely lost along the way. Whenever possible, we framed this work as "pilot projects," projects that provided interdisciplinary research

teams and their stakeholder partners room for trial and error. Many teams have expressed appreciation for the way our funding allowed them to take risks and learn from mistakes. An important way we have come to think about our program is how much it is like jazz. In jazz, you start with a plan and work together but also prepare to improvise around the plan together (Wilson, 1992). In our sustainability research, students may work on sea-run fisheries but then connect to projects related to vernal pools, clam harvesting, or dam removal. Students learn how to collaboratively plan and improvise when enacting those plans. This is not something that academics normally think about. They often think students need to be trained to be precise in following an exact set of protocols. Our experience has shown that this training does not work when it comes to solving complex sustainability problems. It is crucial that students learn how to adapt and keep the overarching goals but also how to improvise reaching those goals if needed.

Teaching for Sustainability Science Commitments

Sustainability science emphasizes that the need to develop problem-solving abilities, communicate across disciplines and forms of expertise, and think in terms of complexity (e.g., cross-scale connections between processes and patterns) are key focal points in learning (Brundiers & Weik, 2017; Clark et al., 2016). To achieve the competencies required in graduate education, the Mitchell Center and its partners have employed several innovative education approaches that step outside the traditional format of semester-based courses. For example, we have offered several 1-week intensive courses during winter and spring breaks where experts from diverse academic, governmental, and non-profit organizations taught students about new sustainability science methods such as conservation action planning and the theory and practice of boundary spanning work. We also offered one-on-one, directed research-focused courses that enabled students to work closely with faculty mentors to co-design coursework that met interdisciplinary training needs more fully. One such example was a directed readings course in applied science communication that filled gaps in the curriculum and served special program needs. Finally, we offered interdisciplinary courses that were team-taught by faculty involved in various sustainability projects. These types of innovative courses did several important things for students. First, they provided them with high-quality opportunities for learning to co-produce knowledge and projects, connect with stakeholders, and link course content with ‘real-world’ action. Second, these courses had built-in activities and discussions that helped develop competencies such as thoughtful listening, reflexive communication, and boundary spanning. For example, in a course focused on building community-university partnerships, students worked within teams and existing partners to develop a webinar and resource library that enabled partners to share important resources, such as templates for partnership agreements, and, at the same time, build capacity to follow best practices within their existing partnerships. To achieve these course objectives, students had to practice the above competencies rather than just learn about them as abstract theories. This fostered an understanding of the complexity of these relationships and helped them identify strategies for working through them. Finally, these courses filled a critical gap between students’ disciplinary

training and the interdisciplinary and sustainability science training they desired – and often needed – for their research (Meyer et al., 2016).

Perhaps one of the most powerful processes in the Mitchell Center approach is the co-production of courses among faculty and students. The act of co-production encouraged students to take ownership of their learning in ways not typically required in a traditional classroom. It also required faculty to ‘let go’ of their role as experts as they learned alongside students and other faculty. Unlike a traditional classroom, students were involved in conversations about how to work together and how to combine different disciplinary approaches. They also experienced, first-hand, the challenges and uncertainties of trying to work across disciplines. These conversations happened in teams and in the classroom rather than behind closed doors in faculty offices and faculty meetings. These experiences helped students see that neither their discipline(s) nor science, as a whole, are black and white; that knowledge is socially constructed; and that there are multiple ways and opinions about how to approach a given topic. This taught certain flexibility in thinking that helped students develop the necessary state of mind needed for doing sustainability work. It also helped them develop essential skills for working in transdisciplinary teams such as collaboration, communication, and linking different forms of knowledge to conduct research and develop solutions.

Another key program feature is learning to work with stakeholders. Learning-by-doing is useful in this process and is a necessary commitment because charting a path to effective partnerships is not always a clear or simple process (Silka, 1999). This is especially true when the context is unfamiliar, or the relationships are newly forming. However, commitment to learning-by-doing also requires deep engagement, research on local histories, and a reading of the literature that provides guidance on forming partnerships in effective, ethical, and lasting ways. The literature on engagement and community-university partnerships has been especially helpful in identifying guiding commitments and practical techniques (Israel, Schulz, Parker, & Becker, 1998; Trickett & Espino, 2004; Van de Ven, 2007). For example, Israel and colleagues (1998) described a set of overarching principles for partnership formation and development. They recommended starting with the perception that a community is a unit of identity as opposed to a distinct location. This perception matters because, as researchers, if we enter into a community with preconceived notions about what or who defines the community without going through the process of generating a sense of community identity with the partners themselves, we run the risk of excluding people from the outset. Further, partnerships need to strive for collaborative research in all phases of the process, especially if partners identify this as important to them, while also accepting that not all partners may want to be engaged in the entire process (Bieluch et al., 2017). Collaborative research should seek to connect with and build upon the needs and strengths of the community in ways that promote the health and interests of the community that the work is connected to (Israel et al., 1998). These broader commitments can help guide the use and adaptation of best practices or collaborative techniques such as the development of Memorandums of Understanding (MOUs) and data management plans (Silka, Cleghorn, Grullon, & Tellez, 2008). Structured approaches can help provide specificity regarding the roles and responsibilities of key partners and what data sharing and reciprocity will mean in practice and are especially important in colonial contexts (Harding et al., 2012; Simonds & Christopher, 2013).



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These partnership complexities and the need for directed learning regarding how to form partnerships could easily make someone steer away from wanting to work with partners. However, when students enter into these partnerships in a listening mode, leading with more questions than answers, they are likely to realize the utter necessity of forming partnerships to identify how to more meaningfully address problems that are of mutual concern. Said another way, partners have valuable knowledge about problems and solutions that can only be accessed and shared through the development of relationships. In many cases, their form of expertise, whether it be local, traditional, managerial, or governmental (Feurt, 2009), does not typically reside in libraries and computer databases. Learning to work with partners is also a process of learning the limits of our own knowledge about the world and potentially strengthening a sense of humility in light of this recognition (Newell, 1994).

In this literature, we have introduced our process, our approach, and some of our pedagogical choices for training graduate students in sustainability leadership. However, how do we know this approach works? How can other higher education institutions use parts of or all of this approach? To help answer these questions, we focus on the perspectives of early career faculty and researchers who were either trained at the Mitchell Center and/or conducted research with them in faculty and research positions. We focus on these individuals because

they are the future – they are the ones carrying this forward into the future. They are essential for shifting cultures and for transforming the ranks of the academy.

Reflections on Program Outcomes

Karen Bieluch, Bridie McGreavy, and Aaron Strong were provided with interdisciplinary sustainability graduate training during the earning of their Ph.Ds. McGreavy and Bieluch were trained at the Mitchell Center. One is now faculty at the University of Maine (McGreavy) and one is a researcher and administrator at Dartmouth College (Bieluch). Strong was trained in the Emmett Interdisciplinary Program in Environment and Resources at Stanford University. He spent two years as Assistant Professor at the University of Maine as a Faculty Fellow at the Mitchell Center and is now an Assistant Professor of Environmental Studies at Hamilton College. One of the established goals of many interdisciplinary sustainability graduate programs is to provide the next generation of workers in academia, government, and non-profit and private sectors with the leadership skills and acumen needed to bring new insights and actions to help address wicked sustainability problems. Many of the graduates of these programs are now sustainability researchers and problem-solvers in leading institutions of higher education, government, and non-profits. However, it is not necessarily a smooth road to career success. Graduate students walking the sustainability science path frequently hear variations of the following refrain, “But you’ll never get a job in academia...what kind of department will hire you?,” or our personal favorite, “But, *what* are you?,” as if being a human being who is an interdisciplinary sustainability researcher makes them not quite as human as being a human being who is an economist or an anthropologist or an ecologist.

While these tropes are still pervasive in many institutions, the rise in the number of sustainability graduate programs over the last several decades means that graduates of programs, like the one at the Mitchell Center, increasingly find themselves in early-career, pre-tenure academic positions – including in places like the Mitchell Center. What are their experiences like? How has their interdisciplinary training in sustainability leadership prepared them to navigate the academy? Reflecting on the ways graduate training has shaped early career academics lives, we offer three key recommendations for graduate students embarking on sustainability careers:

- 1. See yourself as a collaborator.** First, with training that spans epistemological boundaries, cross-departmental collaboration has been something that we are not only comfortable with but has also been something that comes naturally and is actively sought out. As an early career faculty, the feeling of being siloed while executing research in a single unit has not been our experience. Rather, from theoretical political ecology to field-based environmental monitoring to use-inspired, community-based research; our training taught us to speak academic languages of multiple disciplines that facilitate collaboration. We became faculty members sought out for masters and doctoral student committees for students in departments other than our home departments. We submit grants with a wide range of collaborators, often in fields that we had little exposure to in our training. While we never quite shake that “What

are you?” question, or the feeling of not quite having a ‘home,’ collaboration creates an incredibly rewarding feeling that we all share. But, we do raise a flag of caution. Junior faculty are notoriously stretched thin for time and physical and mental energy throughout academia. Acting as boundary-spanners within their institutions, the very same activities that help break down long-derided walls between academic units create a work-life balance challenge for early career faculty who approach their work from a sustainability science perspective. Thus, we also urge graduate students and early career faculty to proactively identify potential academic obstacles and work with supportive colleagues to mitigate potential professional risks.

2. Develop a flexible toolset. Sustainability researchers come in many flavors. They work on many types of problems often using tools of disciplines ranging from atmospheric chemistry to rural sociology. Despite this diversity, there is a specific toolset that is commonly used: experience and skills in team-based science and community-engaged and participatory approaches to our work. Each of us seeks opportunities to work with communities to co-produce knowledge, from the initial problem framing to the analysis of data and information to the long-term commitment to implementing research-based and creative solutions. Each project is different, but the sustainability science emphasis, creating credible, salient, and legitimate knowledge that leads to action, has provided a common set of approaches to research that we use in our work – whether it is in forests, farmland, oceans, or cities at a global or local scale. While we have common tools, we also recognize the limits of one-size-fits-all approaches since the contexts in which we work, need for information, and structures and relationships that guide participation are inherently diverse. Though we are guided by key commitments from engaged scholarships, such as setting up adaptive agreements to ensure that research processes are equitable and mutually beneficial, we also recognize that things like equity and mutual benefit will differ from one individual to the next and across collaborations. Instead of ‘canned’ approaches, we use overarching questions such as: How do you understand the problems in your community? What kinds of questions do you have and how could we design a project together to address these questions? What would you need in order to participate and how do you want to be involved in this project? These types of questions help us use engagement strategies and uphold partnership commitments that have been shown to work while at the same time maintain flexibility so that our tools are tailored to a particular situation.

3. Integrate your training, teaching, and research. Teaching future citizens and the next generation of sustainability scholars and practitioners matters. We teach courses to students who come from *all disciplines*. Our training has led us to design syllabi that attract students from the humanities to the biophysical sciences. This creates unique pedagogical challenges but also means that our courses are high-enrollment, problem-solving affairs that ensure that we will continue to train future generations of sustainability leaders. For example, in graduate courses focused on Environmental Communication in the Department of Communication and Journalism at UMaine, students come to the class with an interest in connecting communication with the social and environmental problems they are most concerned about. In some cases, students have never had a communication course before,

and they have particular views about what communication means based on their life experiences. Often, perceptions about communication are similar to the constrained ideologies about leadership we described above. They see communication as a simple process of information sharing, crafting effective messages, and delivering clear public presentations. Our training in leadership and sustainability science helps us see the need to start with where students are at in their perceptions, acknowledge the legitimacy of those views, and then create learning processes that open up new meaning and an enriched understanding of how communication can connect with and enhance awareness and praxis around issues that matter to students. This training also helps us accept that practical communication experience is its own form of knowledge; building from this practical knowledge base can make for a rich, interdisciplinary learning environment. In contrast to graduate students that come from applied fields such as ecology, environmental sciences, climate science, and education, students in communication may have been introduced to many theories and ways of thinking about communication while being almost completely isolated from the practical problems of the world. Finding ways to encourage mutual learning enhances the collective education experience, much as it does on interdisciplinary teams.

Sustaining Capacities for Sustainability Leadership Development

One of the most important and difficult challenges in building effective sustainability leadership programs is ensuring that they not only adapt but also endure. After all, we are nowhere close to having a sufficient leadership capacity to tackle the increasingly urgent and complex sustainability challenges we face. Moreover, efforts to solve, or at least reduce, the impact of such wicked problems will likely require decades, if not centuries, of work. If we cannot nurture sustained leadership and commitment, what is the point of starting?

Most of the sustainability programs at universities around the world are far too young to assess their potential longevity. The Mitchell Center is no exception. Nonetheless, we have tried to identify strategies for building programs that are resilient to stresses and shocks, whether from internal or external sources. Here, we briefly highlight several of the strategies in which we are actively engaged:

- 1. Support a variety of leaders and leadership roles.** We believe that effective leadership can take many forms and should subscribe to Lao Tzu's leadership philosophy, which predates the Harvard Business Review by over two thousand years: "When the best leader's work is done, the people say, 'We did it ourselves!'" In practice, this means we encourage students and faculty to take on leadership roles regardless of their discipline, rank, or prior experience. Although seasoned academic leaders warned us of the professional risks that early career researchers would face if they participated in stakeholder-engaged, solutions-driven, interdisciplinary research, we also recognized that many such researchers have a deep passion and commitment to "making a difference" (Sandmann, Saltmarsh, & O'Meara, 2016). Thus, we have worked proactively with early career researchers to identify and minimize these

professional risks and are happy to report that all of our faculty have successfully navigated the promotion and tenure process. We are advocates, crisis managers, confidants, and negotiators helping faculty navigate professional passions and academic structures. We view this work as another form of sustainability's commitment to intergenerational equity. In essence, we seek to ensure that the generations of sustainability leaders who follow us are equipped to address the world's future challenges.

2. Plant sustainability seeds in multiple locations. Because sustainability sometimes seems like an all-encompassing endeavor, it may be unrealistic to think it should have a single 'home' within a university. Although the Mitchell Center has its own building, budget, mission, and vision, the UMaine students and faculty who have participated in our sustainability projects have been drawn from more than 20 academic departments and schools in which they spend most of their time. Many of the faculty are now leading other innovative sustainability projects, including an NSF Research Traineeship grant that will help a new cohort of 25 graduate students gain experience in interdisciplinary research and stakeholder collaboration. In addition to the Mitchell Center's emphasis on graduate student training, we launched a novel partnership with UMaine's Honors College that focuses on undergraduates and has become a national model (Amar et al. 2016). Graduate programs can learn multiple things from this model such as how to work across disciplines, how to work with partners, and how to take a solutions focus. We have also developed sustainability collaborations with 18 other New England colleges and universities that have fostered an "adaptive radiation" of sustainability leadership programs tailored to different organizational and geographic contexts.

3. Build the plane while you're flying it! This fanciful expression, coined in an engaging commercial for a data processing company, adds some levity to the very serious challenge of learning-by-doing, including the need to respond effectively to inevitable surprises and setbacks (Alvarado, 2017). Whether these arise due to shifting institutional priorities, reductions in funding, or getting caught in political crossfire, they have the potential to disrupt or completely derail worthwhile programs. In our experience, efforts to build resilient leadership programs must couple patience and persistence with a commitment to learning on the fly. When we began our work, we launched mixed-methods research projects to identify the factors that facilitate or impede the success of key program components (e.g., interdisciplinary teamwork, stakeholder engagement). More than 40 peer-reviewed papers have now emerged from this research, serving as an invaluable resource as we iterate our way to a more effective program. Despite this wealth of information, this body of empirical work cannot prepare us for all the twists and turns that arise in training sustainability leaders. As Dana Meadows (2001) once said, it is also important to "Stay Humble" and "Stay a Learner."

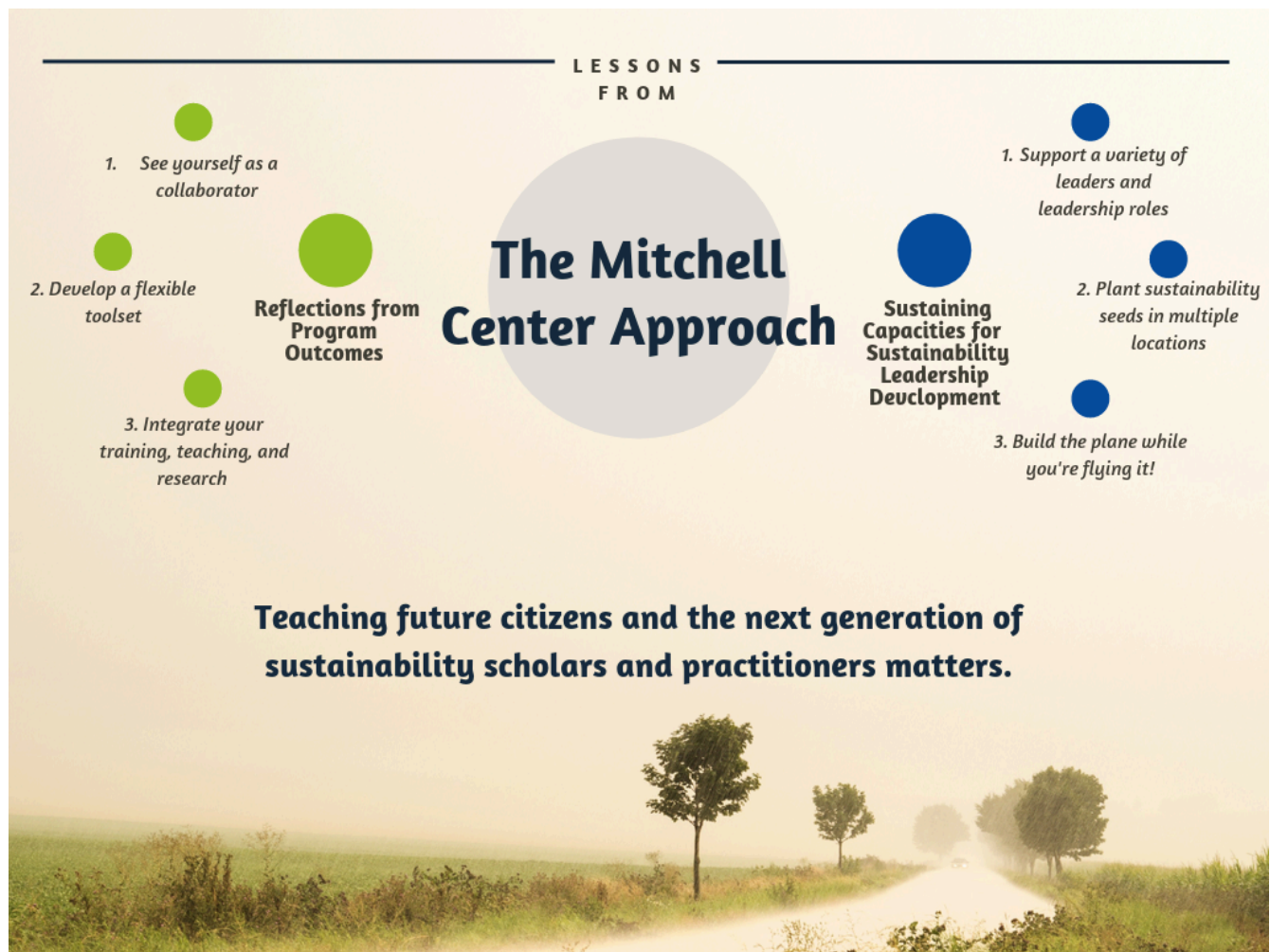


Figure 1: Lessons from the Mitchell Center's Approach

Concluding Thoughts

Universities and colleges have enormous potential to help address a wide range of sustainability challenges which, by definition, involve a tangled mix of economic, social, and environmental issues (Hart et al., 2016). This potential cannot be fully realized unless students and faculty are trained in ways that help strengthen and reinforce leadership-rich academic environments and allow them to practice and gain competency in individual leadership skills to meet the challenges. The Mitchell Center has taken steps to create an atmosphere “that emphasizes mutual respect, adaptability, and solutions,” (Hart et al., 2015, p. 1) that supports organizational learning and reflection, and that provides opportunities for training in knowledge co-production with stakeholders and in interdisciplinary teams, systems thinking across scale, and solutions development (Hart et al., 2015). We offer an approach to training graduate students in sustainability and leadership, an approach that suggests that programs need to consider not only helping develop competencies

and states of mind but also a certain organizational culture that allows individuals and teams to thrive in their efforts to advance sustainability solutions.

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2.

BUILDING A SUCCESSFUL LEADERSHIP PROGRAM

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Why Fellows, Why Now?

The Sustainability Leadership Fellows (SLF) program is run by Colorado State University's School of Global Environmental Sustainability (SoGES). The program draws upon sustainability-oriented students from across campus and disciplines. It is designed to help Ph.D. students and postdocs become articulate, thoughtful leaders in their field. The year-long fellowship provides early career scientists with training to effectively communicate science to the media and public, professional development skills and techniques, and strategies to build meaningful careers that incorporate engagement and interdisciplinarity. Through this program, we help the scientists who will be solving tomorrow's grand challenges of sustainability have a greater impact, reach broader audiences, and think more expansively about their work and its role in the world.

The Program

The SLF program has been running since 2011 and accepts 20 advanced Ph.D. students and postdoctoral scholars from across campus each year. The application process is competitive, with fewer than half of the well-qualified applicants making it into the program. Fellows are required to commit to time requisites including the orientation and workshop and their advisors or mentors must also approve their application. Both internal and external reviewers evaluate and rank applications using a quantitative ranking of 1-5 for each of five criteria

including the applicant's level of interest in communicating science, their interest in building leadership and professional development skills, the relevance of their research to sustainability science, the applicability of the training to their long-term career plans, and the overall quality of the proposal. Reviewers also give an overall recommendation that is converted into a weighted numeric score. A panel meets to discuss all the reviews and provide a final ranking. Favor is given to applicants conducting innovative and cross-disciplinary work and who have a strong motivation to improve their communication and leadership skills. The program also considers diversity across departments and colleges at the university and repeat applicants who demonstrate strong motivation to participate.

Over the program's eight years, there has been a minimum of five of the eight CSU colleges represented by fellows in any given year. Seventeen percent of fellows have been early career postdocs, a group that often lacks access to many campus resources and professional development opportunities. Fourteen percent of fellows have been non-U.S. citizens which adds another layer of diversity and perspective to each cohort.

Today, the SLF program has developed into its own comprehensive and competitive program. It has evolved over the years to be a highly sought after and well-recognized fellowship at Colorado State. The SLF program will embark on its ninth cohort of fellows in Fall 2019. To date, the highly successful program has trained 140 sustainability science-oriented Ph.D. students and postdoctoral fellows in leadership and communication. Each cohort of fellows begins the year with an orientation followed by an intensive two-day science communication training workshop run by COMPASS, a group of people who are pioneers in working with environmental scientists. Fellows then participate in six formal, two-hour training sessions led by local and university experts on a range of topics including time management and workload optimization, interacting with policymakers, data visualization, talking science with skeptical audiences, and storytelling. Fellows also take part in additional skill-building and networking opportunities throughout the year including practicing giving their elevator speeches to the university provost and writing and peer-reviewing for the SoGES blog.

"...I've been impressed by the scientific sophistication of the students and by their unmitigated enthusiasm for learning communication skills. I knew Diana Wall had an outstanding reputation as a scientist, but she also seems to have a knack for finding and motivating the sharpest young minds in the country. If my own kids asked where they should go to become articulate environmental scientists, I'd send them to her" – Christopher Joyce, Science Correspondent, National Public Radio, serves as one of the journalist trainers for the SLF Science Communication Workshop with COMPASS.

Why Communication?

The SLF program is built on the premise that communication and leadership are intrinsically linked (see Baron, 2016). This is particularly true for scientists earning terminal degrees in their disciplines and entering sustainability-relevant fields, where research findings have real-world applicability and relevance and institutional incentives for communicating outside the establishment are often minimal. While the SLF program integrates training focused on other leadership skills including time management, working on cross-

disciplinary teams, interacting with policymakers, and data visualization, the primary emphasis is placed on science communication. We believe that one of the greatest needs in sustainability science is leaders with the ability to articulately and thoughtfully speak to, connect with, and listen to diverse audiences and stakeholders. Through this program, we are creating effective science leaders who can present research findings to relevant audiences using an accurate and compelling narrative. They are also able to relate to and understand stakeholder expertise and research needs and think about how their research can help.

A recent, great example of fellows improving their science communication as a result of the SLF program was sent to us from a young Columbian researcher who was a fellow in the 2017-2018 cohort. In the year following her fellowship, she won the Top Scholar Award for University-wide Graduate Programs at the CSU Graduate Student Showcase, was an invited speaker at the Fort Collins Speaks Ciencia event organized by the 500 Women Scientists organization and won the 2018 Best Student Talk in Aquatic Ecology at the Ecological Society of America meeting. She used skills from her SLF training, including her 'message box,' one of the COMPASS tools, used in the Science Communication Workshop, to prepare and organize thoughts for different audiences and attributes her success in effective communication to her fellowship. This was a major boost to her confidence as a scientist and leader and reflected well on our program too.

"One of the biggest pieces that the training gave me was the ... understanding that it was, in fact, okay to put a piece [of] me in my science. The training, and each one of the sessions, exercises, pitches, mock interviews, and engagements gave me a new perspective on the fact that linking my science to me as a person makes the research more interesting and relatable. This is one of the best ways for the public to relate to scientists. The stories behind the reasons why people become scientists ... are one of the best ways to connect the public to science and to engage them in caring and participating. Sometimes, in the process of becoming scientists, we focus more on creating great science, but disengage [from] the wonder and motivations that got us into it; with that, we lose a great potential to communicate our science, to make it go from theory and paper to actions. Humans can transform the world, and science is a great way to do that, but it becomes less effective if we are not able to communicate it to everybody who can act! The training gave me this insight, and with that, I started opening [up] to speaking about the pieces of me that make my science what it is. People wanted to hear about how me being a mom and a first-generation student from a developing country motivates and drives the way I do science. In turn, I get the chance to spread the word about bugs, streams, and women in science!"

At the end of the program, fellows are able to elegantly deconstruct, define, and communicate their research within the framework of broader global environmental sustainability challenges using cross-disciplinary and integrative thinking.

Background and History

The SLF program was instigated by Professor Diana Wall, the school's founding director, and initially modeled after her training in the Leopold Leadership Program. Diana, a soil ecologist and established leader in the scientific community (e.g., former president of the Ecological Society of America, winner of the 2013 Tyler Prize for Environmental Achievement, and a member of the National Academy of Sciences), had her own fears about communicating science. While she enjoyed talking with her peers, talking to journalists and

policymakers felt like dangerous ground. Through her experience as a Leopold Fellow, Diana realized the benefits of training, overcame her misgivings, and was convinced of the importance of environmental scientists communicating to see their science have an impact. She became a co-lead of the Leopold Leadership Program for a couple of years. From the beginning, The Leopold program was aimed at tenured faculty because, at the time, communicating one's science was still considered risky and controversial. The question Diana, COMPASS, and others often had to answer was, "Why should we?"

Over time, the academic culture has shifted away from *why* scientists should communicate across audiences to instead *how* to communicate well. Diana increasingly felt as if starting sooner and offering these opportunities to early career scientists were critically important and that leadership for graduate students and postdocs was the key.

An important piece of what makes the SoGES program so successful is the leadership and commitment of Professor Diana Wall and Aleta Weller, who was brought on to head all the research and engagement programs at the school, including SLF, in its second year. Bringing on a motivated, dedicated individual to run the program early in its design has had multiple benefits. Weller's commitment and continuity have enabled the program – and the fellows – to evolve and flourish. Aleta brought a Master of Science background, a familiarity with CSU's campus and community, and expertise in collaborative process and facilitation. She developed the metrics for program analysis, was influential in much of its early design, and brings institutional knowledge and consistency to the program.

Any leadership program requires consistent leadership and a long-term investment. While this might seem self-evident, often the leadership programs that thrive and survive have a senior scientist or scientist to provide vision, direction, and mentorship – as well as to help secure funding. A committed staff person is essential to provide continuity, direction, and day-to-day guidance. Successful programs mean that someone wakes up thinking about how to achieve excellence. Leadership programs that are thought of as side projects are less likely to succeed.

We believe that shared strategic decision-making throughout the year and commitment from the program leader and school's director are powerful approaches to keeping the SLF program at the forefront of leadership and communication training. In order to get a long-term institutional commitment for a program like SLF, it requires there to be a knowledgeable point person responsible for its execution.

Over the past decade, we have learned a lot about what works and equally, what does not, in building a leadership program at the graduate and postdoc level. In our experience, there are five principles, or building blocks, that have contributed to the program's success and could be replicated by universities with similar goals. These are: 1) Establishing expectations at the outset, 2) Use of a cohort model, 3) Evolution built on data and feedback, 4) Competitive and prestigious design, and 5) Ongoing mentorship, leadership, and investment.



Figure 1: The five building blocks of a successful leadership program.

The building blocks (see Figure 1) outlined below are what we believe to be central to our program’s success. As program organizers, we are sharing our observations to explain why the SoGES SLF program succeeds where others may fail. Specifically, we are focusing on the five building blocks that aided in the structure and design of the program. These building blocks helped overcome common barriers that appear at similar trainings including establishing trust, overcoming participation barriers for graduate students, selecting and retaining engaged students, and setting the stage for productive meetings and events.

Building Block #1: Create Clear Expectations of Program Commitments and Time Requirements

Leadership and science communication training are particularly timely for Ph.D. students nearing the end of their degree and early-stage postdoctoral fellows. These skills empower them as they embark on their careers and provide valuable perspective and direction so that they can have a greater impact as scientists. However,

most graduate students are under considerable stress. They are managing tight deadlines and are, in general, overcommitted. Even the most honorable of intentions, to participate in supplemental training, can be difficult for this group to accomplish.

Based on discussions with programs at other universities, lack of participation can be a fairly common issue for training aimed at graduate students. Providing useful and compelling content is one obvious solution. However, these students' attention and time are so strained and divided at this stage in their careers that we have found content alone is an insufficient draw, no matter how captivating, and no matter how true their intentions are to participate.

The SLF program clearly establishes expectations and mandatory attendance before fellows are selected. We set required dates early and include them in the call for applications, so applicants are aware of the commitment they are making. We also require that all applicants be on campus over the course of the academic year and Ph.D. student applicants must be finished with coursework to avoid timing conflicts with classes. Applicants that cannot agree to these parameters are removed from the applicant pool. Once selected, when sending letters of acceptance, applicants must reconfirm full participation in the program before they are added to the cohort. While the overall time requirement, roughly 40 hours over the course of the year, is fairly minimal compared to the value of the training provided, the up-front and transparent requirement helps fellows mentally prepare for, and commit to, the program. It also helps them follow through with those commitments when regular stresses of the year become a reality. As with nearly anything worthwhile, we believe fellows will get out of the program what they put in. The explicit expectation helps them make space in their own schedule while also not allowing anyone to displace another applicant that would have made full use of the program.

Building Block #2: Build a Cohort

Use of a cohort model that spans a year – where a set number of fellows are accepted into and undergo the curriculum together – allows the SLF program to be more time efficient and builds social capital and trust among the fellows. The group is able to start finding synergies amongst themselves and build trust at the very beginning. These relationships continue to develop throughout the year and often spur new collaborations and a network of supportive relationships that may last far after the year-end. The cohort model means that each training session can be jumped right in to, without taking much time to build rapport with the group, and can cover more content in a shorter period.

Cohorts Build Trust and Save Time

Use of a cohort model allows fellows the opportunity to get to know one another and build trust throughout the year. Both the orientation and the September, two-day Science Communication Workshop, which happens early in the program, are particularly effective at beginning to break down barriers and build camaraderie in the group because they push participants outside their comfort zone at the outset and

encourage them to help each other improve. The workshop uses fellow peer review in its approach to applying new skills and building competencies in science communication. The result is not only rapid, collective learning but also many new individual connections and a shared sense of satisfaction as they observe themselves, and each other, improve at communicating their science.

The initial investment in building social capital in the group means that, for the rest of the year, our cohort is cultivating, and building on, rapport that is already established with one another rather than starting from scratch each time they meet. We find that the network has its own momentum after the initial orientation and intensive training. While we provide ongoing opportunities for engagement and check-ins at each gathering, less is required at the beginning of each meeting to get the group comfortable working on the topic together. As a result, trainers can dive more quickly and deeply into their content. This also allows each session to build from previous training. We carefully provide trainers with an overview of everything that has been covered to-date and discuss the previous training content. This helps avoid redundancy and also capitalizes on similar themes where appropriate, so each training builds on the foundations established at the outset.

Trust Helps Explore Uncomfortable Topics

In a group setting, developing some of the soft skills needed to become an articulate, thoughtful communicator and leader can be daunting and nerve-racking. Often the fellows may feel apprehension, fear, or embarrassment. This can be particularly true for scientists, who are measured by their expertise and comprehension in their subject areas and who aspire to excellence in all they do. Learning these skills often requires students to go well outside their comfort zone to practice unfamiliar skills and techniques, expose themselves where they lack knowledge, and be willing to reveal scientific weaknesses in order to better understand and refine their ability to convey messages and articulate information.

It is nearly impossible to engage fellows in these areas without first building trust within the group. This allows these areas of discomfort and possible exposure to be explored safely and allows the participants to be fully invested and involved and willing to ask questions and try new methods. Using a cohort model helps because some level of trust and interpersonal expectation has already been established for the group. Fellows are more willing to truly engage with the topic and content in this safe space.

A Cohort Model Builds an Enduring Network of Support

Finally, the use of a cohort model yields a network of fellows that has ongoing connections. Fellows generally feel a sense of belonging with their cohort and, in their end-of-year surveys, frequently report benefits to building their community over the course of the year. It is also helpful that the cohort is made up of sustainability-oriented fellows from across campus and disciplines. The cross-disciplinary nature of the fellowship allows for a robust, dynamic group that is able to share and learn from one another throughout the year and into the future.

Building Block #3: Use of Survey Data to Inform Program Design

The SLF program began sending a comprehensive end-of-year survey to fellows its second year (2012-2013). We have had a 100% response rate from fellows over the past six years and have heavily utilized these data to inform and refine the program's content and design. We also use survey data from the Science Communication Workshop and responses to their original applications as data points to analyze the program.

Use of data has helped us ensure that our perceptions are balanced, accurate accounts of the most effective ways to inform and enhance the fellowship program. Importantly, the data helps us curb our perceptions, that may be based on vocal or charismatic participants, by analyzing responses from the group as a whole. This strategy has been increasingly important over the years, especially when repetition sets in and program leaders have heard or discussed the same topics over multiple years. Surveys can also help corroborate or contradict perceptions based on body language, attention, or mood of the group.

Survey data have informed the time of year we hold the Science Communication Workshop and is the reason we started holding a more focused, and recently, even further revised orientation at the beginning of the year. These data have helped us identify programmatic components such as adding blog posts and peer review and altering the timing and flow of events including alternating which days of the week events are held and times of the year to avoid. Other elements identified include providing more social mixer and networking opportunities and ways to help fellows build a productive group. One of the most useful applications of survey data has been using it to refine and improve training content for the next year's program.

Survey Data. *Survey questions range from feedback on specific training and content to broader impacts on career, communications, leadership, and other skills. The majority of our survey questions are open-ended and include asking how fellows felt they benefited from the program, how they have applied the program knowledge to their work, whether the program has caused them to rethink their career objectives, etc. We ask fellows to give feedback on each training and select the most and least favorite training, as well as give ideas on topics for future cohorts. We also ask for their suggestions about program improvement and several questions related to how the program met or did not meet their expectations. Survey questions have evolved to include quantitative components; however, we have retained the original wording of the open-ended questions in order to continue to collect longitudinal data for the program. We recommend surveys include both closed and open-ended questions.*

Surveys to Refine Content of Training

Survey data for the six, two-hour training sessions serve two primary purposes: determining which training to repeat the subsequent year and knowing how to refine the trainings that are repeated. In advance of each cohort year, program leaders assess all the data to identify the coming year's training schedule and compare those with previous data to ascertain whether the changes that were made accomplished the intended outcome. Early in the program's evolution, the least favorite training was often either dropped from the subsequent year schedule because it failed to adequately meet the needs of the cohort in some way or it was significantly modified to more appropriately fit with the training goals and audience. Now we have evolved to the point where the 'least

favorite' training has less to do with a mismatch and more to do with the least favorite of all the generally well-liked events over the course of the year. In recent years, it is more common to use the least favorite training data to further refine a session than to drop it from the program.

Most importantly, we use survey data to select the most appropriate and useful training and alter content or presenters to have a greater impact. While, to some extent, every year fluctuates regarding what training is held based on a number of factors including trainer availability, attempting to work the schedule with other events and opportunities, and maximizing guest speakers, it is particularly helpful to use surveys to strategize around those factors and give feedback to trainers. When we reach out to prospective trainers for each year, whether or not they were the person to host that training the year prior, we give feedback to that individual about what went well and what can be improved upon. This helps the program continue to hone and provide ever-improving content to fellows.

Example of survey data used to refine training. We ran a new training in science and policy in the 2016-2017 year. In the end-of-year survey, only three of the 20 fellows selected this training as one of their two most favorite from the year, which is a pretty low rating for a training session. Feedback from the fellows included that it needed to be more interactive and that the information was overwhelming and focused on policy at too high a level, where they were unlikely to interact:

"I liked [the trainer's] policy session but I felt it could be improved with more tangible and specific ways to engage in the policy process. His session provided a nice overview of what policy engagement looks like at a national level, but it was hard for me to understand specifically how I could engage in that area. A more practical focus that also includes state and local level engagement would be really helpful." – 2016-2017 Fellow

We provided feedback to the trainer that included comments from fellows, refinements that could be made, and information about what fellows really liked and should be retained. The trainer adjusted the session according to the feedback from the group, including adding more interactive components and details about engaging with policy at local levels. In the subsequent 2017-2018 year, 11 of the 20 fellows selected it as one of their two most favorite trainings and it received a lot of positive feedback from the cohort in their surveys:

"The policy workshop with [the trainer] was excellent. It has given me a new perspective on how science and technology advocacy and funding works. The training session demystified this realm of science for me, and I look forward to using my knowledge to take part in the system." – 2017-2018 Fellow.

Another fellow also mentioned how much they enjoyed the interactive nature of the revised training:

"Eliciting a response of the fellows and starting a discussion was a dynamic way to teach science policy." – 2017-2018 Fellow

Survey Data for Programmatic Adjustments

Based on surveys, we changed the Science Communication Workshop from the spring before the fellowship year to the fall right at the beginning of the year. We found that the workshop energized and inspired fellows and that it was far more effective for the workshop to be right at the beginning of the program. This way it helped launch the cohort and build the network and it kept building momentum and appetite for the additional training pieces. Fellows now leave the workshop revved up and eager to continue. When the

workshop was held in the spring, learning from it was affected by a summer lull that took over before the fellowship year. The fellows felt somewhat let down during the summer before things picked up again.

Using this information, right after new fellows are announced in the spring, we now host an elective welcome mixer with past cohorts of fellows. This allows us to still welcome in the new cohort, have an orientation in August at the start of the semester to ground and network our cohort, and then conduct the Science Communication Workshop in September which gets everyone excited and working together early in the start of their fellowship year.

Based on surveys, we learned to always run our time management and writing productivity sessions early in the fall because fellows felt that the tools learned were highly effective and could be put into practice for the rest of the year, particularly when they were checking back in with the group. We also learned to avoid heavy or slightly depressing topics at the very end of the year because fellows found they left, what was an otherwise inspiring year, feeling discouraged. For example, one year we held a grant and proposal writing training at the end of the fellowship, which covered how much more competitive research grants have become. This felt like a demoralizing note to end on. It is better to end the program focusing on the connections made, the community of support, the bigger sustainability issues, and finding ways to applaud what has happened and can continue to happen.

Building Block #4: Competitive, Well-promoted, and Celebrated Program

Each year, SoGES makes a concerted effort to promote and celebrate the incoming and outgoing cohorts of SLF. It is a priority of the school to regularly and actively recognize and communicate the commitment and effort of these fellows to becoming better leaders and communicators in sustainability science. Externally-focused acknowledgment helps elevate the fellows and the program.

In late spring, we announce the incoming cohort of 20 fellows through university press releases and stories, through the school's email list, and by featuring them on the website and on social media platforms. We send letters individually to the CSU president, provost, and the vice president for research that includes a full list of fellows and their advisors, listed by college, that have completed the program and those incoming. We also send letters to each college dean that individually lists fellows and advisors in their college. Fellows also receive a certificate of completion at the end of the year.

Perhaps more important than the specific announcements is the ongoing effort, on the part of the school, to highlight the program with the rest of the school's engagement activities. We are sure to mention SLF during meetings with our committees and advisory boards and talk about the program regularly when discussing the school and its mission. The program is well-known and recognized at the university and we celebrate and promote the successes of fellows.

Building Block #5: Ongoing Involvement, Support, and Mentorship

A less obvious, but important, piece of the SLF program's success is SoGES's high level of investment and dedication to prioritizing the program and help fellows succeed beyond the curriculum itself. The school's Director, Professor Diana Wall, attends every SLF event, sits through nearly every training, and makes a concerted effort to get to know and remember each fellow. She and other SoGES leadership make themselves available to meet with fellows, discuss career options, lend advice, and write occasional letters of recommendation.

Additionally, in May, when the current-year fellows are wrapping up and the incoming cohort for the following year has been announced, all fellows are invited to the SoGES end-of-year open house and, more importantly, to an SLF mixer at Diana Wall's home. The mixer is fully catered and hosted and sets a welcoming and warm atmosphere with the group. The event is a strategic opportunity to welcome incoming fellows and allow all fellows that still live locally to connect with one another annually. It also sets a tone of decorum and sends the message that the program and our fellows are highly valued and that we treat the program as something more than business-as-usual curricula.

"...this Fellowship truly stands out above all others because of the passion of our organizers. As a fellow, I consistently felt that I was everyone's top priority; I knew that I could depend on any member of the SoGES team to provide me support and honest advice at a moment's notice. Thanks to each of you for making this such a rewarding and life-changing experience!" – 2016-2017 Fellow

While the training, programmatic components, and design elements are important to the success of the SLF program, the personal touches should not be discounted. We provide meals or refreshments at every training, the director personally knows and cares about the fellows coming through the program, each year the program leader communicates with and accounts for fellows' needs and interests during the designing of the program, and we ask fellows for ideas about panels or other school events. Collectively, this all adds up to something deeper and more in-depth than the status quo. We allow fellows to use SoGES conference rooms free of charge and encourage them to tap into other school resources just like any faculty member would. While most fellows do not make full use of the available services, the invitation is meaningful and conveys that they are important.

While these gestures are all small, they help cultivate investment in both directions and set a tone for the program that is meaningful and has a long-lasting impact on the fellows' careers.

Conclusion

As the global population and demand on resources increase, sustainability challenges will only become more pressing, divisive, multifaceted, and intricate. The SoGES SLF program has built a program that helps early career scientists become the leaders and communicators we need to have to address these issues. We believe the program's explicit expectations, use of a cohort model, use of survey data to inform program design,

acknowledgment and elevation of the program, and attention to detail from the highest level of SoGES and university leadership are the most important keys to the success of this program. While it may seem self-evident, leadership's critical investment in leading the program cannot be overemphasized.

Sustainability's grand challenges are entrenched and complex and will affect everyone on Earth to varying degrees, both directly and indirectly. Questions of how to sustain livelihoods on a planet with finite resources require brilliant minds, thinking critically and collaboratively from many angles, to derive creative and innovative solutions. We believe that preparing the up-and-coming innovators and informed leaders in sustainability science with the tools, skills, and network to have a meaningful impact is some of the most influential and important work we can do. The impact is magnified through all of the fellows who have completed and benefited from the program and incorporated its lessons into their careers. This is an investment in the future.

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WHERE LIVING AND LEARNING MEET: BRINGING THE CLASSROOM INTO THE CITY

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It is at the in-between—at the edges—that things really happen, where habitats blend, where life and death meet regularly. Here, dynamic tensions hold and change each other, unexpected growth is possible, and new life can flourish. Ecopsychologist, Sewall (1999) explains, “The edge between land and sea, like other ecological edge effects, is teeming with life, with abundance, as species stretch between ecological zones, as if the world is more, always more” (pp. 135-136).

Many of the challenges that modern society faces demand unprecedented collaboration between sectors, transcend traditional disciplines, are beyond any one sector (Dale, 2001), and necessitate inter- and trans-disciplinary applied knowledge skills. There is also a proliferation of community- and university-led labs in which researchers come together with community leaders and practitioners using design thinking and makerspaces in an attempt to enhance social innovation. Collaboration doesn’t happen independently. It requires unique skills and competencies normally under-valued in the academy and, in many sectors of society, found at the confluence of people, places, learning, and living. In this case, the spaces in between the classroom and the city offer a perfectly entangled place for (edge)ucators to let go of being wise and right and let what wants to happen, happen. . . for a change.

The Context

In 2017, the city of Victoria opened City Studio, a place intended to attract innovative, post-secondary learning and community engagement. At the same time, Royal Roads University was redesigning its Graduate Certificate in Sustainable Community Development program, integrating leading-edge online and face-to-face teaching and learning practices. Grounded in the principle of producing useful knowledge for decision-makers, its design included working with city officials to integrate live, local challenge case studies into its delivery.

The blended certificate program is comprised of three sequenced courses. The first, offered online, takes

students on an erudite dive into current literature and theory. Building upon the four systemic properties of general systems thinking (Lazlo, 1996), the emphasis is placed on new and radical models of collaboration, integrated and creative decision-making, climate change adaptation and mitigation, and diversity and regeneration (Dale, 2001; Dale, Foon, Herbert, & Newell, 2014). In an in-depth examination of key issues, students gain a deeper understanding of the complexities involved in solving modern day “messy, wicked” problems (Paquet, 1989) for which there are no maps, models, solutions, or right answers.

At the midway point of the certificate program, the cohort convenes face-to-face at City Studio in downtown Victoria where students experience deliberately designed trans-disciplinary collaborative processes, informed agency, and community engagement as they actively research real-life cases identified by the City of Victoria’s mayoral taskforce and senior planning staff. This hands-on, highly experiential, weeklong residency cultivates learning in a variety of settings – from traditional lectures and presentations to more spontaneous, arts-based, and improvisational learning that emerges both in and outside the classroom.

In the cumulative final online course, students face the grand challenges of sustainable community development in a co-laboratory or networked space for virtual collaboration and experimentation. Teams refine and craft first-rate practical and applied Action Plans for implementation at the local level and make their final presentations to the Mayor and City Council of Victoria. The face-to-face residency at City Studio, the centerpiece of the certificate, is the primary focus for this chapter.

We began to collaborate on our co-design about a year before it was to be delivered. Coming from two very different teaching methods and, as we discovered, very diverse literature domains, many meetings where we discussed what we read, what we thought about what we read, and our values and teaching styles were necessary. Our meetings were interactive and artful in and of themselves as we often ‘drew’ out our thinking using words and imagery. We ordered and re-ordered our ideas on giant, colorful sticky notes on the walls to find a rhythm and reason that fit the best of both of us at the confluence of our combined knowledge and abilities.

We talked about the skills and competencies we thought were needed for adult learning to be applied to sustainable community development. Learning outcomes included: the ability to effectively communicate a synthesis of insights and knowledge (using several forms of media) to create learning that incites action; demonstrated leadership through self-awareness and knowledge of self and others in order to model values, empower others, build trust, and share mutual successes; and to understand and synthesize knowledge using a systems thinking approach where the interrelationships between human, social, and ecological systems are always in the foreground. The best measure for this program’s success would be if students could take what they have studied and practice it in ways that are collaborative, adaptive, integrated, co-constructive, and change-making.

One of our fundamental assumptions was the need for students to authentically connect with and collaborate on real-world learning opportunities (Brundiers, Wiek, & Redman, 2010) and to experience different ways of collaborating—both virtually and face-to-face. Both of us were deeply committed to integrating the arts and arts-based inquiry into our teaching to illustrate a need to move away from privileging

one way of thinking and knowing over the other (Nachmanovitch, 1990). In our experience, art-making and arts-based inquiry still tend to be the ‘illegitimate children of academia.’ A more common, more traditional pedagogical approach might include readings, didactic lecture, quizzes, discussions, and final essays or projects. While these approaches can offer important learning, to make something together is more of a heuristic process that is not necessarily straightforward with its initial engagements, immersions, incubations, illuminations, creative syntheses, and final explications (Moustakas, 1990). Learning in this way may require the revisitation and repetition of material and concepts as students circle around problems and ideas before acquiring a fulsome understanding of them. By its very nature, active, experiential, arts-based learning implies more about beginnings than endings (Greene, 1995). It does not require a polished, finished product but rather allows for discoveries to emerge and take shape as iterative expressions and impressions that are unique to the learners in the moment and impossible to set beforehand.

Arts-based inquiry acts as a counterpart to the (an)aesthetics of a more static curriculum and to the hegemony of having to find that one right answer so often associated with and tied to fixed learning outcomes and objectives. Aesthetic education brings more of the emotional, personal, inner, and imaginative realms to complement and uplift rational and critical thought (Greene, 1995). “In this way, some outcomes will be unverifiable in their non-science, and often validities must be asserted through the seriousness of experience over predetermined thinking” (Leighton, 2014, p. 339). This brings the kind of learning that cannot be divorced from human-lived experience in its particularity. It requires us, as educators, to be more willingly involved, “to search for more sophisticated ways to understand and pay attention, be involved in our student’s lives,” where, “in the end, we may find we become more pedagogical, and more engaged ourselves” (Leighton, 2014, p. 339).

We also wanted to create a multi-sensory experience of ‘being in the city’ given the subject matter, especially since we would be working out of the city’s lab space, which interestingly enough is across from a safe injection site, underscoring one of the urbanity’s major issues—homelessness and drug addiction in the middle of, often pristine, urban beauty. Building upon the second author’s well-known, three-imperatives definition of sustainability (Dale, 2001), we were conscious of the significance of creating a curriculum that would also purposefully serve the personal, more subjective imperative, and create and convene spaces for transformative learning to take place (Murga-Menoyo, Espinosa, & Novo, 2017) with powerful, life-changing, and self-actualizing effects for the student.

Transformative learning is defined by Simsek (2012) as a process of deep, constructive, and meaningful learning that goes beyond simple knowledge acquisition and supports critical ways in which learners consciously make meaning of their lives. Mezirov (2009) argues that transformative learning is becoming critically aware of tacit assumptions/expectations and assessing their relevance when making an interpretation. Transformative learning also involves simultaneous learning on two levels—cognitive and affective. Bloom, Hastings, & Madaus (1971) defined the latter as including an ability to deeply listen, to respond in interactions with others, to demonstrate attitudes or values appropriate to particular situations, to demonstrate balance and consideration, and to display a commitment to principled practice on a day-to-day basis, alongside a

willingness to revise judgment and change behavior in the light of new evidence. Sipos, Battisti, & Grimm (2008) have another interesting understanding of transformative sustainability education. They believe that learning objectives are “organized by head, hands and heart—balancing cognitive, psychomotor and affective domains” (Sipos et al., 2008, p. 68). Hart (2001) encourages “an education of inner significance” (p. 7), where transformational experiences are more likely to occur when a link is made, and capacity is built between the interiority of the student and the external world. A richly layered curricular focus concerned with depth overgrowth means looking deeply into subjects rather than at the surface of things (a practice often associated with more traditional education). Hart (2001) suggests that we move from mere information exchange to open up into the rich terrain of knowledge and intelligence carved from both “the dialectics of intuition and the analytic” (p. 2). This is cultivated through directly lived experiences so students may become more capable and compassionate and have the wisdom and confidence to act ethically and the passion to do so.

Therefore, a genuine approach to transformational sustainable education requires an immersion into the environment itself, encounters with ‘Other,’ and notions of interrelatedness with all of life. This acts as an antidote to the (still) prevailing ‘epistemological error’ (Bateson, 1979) at the heart of the Western worldview, with its perception of separateness and rugged individualism, and may be viewed as an end in and of itself, with processes and outcomes particular to each student. Within a more formative and emancipatory educational context of “being in the world” (Heidegger, 1927/1962) and, in this case, *‘being in the city,’* self-knowing leads to self-actualization, reaching out beyond the discourse that happens in the classroom to consider the human soul in conversation with the world. Self-actualization (the ability to act in accordance to one’s true nature in contribution and service) as we were seeing it, more often than not leads a person to change (for the better) and is in and of itself transformative (Sterling, 2008). This is explained further in the description of the exercise called ‘Walking and Writing the City.’

In practical terms, in order to best explore issues and barriers, dialogue and consult, convene public forums and presentations, prototype and experiment, we needed to create conditions for students to systematically examine the issues of a place from its social, economic, and ecological perspectives (Dale, 2001). Therefore, we designed the program to embrace the self-organizing principles of living systems thinking. This type of system is recognized as not being able to be reduced to its components; self-stabilizing despite continual perturbations of, in, and through flowing information (and matter-energy); having the innate ability to evolve in complexity amidst this flux, and a whole in its own right as well as part of a larger whole or ‘holon’ (Lazlo, 1996; Macy & Brown, 1998). Beyond anthropocentrism, this holistic approach brings the interrelatedness of all life and our relatedness to all things into focus and suggests that what we do to the one we, in effect, do to the other, placing greater responsibility upon students for their actions and inactions. Systems thinking is now spreading through the social and natural sciences through its integration into the design of curriculums/programs themselves yet is slower to gain ground in education, even environmental education (Sterling, 2017), especially beyond mere content. For us, this meant creating the necessary space and time in the classroom to critically examine and perceive the issues from various lenses and perspectives through multiple integrated modalities (e.g., visual, auditory, ambulatory, cursive, reflective, experiential, dialogic) in an attempt to reveal

more of the interdependencies and correspondences that exist within the larger context or story rather than focus on what may be erroneously identified as “the problem.” This also meant our students were going to get outside and immerse themselves in the city (see Figure 1).



Figure 1: Elements of Bringing the Classroom into the City

If we were to have described one another before co-teaching for the first time, we would have said that one, as an ecopsychologist and arts- and nature-based educator, is very comfortable with the affective domain and the other with the cognitive domain since, as a social scientist, they have been trained in more traditional methods. In our case, co-teaching meant that we taught together each day, moving back and forth in terms of leading content areas that we each held some expertise in and converging on those that we shared. Each day we laid out who might take the lead on each 90-minute section and remained flexible to allow changes and detours to occur. We gauged this by tracking students’ responses and energy and what was happening in the ‘field’ around us (or atmosphere, if you will, which includes weather and city activities just as much as the group field). To ensure something meaningful would happen, we trusted our collective intuition about where the learning needed to go. Transparent leadership meant we openly checked in with each other several times over

the course of each session. We began to discover that each of us had a lot to learn from one another and that co-teaching would be a key learning experience for each of us. It nudged us out of our comfort zones to develop our sub-dominant styles. At first, co-teaching requires an inordinate degree of trust in one another and requires the ability to be able to creatively and respectfully ‘bridge’ one another’s differences, not by dominating, but by building on one another’s thinking and delivery. Oftentimes, co-teaching requires transparently co-creating emergent knowledge in front of students who may be unused to and unsettled by the blurred edges found in such interactive and responsive ways of teaching.

Integrative Curriculum Design

We began designing the curriculum (which included defining assessment criteria as well as learning outcomes) by first determining what affective/cognitive/critical knowledge was needed to solve messy wicked social problems and what skills/tools could concurrently be taught and showcased in practice. Working closely with city staff, we identified a number of the city’s issues of interest. The cohort then self-organized and selected the issue they were most passionate about solving. Issues such as affordable housing, sustainable transportation, urban design and public space activation, climate leadership, and social enterprise and social procurement were all on the table.

Key cognitive domains focused on applied knowledge; moving from the practicalities of sustainable community development to connection, regeneration, integrated planning, adaptation, reconciliation, and diversity, from local to global processes. If we guided the students through the problems they were facing, we wanted them to apply a myriad of lenses and theories, principles, and practices from a variety of disciplines such as architecture, art, science, nature, ecopsychology, anthropology, and dialogic inquiry. Curriculum content and design included upcycling (designing for cradle-to-cradle circular economies; see McDonough & Braungart, 2013), biomimicry (borrowing genius from nature’s designs to innovatively solve human problems; see Benyus, 1997; Harman, 2014), design thinking using makerspace (taking problems into fluid, constructive spaces of innovation, curiosity, risk-taking, and empowerment combining empathy, creativity, and rationality; see Doorley & Witthoft, 2012), bricolage (combining on-hand materials to craft the new; see Kincheloe & Berry, 2004; Wiseman, 2007), and open space technologies (allowing time and space for spontaneous, self-organizing conversations around important issues; see Owen, 2008).

While sustainable community development can be approached theoretically, it is primarily about relationships and interrelationships— with the land, with other human communities, and with our fellow creatures. “No single element in the world is not bonded to, flying away from or catalytic with another element in the world...every ecosystem is an astonishing meeting, this conversation between various dynamics that contribute to the central conversation of life” (Whyte, 2012). A primary motive of ‘relatedness’ implies that competencies developed by a systems approach that stresses an indissoluble unity of people and place in ‘conversations’ with one another is necessary for us to handle the pressing challenges facing modern societies. However, “More often than not (in education), emotional or intuitive understandings are marginalized,

considered too personal and unruly, or are discounted entirely” (Leighton, 2014, p. 139). Yet, Orr (2004) reminds us that, “There is no way to separate feeling from knowledge. There is no way to separate an object from a subject. There is no good way and no good reason to separate mind or body from its ecological and emotional context,” (p. 31) and to think otherwise constitutes “crises of perception” (Macy & Brown, 1998, p. 4). To mitigate this, we firmly rooted more embodied and embedded practices into our design so that the living world and learning had a chance to meet through the daily practice of ‘being in place’ by walking and writing about the city. Students learned to slow down, deeply listen and observe, notice, and feel their surroundings as they captured their impressions of the place through journaling, sketching, photography, etc. These ‘conversations’ with the world facilitated an understanding of the depth and sense of this place, beyond anything we could have possibly taught in any classroom.

The first assignment, called *The Lay of the Land*, had two parts. The first, due prior to the residency, was a short, introduction written from the perspective of the student’s sense of their home place that was accompanied by a photograph, drawing, or some other visual representation of the lands they were from. Guided by questions such as, *Where is the place you live? What is this place like? What do you love about this place? What is your relationship to it? How has it shaped you or have you shaped it?*, students were asked to examine their relationship to their communities to help “place” themselves both geographically and socially and provide a glimpse into their worldviews, values, beliefs, influences, etc. This assignment was intentionally designed to both literally and figuratively help the cohort better understand and appreciate the diverse places each member was ‘coming from.’ The second part of this assignment (due in the studio at the residency) required students to bring an artifact — something small (e.g., something that could fit into their hands and, of course, their luggage) — that best represented what they loved about where they lived and their relationship to that place (As environmental educators, we were, of course, careful to ask students to avoid any inadvertent destruction of habitat if they were retrieving natural objects.). After each student shared their written introductions and photographs the first morning of class, they proceeded to take their individual artifacts and use bricolage to improvise and create something of a unifying design from these diverse objects around the notion of ‘community,’ thereby creating something of a collaborative design greater than the sum of its parts. The nature of bricolage is such that the placement of one thing next to another can sometimes create new connections and insights where none existed before; therefore in the making, more, and often unexpected, meaning arises. As the week progressed, and with the accrual of more knowledge and insights, students, in effect, became bricoleurs by revisiting their initial design to continue to shape and rearrange things and add and collage in things they had found to create a kind of creative, mixed media discourse between themselves, the artifacts, and their emergent understandings. Here the metaphor of community took on a life of its own without any further instruction from us.

Continuing with the emphasis of the importance of embeddedness and place, each day, an hour was set aside within the curriculum (scheduled strategically after the lunch break) for students to individually go out and walk and write about the city. The instructions for this assignment, called *Terra Incognita*, were to traverse this unknown territory, find a place that appealed, and go there every day (in all kinds of weather) to sit and

listen, reflect, and write in their journals. Given the complexity of the issues involved in sustainable community development and the need for transformative learning on multiple levels, including personal movement and reflective practice was important for integrating and synthesizing learning. It allowed for new connections that were found at the intersection between the inner and outer worlds they wandered to be formed. Walking the city, sitting in place, slowing down, and deeply listening brought about a more conscious, participatory engagement with the world. Thought was allowed to open from the inside, connecting to the outside in rich, subtle, complicated ways, encouraging sensitivity and awareness, while striking a balance between rational thinking and the deep imagination. This was evidenced in the student journal pages that were in one and a half pages increments that were submitted three times over the course duration. We, humans, are open systems conditioned to relationship and, according to anthropologist and cyberneticist Bateson (1979), are designed as such to receive, interpret, and respond, in patterns of repetition between incoming signals and flow through information and energy and throughput/feedback in an endless spiral of give and take. This type of recursive, reflective practice stimulates a kind of soaking in of information that brings new connections and an enhanced ability to identify the permeability and interrelatedness of the local and global, people and community, species and biomes, urban and rural, and past and future, often creating new and original thought in the process. We encouraged students to consider the widest range of expression for their individual pages – writing, map-making, drawing, poetry, rubbings, photographs, sketches, pasted-in found ephemera, etc. – as they studied the deep meaning of the city in its full grit and glory.

Happily, we found that these ‘conversations’ helped students enter the sensorial present and awaken to the sounds and silences, structures and patterns, light and atmosphere, and people and energy of the cityscape. This exercise allowed them an opportunity to better attune to the lived experience of what was happening on the ground. What might have started out as a kind of surface reporting or descriptive chronicling of events, soon turned toward the personal with surprisingly deep excavations and, sometimes, revelations. These reflections afforded us a glimpse into what was stirring for individual students so that we could help closely track and kindly encourage their progress toward increased self-awareness and awareness of others throughout the course.

Building upon their residency journey, students created and curated a vivid social media presence (in this case, Pinterest) as a substantive approach to showing their perceptions and approaches to community development. Tapping into the power of visual storytelling, they posted interesting and evocative photographs after their daily encounters with the city along with additional links and videos connecting what they were learning to other innovative research from sustainable-minded cities and places. Pinterest allowed the students the immediacy of uploading and sharing a rich array of resources during the course and to continue doing so long after the course ended. Acting as a kind of ‘living library’ to chronicle their city experience, it also became an archive of resources to draw from for their final assignment and a way we could assess their individual interest and participation in using multiple forms of media and techniques.

With *Studio Time*, we used another critical reflective practice to begin each morning. A writing prompt that arose from class discussions or that was crafted as a natural segue into that day’s curriculum was offered.

In response, students wrote intuitively and freely in their journals for 10 minutes. Not only did this type of journaling act as a way to slough off extraneous and distracting thoughts, but it also cleared the way for students to hear their own voices and allow space for something to write itself *through* them. Importantly, timed writing ‘primes the pump’ (Goldberg, 1986) for further creativity and the flow of ideas, inviting what wants to surface to do so. Journal writing comes closest to reproducing how we think and how consciousness evolves (Rainer, 1978) and can be liberating when compared with the tight restrictions placed on so many other forms of writing, particularly academic. As students get to know themselves better through writing, they are more likely to make space for an ongoing, internal relationship that leads them toward the larger implications of their lives and their work (and what is unfolding in both realms) as well as allows them to bear witness to their own changes with a deepened sense of self-awareness. Demonstrations of self-awareness was not only part of the assessment criteria for learning outcomes pertaining to positive human interaction and developing leadership skills, but is also an essential competency when working with others toward shared goals and outcomes in community development as it not only allows us to bring our full selves to the table, it also allows us to bring a more conscious approach to problem-solving and collaboration overall.

As mentioned above, human-centered design thinking (Maguire, 2001; Manzini, 2015; Sanders & Stappers, 2008;), makerspaces (Doorley & Witthoft, 2012), and open space technology (Owen, 2008) were used to help each team cohort develop innovative, socially-responsible approaches to the complex city issues they were investigating. Makerspace, an all-day, design-thinking exercise, also involved city staff participating alongside the students as they moved from developing empathy around their city’s challenges to ideation to playing and tinkering to the final creation stage. Limited to using only the materials provided by their instructors (for example, kits including a range of things from cardboard to cotter pins, elastic bands, jumbo straws, doweling, clothespins, muffin cups, and playdoh) and under tight time constraints, teams developed prototypes of their collaborative ideas to address diverse stakeholders’ needs and seek new, arts-based perspectives for old problems. In the end, the students made their colorful, resourceful solutions visible through highly innovative art in a final Gallery Walk at the end of the day that was open to city officials and their staff. To further highlight the importance of inter- and transdisciplinary research and knowledge, we held an evening event, called ‘The Human Library,’ where students ‘read’ people instead of books. Human libraries were designed in Denmark in the year 2000 (<http://humanlibrary.org/>) as a positive framework to hold wide-ranging conversations where real people were put on loan to readers. At human libraries, barriers and prejudices are challenged through 20-minute dialogue sessions where difficult questions are anticipated and welcomed. Students ‘checked-out’ and ‘borrowed’ a variety of people they might not normally have an opportunity to talk with including the mayor, a social profit representative working for the homeless, a street installation artist, a city planner, a local businessperson, a place-maker, a First Nations man working in provincial government, an architect, a horticulture therapist, an academic, etc.

All of these creative curricular activities, along with in-class lectures, numerous guest lectures, and field trips allowed students to gain the necessary rich experience, skills, and leading-edge practices for integrative planning and informed decision-making as evidenced by the student final panel presentations the last day of

the residency. Working from the premise that students construct knowledge on a continuum of creativity from childhood to maturity and are not empty vessels to be filled (Piaget & Inhelder, 1969) by innovative curriculum or enthused teachers, we knew that students choosing a graduate program were also, more often than not, seeking change in their lives in some capacity. Each arrives with rich and diverse experiences and vast stores of a priori knowledge, a willingness to roll up their sleeves and dig into the messiness of the issues, and to work in a kind of radical collaboration with one another in fairly short order. Every morning, to honor the wisdom and enthusiasm in the room, we flipped the classroom to provide each student the opportunity to briefly teach the class something of significance to them, which helped build their confidence. This took the format of five minutes of ‘anything goes’ and resulted in students teaching us games, offering instruction for hands-on skills, showcasing a past or current work project, playing an important piece of music to them, reading a poem or part of an article of interest, etc. While each offering was unique to that student, repeatedly, the sessions illustrated the need for diverse ways of knowing, seeing, and experiencing the world in order for true collaboration and appreciation to take hold. Of course, we also all learned something new. As the classroom became more tensile and safe over time and as students wrestled with the edges of their own agency and the needs of the community through the issues at hand (perhaps aided, in part, by this type of rehearsing each morning and learning by doing through makerspace and open space), they appeared more fluid in their thinking, more willing to make mistakes and learn through experimentation, and more willing to improvise and even change direction midstream if need be.

Through their encounters with self and others, through writing, moving, sitting, reflecting, making, tinkering, prototyping, and presenting, we noticed the students were being compelled to act on behalf of the city and its inhabitants, were becoming more confident about taking action (and making plans), and, in effect, were actualizing their knowledge in response to the challenges they faced. Their increased ability to track and synthesize a flow of ideas in order to clarify, critically co-create, analyze, and further synthesize and reason was apparent in the culmination of ideas and insights found in their rich, relevant, multimedia draft presentations at the end of the week. Their final research assignment was evaluated by a panel comprised of city planners and academics from the university who critiqued each team’s preliminary thinking and ‘work-in-progress’ to date in preparation for the final course where further refinement of their research would take place online.

In the beginning, we had very differing views about what to integrate and how much. The first author is also a poet and thus wanted to bring in poetry to punctuate teaching points throughout the classes. The second author was somewhat uncomfortable with this but decided, in the interests of collaboration, to flow with this, in her opinion, unusual way of teaching. In the end, it proved to be a very moving experience with the second author closing the final class with one of her favorite poems. The classroom was intended to be an inviting space, so we thoughtfully curated with beautiful fresh flowers, refreshments, food, and plenty of resources such as topical books, magazines, and art materials that could be used anytime. Each morning, the students arrived to a new quotation on the board that was intended to spark further conversation. We considered pacing and timing, planned and unplanned spaces for reflection and dialogue, and checking in, all very important for continued personal care and transformation. Lectures moved from the very personal anecdotal to the more

standard knowledge sharing and reiterating. At last, we reached our stride over the last three days where we could easily model an authentic, transparent, and interdisciplinary teaching practice and more integrated, synthetic knowledge sharing. Teaching in this way, moved us from feelings of service to joy.

Lessons Learned

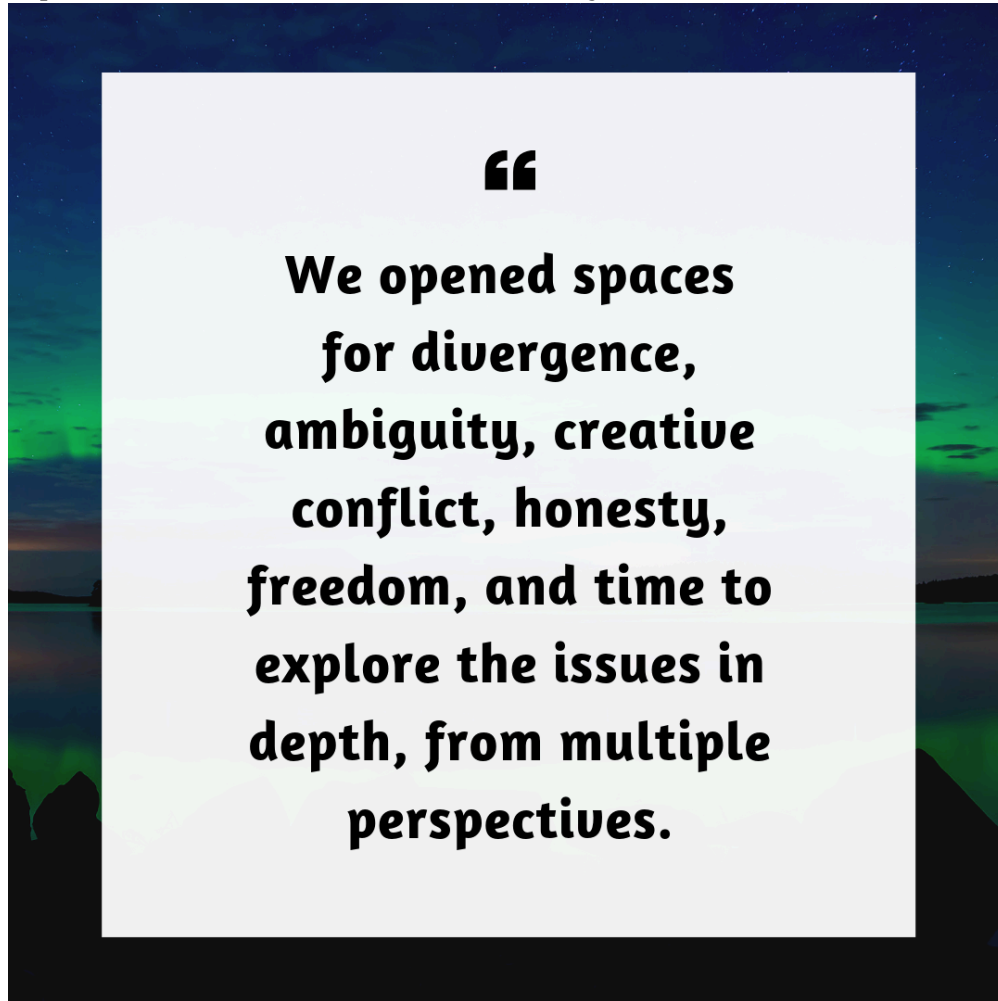
As individuals and part of a co-teaching team, we consciously implemented a ‘both-and’ approach to designing and delivering our residency, one that invited natural and social science, the urban and the rural, the cognitive and the affective, individual assignments and group work, and rational and imaginative thinking, to embrace the wholeness necessary for human development and maturation (Jung, 1921/1971, 1953/1968). This was a constant reminder for both of us to keep heuristically opening up to one another’s viewpoints and continually inviting what was emerging from the class moment to moment rather than stay focused on any fixed idea of set outcomes. Through this shared experience, we have come to understand that leading from the edge means being willing to humbly walk (and meet) the edges of ourselves and be willing to be changed in the process too.

As our students went out of the classroom day after day, we noticed they were becoming incrementally braver. They reported that they began to see the city with new eyes and, as a result, found more compassion for those living on the street. We noticed their language was changing from an objective ‘them’ toward a more inter-subjective ‘we’ as they began to see themselves as obligated citizens rather than students simply studying a problem from afar. We also saw the city in a new light as we both walked out each day and began to peer beneath the veneer of this garden-like city at the harder edges of our downtown neighborhood. Several teams brought this to bear in their research when they made recommendations for the designing of public access spaces appropriate for pedestrians, wheelchairs, baby carriages, bicycles, and grocery carts. Not rushing to fix or solve, the students were more interested in widely and sensitively consulting for a more systemic and integrative view of the challenges the city faced. The modalities of paying attention, asking good and difficult questions, listening, reflecting, and building empathy and understanding, that they were experiencing in the class, were being applied directly to their research approach.

“What scholars now say – and what good teachers have always known – is that real learning does not happen until students are brought into relationship with the teacher, with each other and with the subject” (Palmer, 1998, p. xvi), and we would like to add— and with *themselves*. Our experience convinced us that personal change must come from the inside rather than exclusively from external sources and pressures alone. For this to occur, a whole person perspective of teaching must include the body, mind, heart, and soul with attendance to the student’s experience and interests through divergent practices that build on their “capacity for personal strength, self-knowledge, integrity, compassion and cooperation” (Todesco, 2012, p. 115). Effective and responsive teaching requires that we draw from the entire epistemological spectrum of cognitive, aesthetic, emotional, physical, and spiritual intelligence to align meaning and purpose for what is essential to each student (Hart, 2001; O’Sullivan, 2008; Palmer & Zajonc, 2011; Selby, 2002; Sterling, 2001). We also must be “careful to provide a balance of creative, practical, scientific competencies and artistic skills

as well as environmental awareness toward the efficacy of that student” (Leighton, 2014, p. 312) to create the changes required within the whole ecology to create an emerging new world.

What we didn’t fully anticipate is how much the students would claim they had changed as the result of an integrative approach and how, in turn, they seemed to be self-actualizing with some immediacy in their lives and work. Direct feedback from one student was that he won a significant job competition in the field of community development and claimed this was due to the experience and confidence he accrued from this kind of learning. A handful of students decided to enroll in the graduate interdisciplinary program that will incorporate these nine credits toward a master’s degree.



Upon reflection, we believe that to meet ‘messy, wicked problems’ head on in sustainable community development, we need to meet messy with messy in our curricular design. We opened spaces for divergence, ambiguity, creative conflict, honesty, freedom, and time to explore the issues in depth, from multiple perspectives. This allowed our students to be able to deeply grasp the seriousness of what is at stake when recommending a change in real time. The courage to teach something emergent requires risk-taking with the curriculum (Palmer, 1998), transparent and respectful co-teaching, and an ability to invite art, nature, and innovation every day. We learned that if we were willing to let learning arise and shape itself around a city’s difficult issues in ways we could not know until the students had enough time familiarizing themselves with

the city and its inhabitants, then something extraordinary would happen. We let go of rigid timetables to accommodate spontaneity, opportunities, and last-minute guests, and we let go of the notion of a finished product at week's end, as this residency was clearly about allowing thinking-in-progress. Our sense was that the students were on a quest (toward their own futures as well trying to find answers and make recommendations to the city), so we had to be flexible and responsive to what was emerging, all the while trusting that overarching certificate learning outcomes would be reached during the third and final course where the polishing and refinement takes place. We had to resist tidying everything up, expecting concrete or finessed presentations on the last day which, in the end, served the student's in positive ways as we placed our trust in them to get from here to there. While the city has its own grittiness, so does teaching in this way. Our takeaway is to be reminded that when we invite humility over hubris, emergence over expectation, and grace over glory, and when we keep the space hospitable, energized, bounded, and open, we can trust intelligence will flourish and transformations will occur. Finally, to know our subject well was clearly not enough. We needed to get to know our students equally as well which meant allowing each one time to teach us what they knew and to give them enough time to think, wander, reflect, make, play, metabolize, and finally actualize their knowledge (as individuals and as a team). This effort was happily reflected in their ongoing participation, journal reflections, and engaging final team presentations.

Self-actualization is change. Sewall (1999) notes that the ecotone is always "teeming with life, with abundance...where "the world is always more" (pp. 135-136), more complex and mysterious, more diverse and uncertain, and indeed, more possible. In creating a curriculum of confluences that faithfully attends to each student's experience and interests, artistically building upon their knowledge and confidence, and helping ready them to respond to the complexities at hand where meaning and purpose can align with action, we found learning accrued at a new, integral, and critical edge. This suggests that with well-curated, embodied, arts- and nature-based experiences and practices (in complement with other traditional forms of study) information can metabolize into deeply held personal understandings and convictions and transdisciplinary knowledge, where students can become agents for a kind of action-oriented change that not only transforms themselves but holds the potential for transforming whole communities and perhaps, even at this teeming edge of possibility, the world.

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SCIENCE OUTSIDE THE LAB (NORTH): A SCIENCE AND PUBLIC POLICY IMMERSION PROGRAM IN CANADA

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We cannot solve the sustainability challenges that we face today simply by generating more scientific information and advice and supplying it to decision-makers. Mitigating and adapting to climate change, managing natural resources, and responding to emerging public health needs typify the highly interdisciplinary contemporary issues that require decisive political and corporate action. In all these areas, reliable scientific expertise is needed to support decisions made by governments and industries – but it must be integrated in upstream, nuanced, contextually-appropriate, and relationship-driven ways to solve pressing sustainability problems (see, for instance, the emerging literature on the nuance of science advice including Hoffman, Ottersen, Baral, & Fafard, 2018). Furthermore, a ‘loading-dock’ approach – such as ‘dropping off’ semi-relevant science or having notable misalignments between researcher agendas and practitioner needs – is intrinsically problematic for the scientific community and often results in augmenting value-based controversies rather than solving underlying disagreements (Sarewitz, 2004; Sarewitz & Pielke, 2007). This reality means that there is a need for decision-makers who can straddle the boundaries between science and policy, including both scientists who can provide policy-relevant science and policy makers who are scientifically literate.

But, how can we best train science professionals to work across the science-policy interface? Many research institutions offer in-depth public policy degree programs such as Master of Public Administration (MPA) or specialized, graduate-level courses in policy for students who are training for careers in public service. However, these policy-oriented programs and courses are not always available to students in science, technology, engineering, and math-based (STEM) graduate programs and career tracks, and they do not often include

specializations for those who want to focus on science policy and decision-making. Moreover, these opportunities rarely integrate neatly with the structure of STEM programs that focus on lab- or field-driven research while offering few opportunities for studying subjects outside of the specialty area. The academic job market compounds this problem. Science, technology, engineering, and math graduates are less and less likely to find careers in tenure-track roles and are more likely to work outside of academia in contexts which require an understanding of, and skills in, governance and administration.

In this chapter, we outline the role that public policy skills play in supporting sustainability, the growing impetus for graduate students in STEM to broaden their knowledge and experience in public policy, and the need for targeted public policy training for STEM graduates to support sustainability. We then introduce Science Outside the Lab (SOTL) North, an immersion program in science policy, and examine how it addresses the gaps and challenges of providing policy training to STEM graduate students in Canada.

Background

The need for STEM graduates to receive science policy training arises from today's intractable sustainability challenges which require more than deep, technical expertise in economic, social, or environmental disciplines (Wallimann, 2013). The realm of policy encompasses how decisions are made, how values are incorporated, and how uncertainty is addressed, and scientific information is just one of several factors therein. Whatever forms they take in principle and practice, initiatives that respond to sustainability challenges need sophisticated policy development and support and effective implementation. This requires an "active and urgent process of policy learning" to facilitate the framing of policy and decision-making (Wilks-Heeg, 2015, p. 43).

Science graduates working on increasingly complex challenges, such as climate change or equitable public health systems, cannot assume that their research, once disseminated, will guide public policies. This is because the drivers and effects of sustainability issues transcend geographic boundaries and often span several local and global spheres of influence. Furthermore, as exemplified by climate change, sustainability issues include a multiplicity of social, environmental, and economic dimensions for which there are no integral, technological fixes – only highly contested issues and heterogeneous stakeholder communities. As a result, STEM graduates will need to participate as equal partners in the process of building sustainability in ways that foster and balance strong communities, economic productivity, and environmental 'stewardship.' They must understand policy processes, governance, and how to participate in policy making by working and communicating effectively with various stakeholders. Key knowledge and skills in public policy are summarized in Box 1 (Bergerson, 1991).

With less than 20% of Canadian post-bachelor graduates staying in academia (Lypka & Mota, 2017), there is also an oversupply challenge facing the traditional model of transitioning from doctoral research into tenure-track academic positions. Whether because of increased competition or increased demand in non-academic roles, the training of graduate students must increasingly incorporate the skills and competencies required for employment in government, business, and the nonprofit sector (Edge & Munro, 2015; Helm, Campa, &

Moretto, 2012). Graduates in the fields of natural science, engineering, and health are even more likely to find employment outside of academic roles than their counterparts in the humanities, education, or social sciences (Edge & Munro, 2015). For these STEM graduates, their in-depth specialized knowledge and research and analytical and information management skills are highly prized by employers who are involved in the creation and implementation of public policy. For example, graduates with Ph.Ds. have the potential to facilitate the adoption of new evidence and the integration of academic research methods in areas as diverse as public health, technological management, and environmental governance.

However, there are gaps in post-graduate training that warrant the attention of graduate programs. In a 2-year investigation of graduate professional development programs at North American universities, the Council of Graduate Studies found that 8-11% of employers in the STEM workforce identified governance and science policy skills as being insufficiently addressed in the professional development of STEM graduates (Denecke, 2017). Edge and Munro (2015) also found that graduate students usually have strong networks and allies within academia, but they often need help building networks outside the academy. Therefore, the challenge is stark: sustainability requires new kinds of policy thinkers and decision-makers from an ever-growing (and potentially over-produced) cadre of graduate students. Yet, these students are often lacking the practical policy knowledge, networks, and skill development necessary to contribute their research talents to doing good outside of academia.

This generation of graduates is also launching their careers at a time when democratic norms are rapidly evolving, described by some as a “post-truth” era (Higgins, 2016). Both scientific information and misinformation are equally available and hyper-partisanship has reshaped public perceptions of science and experts. Society’s expectations of the roles of scientific and other realms of expertise are also changing and becoming polarized (Collins, 2014). Post-graduates who are preparing for careers in STEM are aware of how shifting public values and the changing roles of science in society call for enhanced approaches to sustainability. Many are interested in understanding how public policy decisions are made and how their research can better inform political decision-making and respond to policy (Science & Policy Exchange, 2016).

In addition to the drivers of both the demand for and supply of, science policy skills, Canada finds itself in a unique policy moment with respect to the role of science and evidence in decision-making. According to several public thinkers, the election of Justin Trudeau in 2015 represented an end of a period of contentious relationships between scientists and policy makers that had been present under Prime Minister Stephen Harper, a period sometimes called the “decade of darkness” (Greenwood, 2013; O’Hara, 2010). Having entered a time of less overt conflict, the scientific enterprise in Canada appears to be reinvigorated, improving the relationship with political decision-makers and cultivating the skills scientists need to work well at the interface of science and policy (Quirion, 2017).

Some intra- and inter-institutional initiatives have begun catering to the needs of STEM graduates who need training and exposure to public policy in Canada. For example, since 2008, the Ottawa-based Canadian Science and Policy Centre (CSPC) has provided a key venue for capacity building and networking among science policy leaders through the annual Canadian Science Policy Conference. According to the CSPC, more

than 500 graduate students have gained experience at the intersection of science and society; joined policy discussions; and networked with senior scientists, provincial and federal science advisors, and policy makers through the CSPC conference (Canadian Science Policy Centre, 2018). As part of its thematic workshops before and after the conference, CSPC also offers an optional, short (2-3 hour) introduction to the basics of science policy. Since its initiation, the number of graduate students attending the annual CSPC conference has been steadily increasing. By 2017, graduate students and postdocs accounted for 22% of the 677 delegates at the conference, doubling both their numbers and proportion from 2016. Montréal's student-led Science and Policy Exchange facilitates graduate students advocating for science-policy-relevant issues, exemplifying another example of STEM graduate's growing interest in science policy learning (Science & Policy Exchange, 2018).

These factors – the demand for a new generation of leadership at the science-policy interface during a time of partisanship and growing distrust of experts, the need to help recent graduates transition into and become prepared for non-academic roles, and the enthusiasm within the country for building scientific capacity – led to the emergence of a leadership development program in Canada called Science Outside the Lab (SOTL) North.

Introduction to Science Outside the Lab (SOTL) North

Science Outside the Lab (SOTL) North is an extracurricular immersion program which offers graduate students from universities across Canada an intensive introduction to science and policy issues in Canada and direct exposure to the realm of governance. Science Outside the Lab North provides a diverse group of graduate students, post-doctoral researchers, and young professionals an opportunity to gain key knowledge and insights into the real world of policy making and the role of science in society.

Science Outside the Lab North ran its first program in 2016. It was developed by a small team comprised of authors Kennedy (York University, then at Arizona State University), Harsh (California Polytechnic State University, then at Concordia University), and Dr. Heather Douglas (Michigan State University, then at the University of Waterloo). From its inception, close partnerships were formed with both the University of Ottawa (specifically the Institute for Science, Society, and Policy, via its director Monica Gattinger) and the Centre for Engineering in Society at Concordia University for program space and logistics in Ottawa and Montréal, respectively.

Initially, support for the program came from generous contributions and donations, like administrative and financial support from Concordia University and the University of Waterloo, and from program fees paid by participants. In 2018, to make the program more sustainable in the long-term, Kennedy founded the *Forum on Science, Policy, and Society* (FSPS) as a Canadian federal not-for-profit organization to house SOTL North and other training initiatives at the science-policy interface. The not-for-profit provides administrative capacity for running the program and increased flexibility for efficiently using limited financial resources while allowing

for the maintenance of strong partnerships with universities to access classroom space and support student recruitment efforts.

This Canadian program, SOTL North, was initially inspired by a program of the same name, run by Arizona State University's Consortium for Science, Policy, and Outcomes (CSPO) in Washington, D.C., that started in 2007 (Bernstein, Reifschneider, Bennett, & Wetmore, 2017; Consortium for Science, Policy & Outcomes, 2018). The Canadian version of the program differs, however, in a number of respects. The American program recruits some of its cohorts from large US National Science Foundation-funded projects where principal investigators support the students because they see the benefits that providing training to members of their labs have on the 'broader impacts' of science. Other US cohorts are associated with specific graduate programs, research networks, or policy themes. The Canadian program, on the other hand, currently runs a single, competitively selected admissions process across the country. The Canadian program is also slightly shorter (6.5 instructional days versus 10 instructional days in America), in large part to make the program more accessible to students with academic and employment obligations and to reduce the cost borne by students. Finally, as will be later discussed, the Canadian program emphasizes speaker participation from experts in all career stages (ranging from junior policy analysts to chief scientists) while the American program focuses on early-career speakers.

Program Structure

Science Outside the Lab North is an eight-day, intensive, in-person course split between Ottawa and Montréal. Participants interact directly with a wide spectrum of policy practitioners including government scientists, research funding agency officers, science-focused interest groups, science communicators, academics, and science advocates. Science Outside the Lab North organizers moderate the interactions using a modified version of the Chatham House rule (described later), which provides speaker anonymity and ensures that students receive authentic policy experiences from the guests.

Each SOTL North cohort consists of twelve to fifteen graduate students and junior researchers (at the Masters, Ph.D., and postdoctoral levels), as well as two faculty mentors who facilitate the program and live in residence with the program participants. The participants come from a variety of different countries. Past participants have come from Canada, the United Kingdom, and the United States. During the first 36 hours, participants are introduced to the basic structures of provincial and federal governance and decision-making that affect science in Canada. Throughout the five days that follow, the participants learn directly from a wide range of invited decision-makers, ranging from junior policy analysts to provincial and agency chief scientists. Under the guidance of the faculty mentors, the participants lead informal, 90-minute, group interviews with guest speakers. These sessions begin with speakers giving very short overviews of their career trajectory and duties of their current job. They then proceed through a participant-led Q&A format that covers a broad range of topics including the policy making process, the science/policy interface, career opportunities outside of academia, and personal challenges in working on science-related topics in a political or public service setting.

Speakers are discouraged from using PowerPoint or giving formal presentations so that the interaction can be driven by participants and focus on lived realities of science policy in Canada. These sessions often occur at the offices where speakers work so that participants can see the working environments and get to know the geography of science policy organizations in Ottawa and Montreal.

In addition to the sessions with decision-makers, interspersed throughout the program, participants engage in guided group reflection sessions where they are encouraged to examine their learning experiences. Additionally, SOtL participants informally meet with speakers and alumni from past programs at mixers, in Ottawa and Montréal, that facilitate more in-depth discussions and networking opportunities outside of the sessions.

As a program, SOtL North has three primary pedagogical goals related to helping participants: 1) learn key knowledge about policy, 2) acquire skills related to real-world policy making, and 3) build networks and develop careers. In terms of skill development and knowledge acquisition, participants are (a) introduced to the basics of policy mechanisms and science policy and (b) taught basic principles about communicating their research to non-academic audiences and given opportunities to practice these skills with feedback. Key knowledge includes the relationship between Canadian ‘policy for science’ (i.e., the funding, directives, and goals for publicly funded scientific enterprise) and ‘science for policy’ (research geared to decision-making), the organization of government departments, and the theory and practice of the Canadian legislative process. There is also an explicit pedagogical focus on contextualizing these abilities to help students reflect on how real-world decision-making differs from textbook models as well as some of the limitations of science and how they can be accounted for in policy-relevant settings. The third goal, that of network development, includes facilitating connections between the participants and the roughly 15-20 visiting experts who participate in the program, helping the participants refine their networking skills and increase their confidence in building these connections. Exposure to the visiting experts also helps participants expand their sense of the opportunities to engage in policy, be it through continuing in academic roles, entering the public sector, quasi-research, advocacy, or activist organizations.

Overall, through SOtL North, students are asked to consider some of the more intractable challenges of working at the science-policy interface including the difficulty and complexity involved in developing science and technology policy; how these complexities impact relationships among science, engineering, and society; the roles of science and engineering expertise in science policy; and the limitations of scientific information in resolving values-based policy debates.

SOtL North's Approach to Training Leaders

Since 2016, 67 graduate students and junior researchers have participated in SOtL North. These participants have come from universities across Canada and represented a wide range of both STEM (including medical sciences, natural sciences, and engineering) and non-STEM fields (such as social sciences, humanities, communications, and languages). In turn, the invited speakers have also come from different disciplines (food,

health, defense, etc.), federal and provincial governments, and non-profits and industries, where they deal with politics and expertise in different ways.

For early to mid-career scientists, SOTL North serves to enhance their preparedness for work in sustainability at the interface of science and public policy. The program (see Figure 1) also helps meet the individual and societal needs for knowledge and awareness of governance processes, the reinforcement of leadership skills, and the creation of broader professional networks that would support STEM graduates' careers outside of academia. The program begins with a one-day boot camp on the basics of policy and science policy in Canada. This is the only session that does not involve outside speakers since faculty mentors facilitate it. The session distills fundamental understanding about what science is and about basic civics – how the Canadian government is structured at the federal, provincial, territorial, and municipal levels – before introducing key interactions between science and policy in Canada.

Deep and nuanced awareness of science policy issues is built through unfiltered contact with diverse practitioners who funnel decades of experience into the participants. The critical leadership skills of self-directed learning, communication, and networking are strengthened as participants lead discussions with the speakers and many follow up with speakers after the program. Finally, in the debriefing session, participants synthesize what they have learned and provide critical and constructive feedback of the program's effectiveness in meeting their needs. The qualitative and quantitative information that emerges from this session has been used to continuously refine the structure and content of SOTL North (see Harsh, Kennedy, Bernstein, & Reifschneider (2016) for a detailed description of program evaluation methods and results).

Former SOTL North participant and author Kimberly John described her experience in the program as a rare exposure to the technical, personal, professional, ethical, and political realities and trade-offs that science graduates and professionals face at different life stages. The program fostered integrated perspectives as participants and guests alike shared and examined information at the local, provincial, national, and global scales and charted their careers through various public and private institutions including academia, government agencies, think tanks, museums, funding agencies, consultancies, and non-profit groups.

Because of the complicated value trade-offs and complex institutional networks that characterize the science-policy interface, almost all of the speakers discussed how their career trajectories were non-linear and the unique mix of skills that supports their career. For example, one guest was a trained biologist who, after completing a Ph.D., found that in today's political climate, they derived more value in advocating for science than in working as a pure scientist. Other guests spoke of the tensions between science advocacy and providing science advice in their everyday work. Some guests shared the struggle of maintaining one's sense of identity as a scientist when no longer working closely with the scientific community, the challenge of navigating the public service's rigid hierarchy, and the hard-won satisfaction of ushering scientifically sound trade deals or legislation through the Canadian Parliament.

At the end of SOTL North, there was a noticeable improvement in participants' competence and confidence in communicating the relevance of their scientific work to various audiences, as seen in the evolution in how participants introduced themselves to speakers and the way they spoke about their research at the beginning

of the program compared to the end of the program. However, simply communicating research may not be a priority training gap as many universities already offer science communication training for graduate students. As such, SOTL North is increasingly focusing on introducing participants to specific science-policy skills that are not addressed in their home institutions such as non-academic technical writing of memoranda, policy briefs, or op-eds. All the same, the program helped participants to identify the skills they would need and training opportunities for real-world policy development. More importantly, participants left the program significantly less convinced that scientific research is the most important factor in shaping policy (Harsh et al., 2016). This represents a major attitudinal shift and suggests the development of a more nuanced understanding of the relationship between science and policy.

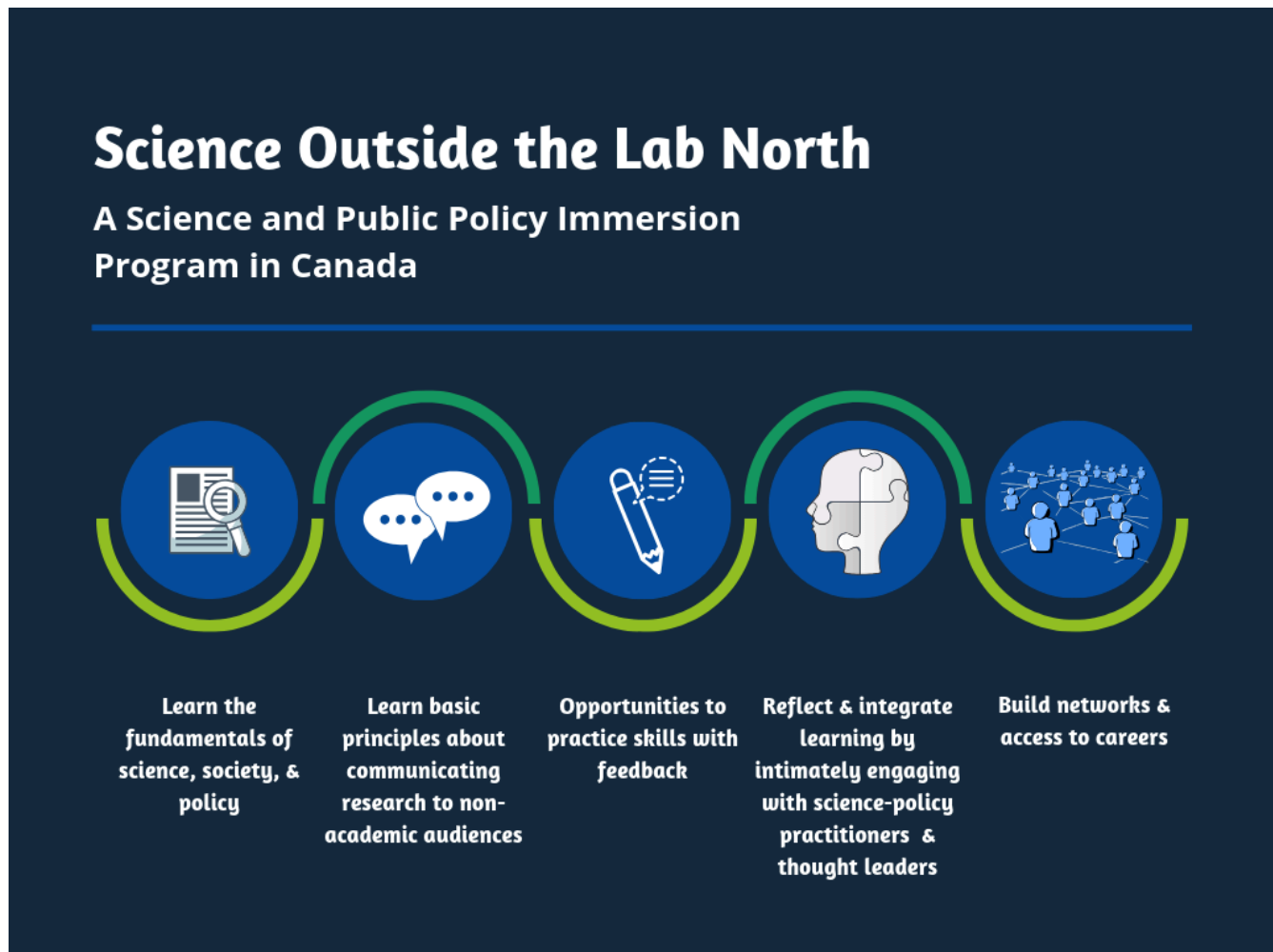


Figure 1. Science Outside the Lab North's program model.

Successes, Growth, and Challenges

As with any emerging educational program, SOTL North has had both success stories and issues that continue to need development. In the remainder of this chapter, we highlight four points of success, challenge, and

reflection. The first point has largely been a success: building a trusted space for authentic dialogue between participants and visiting experts that has led to the emergence of a system of ‘SOTL House Rules.’ The next three points – increasing diversity among speakers and participants, scaling to meet demand, and placement and alumni networks – have included both success and challenges.

Trust and the ‘SOTL House Rules’

Because the program is so heavily focused on learning directly from experts in the field, it is crucial to be able to establish an environment of trust where all participants can be authentic, open, and honest. Lines of questioning can vary significantly, ranging from discussion of roles and responsibilities to detailed conversations about current issues and program roll-outs to very individualized and personal questions about achieving work/life balance or dealing with awkward or discriminatory situations in the workplace.

As such, trust is important throughout multiple timescales. During the session itself, establishing a culture of trust is crucial for obtaining authentic answers. This trust is also critical on a year-to-year basis, in terms of recruiting speakers to return and them recommending their colleagues to the program. This means achieving both qualitative feelings of trust and a dependable system to prevent participants from sharing sensitive information post-program. During the 2016 and 2017 versions of the program, SOTL North adopted the *Chatham House Rule* to meet these aims. In its original formulation, the Rule states that:

“When a meeting, or part thereof, is held under the Chatham House Rule, participants are free to use the information received, but neither the identity nor the affiliation of the speaker(s), nor that of any other participant, may be revealed” (Chatham House, 2019).

The modified ‘SOTL House Rule’ gives speakers an option for organizers to use their names in promoting the program and for participants to use their names after the program, as long as specific information relayed during the program is still not attributed to an individual or an organization. This has largely been deemed a successful modification to the Chatham House Rule based on the number of speakers who have been willing to participate in the program year after year.

Diversity

While the program has seen significant success in attracting participants from diverse disciplinarily backgrounds, there are other dimensions of diversity that remain more challenging to fulfill. Interestingly, both the applicant pools and selected cohorts (a blinded process) skew heavily female: only 22% of program participants have been male. Yet, other forms of diversity are more elusive. For instance, because of the disproportionate number of universities, program participants often lean heavily toward being Quebec and Ontario-based. More attention also needs to be given to recruiting from under-represented groups (especially Indigenous participants). More substantial program funding would also make a significant difference in

supporting increased participation from those a greater distance from Ottawa and Montréal (those who face higher travel costs).

Similarly, the program has had a mix of successes and challenges in terms of the diversity of speakers. The program has been successful in recruiting a mix of male and female speakers and speakers that represent great diversity in terms of disciplinary training, area of work, sector of work (government, industry, and non-profit), and level of government. However, we have had more federal employees serve as speakers compared to industry and nonprofit sector speakers and more federal speakers compared to those working on policy at the international, provincial, and local levels. Recruiting a more racially diverse group of speakers also remains a challenge.

Science Outside the Lab North organizers are also developing ways of scaling to meet the demand for the program which now far exceeds participation. With the establishment of an alumni community (including a listserv, online community, and regional meet-ups), there are also increased opportunities for ongoing mentorship, networking, and training. The success of the alumni community has been significant, including alumni winning both the 2017 and 2018 CSPC Youth Science Policy Awards of Excellence. Science Outside the Lab North alumni have also been involved in the creation of a student science policy network at the University of Toronto and have had successful career placement into public service positions (such as the Natural Resources Canada recruitment program and the Government of Quebec foreign service). Also, author Kimberly John, is supporting the Trottier Institute for Science and Public Policy's proposal for a Program Option in Public Policy at McGill University. This program option would be available to graduate students who want to understand how public policy works but are not enrolled in the Public Policy program.

Conclusion

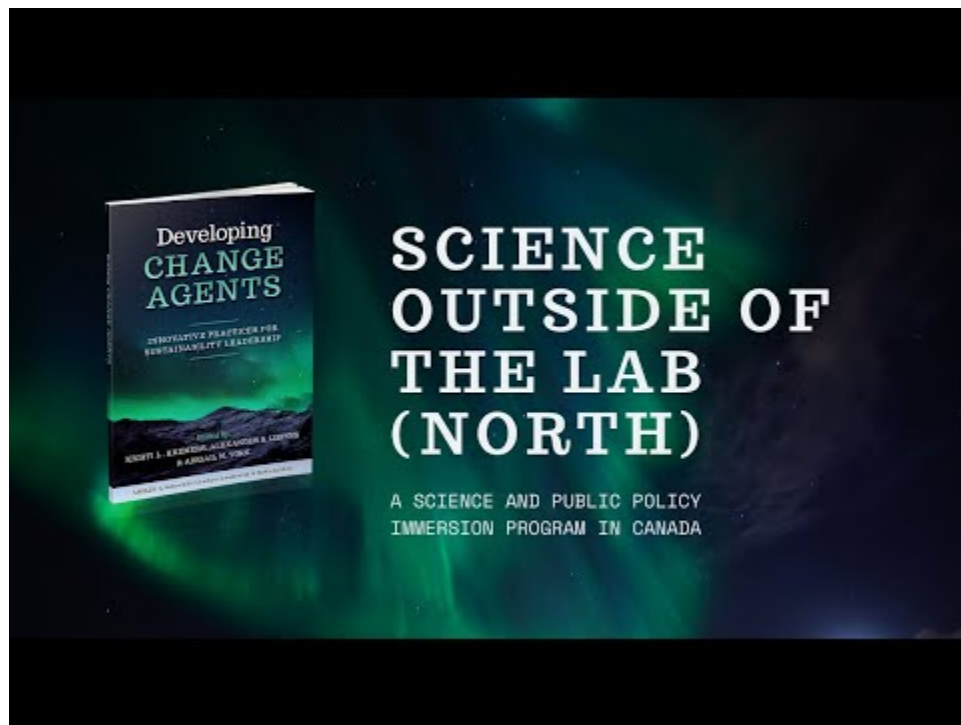
We have shown that the current sustainability challenges and societal changes require improved approaches to integrating science into public policy. Science Outside the Lab North is a unique training program for STEM graduates across Canada that directly facilitates critical thinking about science, society, and public policy in the Canadian context. The program offers participants an opportunity to 1) learn and reflect on the fundamentals of science, society, and public policy while 2) intimately engaging with science-policy practitioners, thinkers, and real-world issues; and 3) developing their careers. This program addresses the needs and realities graduate students who have limited time and funding for full-blown courses and programs face yet provides depth and breadth for deep learning.

It would be easy to recommend the replication of SOTL's approach to developing leaders in sustainability. However, any replication at the municipal, provincial, or national levels must consider the factors that have contributed to the program's growth and effectiveness over the last few years. These factors include SOTL's relatively low cost (due in part to the small, nimble organizing team) and short duration; the trust cultivated between instructors, guests, and participants through the SOTL House Rules, and the overall Canadian context where a (small) majority of the population holds science in high regard.

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A YouTube element has been excluded from this version of the text. You can view it online here: <https://open.lib.umn.edu/changeagents/?p=21>



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5.

THE MASTERS OF DEVELOPMENT PRACTICE (MDP): REFLECTIONS ON AN ADAPTIVE AND COLLABORATIVE PROGRAM STRATEGY TO DEVELOP INTEGRATIVE LEADERS IN SUSTAINABLE DEVELOPMENT

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This chapter presents the origins of a graduate degree program designed for the sustainable development era. The idea for the Master of Development Practice (MDP) program emerged in 2007 and the first students

matriculated in 2009. Today, the MDP degree program and the associated MDP Global Association include nearly 40 universities and countless partners among civil society and public and private sectors (Global Association, 2019). What follows details the conditions that led to forming a commission to explore the need for a new educational model and an overview of the key features of the sustainable development education model that resulted. There is then a reflection on the separate and shared experiences of the MDP program, viewed primarily through five programs in the North American region, followed by learning and adaptation that occurred, and how collaboration among programs fostered the evolution of a shared program. The chapter concludes with reflections on the strengths and challenges of the MDP model and the collaborative endeavor.

Recognizing Sustainable Development Education Challenges

In the early years of this millennium, those generally engaged in global sustainable development efforts and, in particular, the Millennium Development Goals (MDGs), came to recognize glaring shortcomings in the way that complex global challenges were being conceived, analyzed, and addressed. At that time, John W. McArthur of Columbia's Earth Institute wrote about a paradox: that the training for a major category of development professionals, though deep, was often quite narrow, and commonly misaligned with the breadth of responsibilities and the far-reaching influence of decisions made (International Commission on Education for Sustainable Development Practice (ICESDP), 2008). In light of this challenge, the MacArthur Foundation supported the creation of the International Commission on Education for Sustainable Development Practice (the Commission) and its mission to investigate current training for development professionals and to identify gaps and opportunities for improvement (ICESDP, 2008). The Commission consisted of a group of experts and practitioners from fields considered to be related to international development. In total, 20 individuals representing six regions participated in the commission, which was co-chaired by John W. McArthur and Jeffrey D. Sachs. The approach was inspired by a report written by Flexner (1910) that revolutionized medical training at a time when medical training was dominated by trade schools typically unaffiliated with institutions of higher learning and lasted only two years. The work of the ICESDP commenced in 2007 and culminated with a comprehensive report (ICESDP, 2008).

Situation Analysis (The "MacArthur Report")

The Commission conducted a diagnosis of the current state of sustainable development training and practice. Under the guidance of its six regional coordinators, members undertook a series of consultations that engaged a cross-section of practitioners from universities, government and non-government agencies, financial institutions, and other development-focused organizations in Africa, East Asia, Europe, Latin America, North

America, and South Asia (ICESDP, 2008). Consultations included interviews, regional conferences, surveys, and questionnaires. Consultations focused on professional education programs and training opportunities within sustainable development-oriented organizations. Throughout the process, commissioners explored training approaches related to problem-solving across disciplines and systematic skill-development for a range of core competencies.

High-level findings

The Commission's effort highlighted a deficiency of cross-disciplinary knowledge and skills within the field of sustainable development. These findings suggested the need for a new type of "generalist practitioner," one who understands the complexity of the interactions between areas of specialty (fields) and is capable of coordinating, translating, and implementing insights that emerged from subject experts. The Commission envisioned these individuals taking roles in government; non-governmental organizations; multilateral institutions, such as the United Nations; foundations; and the private sector.

This new cadre of professionals would complement the role of disciplinary specialists by navigating and forging connections between the "intellectual and institutional silos of specialized disciplines to develop integrated policy solutions that are scientifically, politically, and contextually grounded" (ICESDP, 2008, p. 4). In effect, these sustainable development practitioners would serve as the missing link in the professional sustainable development "ecosystem" (see Figure 1).

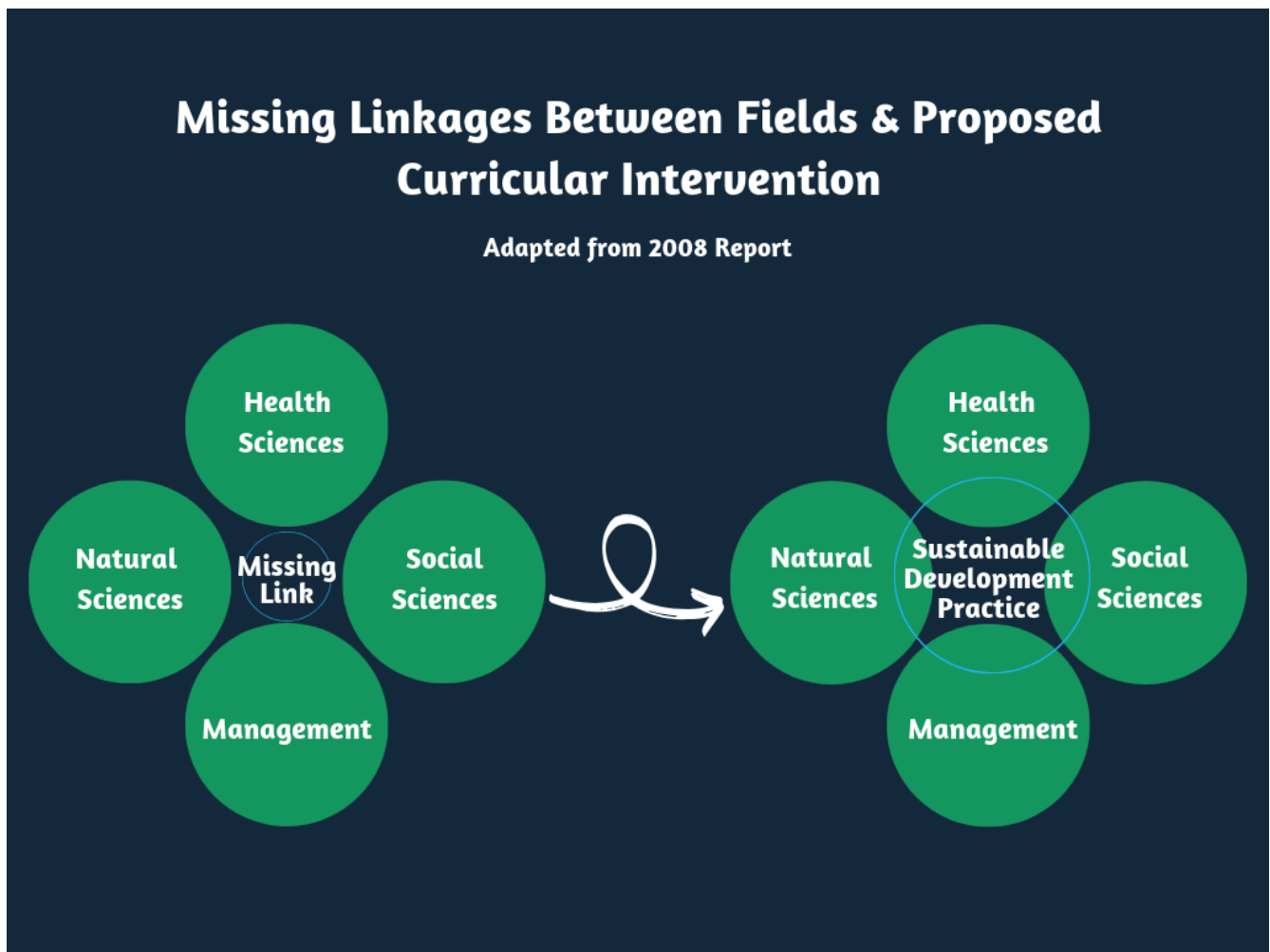


Figure 1. Sustainable development practice, the “missing link” (adapted from ICESDP, 2008).

Recommendations

The Commission generated four, specific recommendations to address the general shortcomings identified through its effort. First, it recognized the need to establish a set of core competencies for sustainable development practitioners. These competencies would feature universal knowledge and skills essential to the integrative role envisioned and would also provide a sound foundation for the life-long learning that was perceived to be essential to ongoing success and relevance in a complex and dynamic world. Second, the Commission recommended the creation of the MDP program that would incorporate the core competencies and, notably, the interdisciplinary and integrative approaches that would distinguish program graduates. Moreover, it was suggested that MDP programs should be affiliated through the creation of a global network that attended to local contexts but also fostered the exchange of ideas and people for a more holistic cross-learning and professional development experience. Third, the Commission advocated for the creation of professional development programs capable of providing ongoing training to graduates of the degree program, as well as to a vastly greater number of professionals who are already in the field and are unlikely to participate

in a formal, degree program. Finally, the Commission recommended the creation of a Secretariat responsible for the oversight and coordination of the network for the MDP degree program. The Secretariat would establish curriculum standards, represent the degree at major forums, and facilitate the network's engagement with academic and professional communities. This chapter focuses on the Commission's second recommendation, the MDP program, which also embodies and relates to elements of the Commission's other three recommendations.

Developing a Shared Vision for Sustainable Development Education

The impact of any particular educational intervention relates not only to content and delivery, but also to timing. The decision to develop a masters level degree program focused on sustainable development practice surely factored in the benefits of targeting students who had already completed a university degree with a particular focus. That education, augmented with some early career experience, perfectly positioned prospective students for the objectives of the MDP degree.

The Master of Development Practice (MDP) Program

The Commission provided a template for an MDP degree program designed to “produce highly skilled ‘generalist’ practitioners prepared to confront complex sustainable development challenges” (ICESDP, 2008, p. 24). The vision for both the degree program and other professional development opportunities was shaped by four, guiding principles. Such training should aspire to prioritize:

1. **Integrated knowledge** among health sciences, natural sciences, social sciences, and management;
2. **Lifelong learning** fostered and facilitated through ongoing openness and access to professional training;
3. **Practical training** utilized throughout the program to enhance the curricular experience;
4. **Partnerships across boundaries** (geographic, cultural, etc.).

With these principles in mind, the Commission outlined a set of key components that they believed necessary for a master's program (the MDP) intended to train practitioners to be the “missing link,” of sustainable development practice. Of these components, the following four seem essential to realizing the initial vision: 1) a common and interdisciplinary core curriculum; 2) extended field-based training or apprenticeships; 3) an active global network of programs and partners, and 4) enhanced classroom instruction featuring practical casework. Together, these four essential components of the MDP degree program serve as the building blocks for an innovative program model (see Figure 2) for the education of sustainable development practitioners.

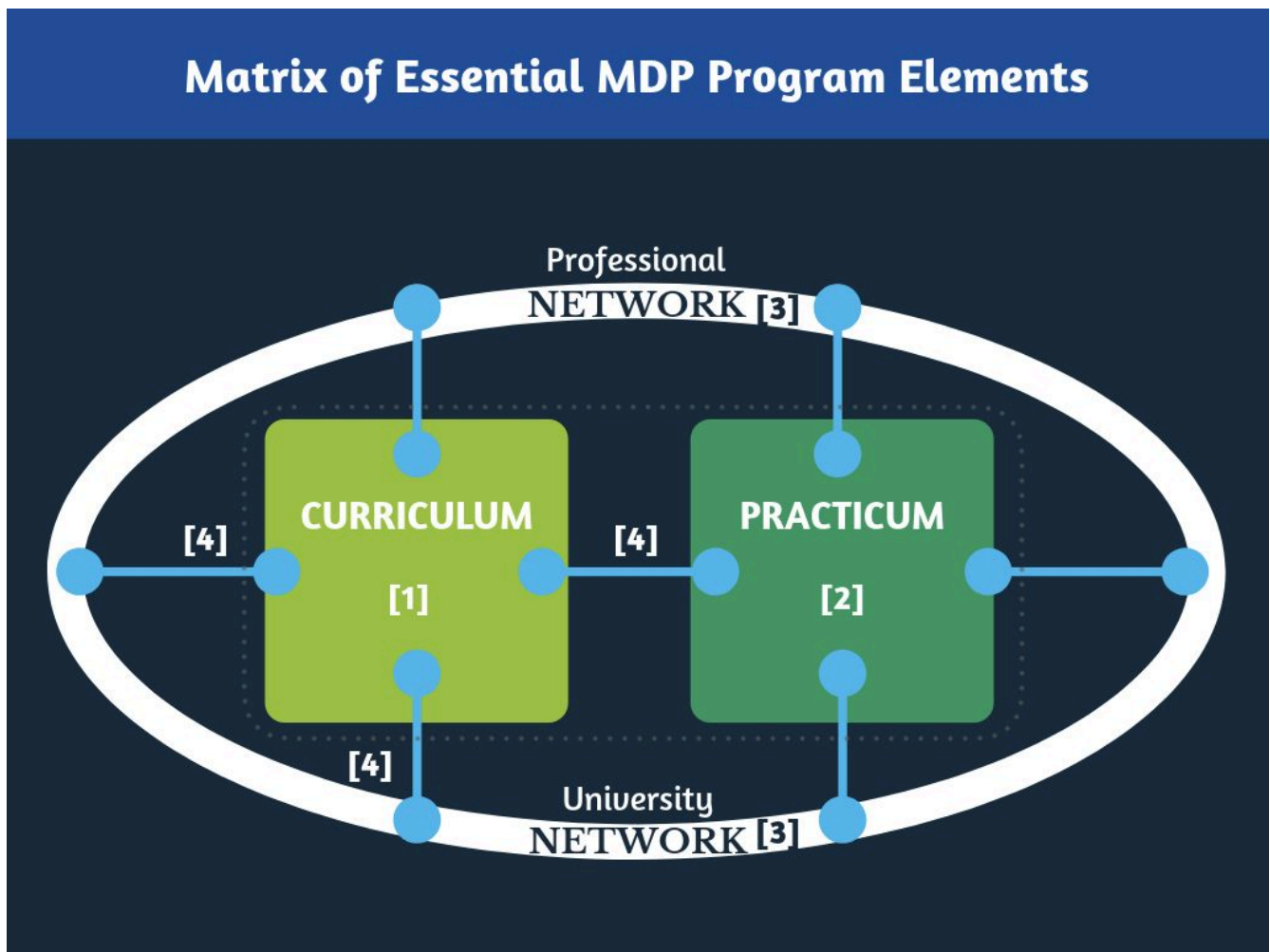


Figure 2. The Master of Development Practice (MDP) model as envisioned by the authors.

A common, interdisciplinary core curriculum (Figure 2, [1]) is one essential element of the MDP degree program. The core curriculum draws upon the knowledge, skills, and other competencies found across the disciplinary landscape (see Figure 1). Required coursework across the university helps students to traverse this landscape to build a broad knowledge framework and skills toolkit and is an essential part of the MDP curricular experience. Likewise, the MDP core curriculum strives to build student capacity to connect and integrate across disciplines, for this particular competency is the hallmark attribute of the MDP alumnus. The ICESDP (2008) report states that “courses and learning activities [will] be anchored in an understanding of the inter-relationships among fields and course content [will] integrate cross-disciplinary approaches for sustainable development” (p. 25). Exactly how the MDP curriculum fosters disciplinary movement and integration is addressed in the next three program elements.

The MDP field practicum (Figure 2, [2]) represents the second essential element of the degree program. The field practicum complements campus-based learning through long-term placements, typically ranging from eight to twelve weeks, with practitioner organizations. The field practicum focuses on the application of learned knowledge and skills and on contextualizing knowledge and skills *in situ*, through close collaboration

with program partners. The field practicum is a distinguishing and typically transformative experience in the development of MDP students. It draws heavily on cognitive knowledge and professional skills acquired prior to arrival and throughout the experience; it also draws upon and enhances the social-emotional attributes necessary to succeed and thrive as practitioners within complex, adaptive systems (Chan, 2001). Though the field practicum varies considerably by institution, most feature some combination of the following four characteristics:

- One or more practical training experiences in collaboration with partner organizations;
- Field-based academic programming that may include “formal” instruction by local actors and/or periodic engagement with campus faculty that focuses on supplemental knowledge, skill development, and experiential reflection;
- Organized social and cultural programming that may begin as early as the onset of the program and that likely continues through and after the field practicum; and
- A final report and/or set of project-driven deliverables that consolidate the knowledge gained, lessons learned, and implications for the challenge addressed and the work of the partner organization.

Competencies favoring successful classroom learning can differ from those that favor success in the field, resulting in the MDP core curriculum needing to foster student development in both realms. The MDP curriculum and field practicum are, therefore, complementary and mutually reinforcing elements. Individual degree programs may differ in how they address the curricular and logistical challenges associated with these two elements but, in almost all cases, learning opportunities associated with the field practicum extend well beyond the temporal boundaries of the experience itself. Development of these field-based experiences and the campus-based learning that precede and follow them relies heavily on a third essential element of the MDP program: the network.

The Global MDP Network (Figure 2, [3]) is the third essential component of the MDP degree program model. Two types of partners comprise the MDP network. The first is university partnerships which include those within a single institution (i.e., partnerships across disciplines and departments) and second are those between institutions offering the MDP degree. Both partnerships facilitate core operations and continuous improvement through the exchange of ideas, innovations, connections, and opportunities for student and faculty cooperation. University partnerships foster opportunities for both students and faculty to connect with other students and faculty across or between institutions. These linkages provide important opportunities for faculty to exchange relevant content and pedagogy within the network. Professional partnerships with sustainable development organizations complement university partnerships within the MDP network. Professional relationships can initiate from within the network (outreach by a program) as well as from the field (“inreach” by an organization) and can be short- or long-term.

This diverse and vibrant MDP network enlivens an educational model that depends on meaningful, field-based experiences with institutional and community partners. It facilitates the identification and movement

of knowledge and skills central to the evolving practice of sustainable development and it fosters pedagogical exchange among MDP faculty. Finally, the network serves as a prospective employment network as students transition into their professional lives. The network's multifaceted role in creating new linkages that foster the movement of knowledge, skills, and approaches to pedagogy make it an indispensable asset for the operationalization of the fourth and final essential component, the infusion of practical experience into the classroom.

Enhancing classroom learning with practical cases and experiences (Figure 2, [4]) provides a fourth and final fundamental program component, one that specifically targets the curriculum (Figure 2, [1]) but is substantially influenced by the field practicum (Figure 2, [1]) and network (Figure 2, [1]). Here, the emphasis lies in blurring the boundaries between classroom learning and practical experience through known and novel approaches. General examples include the use of prepared study cases; the use of real-world challenges as the focus for course work, often in close collaboration with professional partners; development of courses that specifically serve to interface with clients through real-world challenges; and the use of group-based training (or project teams) to mimic the multidisciplinary teams encountered in sustainable development-related fields. Moreover, the Commission emphasized that each individual course should, whenever possible, endeavor to link disciplinary knowledge and skills to practical policy, management, and other contemporary sustainable development challenges.

Master of Development Practice program affiliation is defined and determined by attributes and features held in common, aspects largely covered by the principles and essential components highlighted above and below. Each MDP program, however, is unique. Individual programs reside within different departments within their respective academic institutions. Each academic institution is, likewise, situated within a distinct context. The Commission report recognized and valued this complex reality, stating that programs may “modify the [program] to incorporate regional focus, to include a discipline-based specialization, or to provide complementary skills training within a specialized program of study. Any variation, however, should be anchored in the core competencies” (ICESDP, 2008, p. 36) and should adhere to the “essential components,” described above and represented in Figure 2. In other words, variation among MDP programs is both a necessary aspect of program design across place and time and an important part of the original vision.

Current State of the MDP Network

In the wake of the 2008 Commission report, an MDP degree program was established at three universities in 2009. This number quickly expanded to 15 programs in 2010 (see Table 1). Much of the initial delay in establishing programs stemmed from challenges associated with degree program approval at participating universities. Most of the pioneer programs were established with the financial support of a three-year startup grant from the MacArthur Foundation which supported program design, development, and staffing. Within three years, the global MDP network boasted 21 programs and, in 2018, 36 programs planned to offer the MDP degree. Annual enrollment has grown from roughly 300 students in 2010 to more than 500 in recent

years. Growth in overall degree program enrollment tracks network growth, but individual programs with the capacity to expand have also seen notable growth in enrollment.

Table 1: Participating Institutions and Year of First Cohort Entry

Institution	Country	Entry Year
Columbia University	United States of America	2009
Centro Agronómico Tropical de Investigación y Enseñanza (CATIE)	Costa Rica	2009
University of Colorado-Denver	United States of America	2009
BRAC University	Bangladesh	2010
Emory University	United States of America	2010
James Cook University	Australia	2010
TERI	India	2010
Trinity College / University College Dublin	Ireland	2010
Tsinghua University	China	2010
University of Idaban	Nigeria	2010
University of Botswana	Botswana	2010
Université Cheikh Anta Diop	Senegal	2010
University of Florida	United States of America	2010
University of Minnesota	United States of America	2010
Birla Institute of Management and Technology	India	2011
Sciences Po	France	2011
Lund University	Sweden	2011
University of Arizona	United States of America	2011
Universidade Federal Rural do Rio de Janeiro	Brazil	2011
University of Winnipeg	Canada	2011
University of Peradeniya	Sri Lanka	2011
Universidad de los Andes	Colombia	2012
University of California Berkeley	United States of America	2012
University of Waterloo	Canada	2012
Monash University	Australia	2014
University Sains Malaysia	Malaysia	2014
KDI School of Public Policy and Management	Republic of Korea	2015
Royal University of Bhutan	Bhutan	2015
Regis University	United States of America	2016
Sunway University	Malaysia	2016

Institution	Country	Entry Year
Al-Farabi Kazakh National University	Kazakhstan	2016
Hebrew University	Israel	2017
Harvard University Extension	United States of America	2018
University of Pretoria	South Africa	2018
Porto Politecnico	Portugal	2019

Note: The MDP degree program network by academic institutions, country, and initial cohort year.

Master of Development Practice Program Differentiation, Innovation, and Adaptation

This section highlights three important program dynamics that influence the characteristics of the individual programs as well as the overall network. Program differentiation refers to the ways that individual programs uniquely feature attributes specific to context and focus. Innovation and adaptation refer respectively to proactive and reactive responses to changes in context, focus, and experience that may affect differentiation through program divergence or convergence. All three dynamics represent important considerations for a network of programs seeking to retain a shared identity.

Program Differentiation

Productive tension between curricular standardization and differentiation across the network represents a central tenet within the MDP program vision. As indicated above, institutional differences – both intrinsic and contextual – make differentiation advantageous to adoption and survival. Over time, differentiation and differential adaptation present challenges to the overall integrity of the MDP degree; these issues will be addressed later in this chapter. From the outset, individual MDP programs took the model advanced by the Commission and MDP Secretariat and adapted it to local conditions, interests, and priorities. The result was a global network of differentiated programs espousing common guiding principles and essential components, such as the field practicum, and offering a curriculum that largely targeted common core competencies through different course configurations and pedagogical strategies. Additionally, many programs developed a unique focus within the broader realm of sustainable development. To showcase this differentiation, this section highlights a subset of MDP programs in the North American region.

Table 2: MDP Programs in North American

Institution	Effective Program Name	Program Focus
University of Arizona	Master of Development Practice	Arizona’s MDP program unites talented students and faculty dedicated to addressing the challenges of global poverty and defining new approaches to enhancing well-being for the under-resourced and socially excluded. The Arizona MDP emphasizes holistic, social justice-based approaches to pressing development challenges and prioritizes context-specific solutions. As a practice-based professional degree program, we welcome students interested in gaining the skills and perspective necessary for work in the field of international and community development, as well as students with existing professional experience who wish to further hone their analytical and managerial skills and practice.
University of California Berkeley	Master of Development Practice	The UC Berkeley Master of Development Practice (MDP) is a full-time, two-year professional degree program created to prepare students to face the multidimensional challenges of sustainable development with a broad understanding of physical and management sciences and practical, hands-on experience in the field.
University of Florida	Master of Sustainable Development Practice	Although tropical and sub-tropical countries contain some of the most diverse and resource rich environments, they also face the most significant development challenges. University of Florida’s Master of Sustainable Development program is administered jointly by the Center for African Studies (CAS) and the Center for Latin American Studies (LAS). These centers attract faculty from numerous academic units and departments, covering a wide array of disciplines who share a passion and commitment to development and conservation work with communities in regions throughout Africa and Latin America and sometimes other parts of the world.
University of Minnesota	Master of International Development Practice	Minnesota’s Master of International Development Practice (MDP) degree program prepares students for careers in international development, equipping them with the skills needed to address the problems of poverty, social justice, and sustainable development. Minnesota’s degree program is jointly administered by the Humphrey School of Public Affairs and the Interdisciplinary Center for the Study of Global Change (ICGC). While the large majority of our MDP students focus on the developing world, some graduates use their skills to work in the domestic arena.
University of Winnipeg (Manitoba, Canada)	Master of Development Practice in Indigenous Development	The University of Winnipeg is uniquely situated to offer a specialization in Indigenous Development. The University of Winnipeg has well-established relationships with Indigenous Elders, communities and organizations, governments, students, and faculty. We provide opportunities to discuss and share with people in all of these areas and contribute to critical thinking and sustainable change and development. The University of Winnipeg nurtures Indigenous scholarship including teaching, research, and application of skills by and for Indigenous peoples. The University of Winnipeg is honored to have one of the fastest growing Indigenous student populations in the country and we take pride in attracting and retaining Indigenous students from across Canada and many parts of the world.

Program Innovation and Adaptation

This section showcases examples of program innovation and adaptation in two realms: the curriculum (on campus) and the field practicum (off campus). Each learning context presents unique and often

complementary opportunities and challenges for practitioner development and both are essential. The former tends toward relatively higher levels of structure, control, and predictability whereas the latter tends toward substantially lower levels.

Within the curriculum

Though all organized learning experiences within the MDP program comprise the curriculum, this section refers primarily to classroom learning experiences, including both on and off campus components (i.e., community engaged learning). It includes *curriculum focus* – thematic lenses that bound or focus the MDP learning experience – as well as *curriculum extensions* – additional knowledge or skill sets that augment or complement the MDP curriculum. A third section, *pedagogical innovations*, focuses on course design and delivery.

Curriculum focus. While the preceding section highlights some program differentiations in North America, it is illuminating to take a closer look at one program that has uniquely adapted its focus to leverage and honor local resources and priorities. The University of Winnipeg’s MDP (UW-MDP) program focuses on Indigenous thoughts and worldviews and showcases the adaptability of the general MDP program model. First-year UW-MDP students take an integral, foundational course entitled *Indigenous Thoughts and Worldviews*. This full-year course brings the student into ceremonies, discussions, research, and conceptualization exercises that enable them to begin understanding Indigenous thoughts and worldviews from the perspective of an Anishinaabe Elder, his Anishinaabe colleagues, and those from other Indigenous traditions. Lectures and experiences help students gain insight into the core concepts of sustainable development, global sustainability, earth stewardship, and self-determination through Indigenous perspectives. Students carry the shared teachings beyond the classroom and many remark on how the course has transformed their way of thinking and being. The program is inherently interdisciplinary, not just because the specific course content intersects with the complexity of development topics but also because the course gives students the opportunity to learn from different learning traditions and knowledge systems; something that is absolutely vital to effective development work.

Curriculum extension. Most MDP programs encourage students to extend their curricular training through graduate minors and certificate programs focused on specific content areas or skills. The addition of a graduate minor or certificate allows students to signal interest and ability in a specific realm. Popular areas for additional training include public health, natural resource sciences and management, non-profit leadership and management, and program evaluation. Likewise, some MDP programs offer minors and certificates in development practice with the goal of attracting students from other programs and/or working professionals to core MDP courses. Master of Development Practice minors and certificates serve to extend the reach of the program principles, knowledge, and skills. Finally, some MDP programs offer joint degree options, allowing students to complete the full MDP curriculum and take a degree in some other area of interest. One example is the University of Florida’s joint MDP-Law degree, a program in which students simultaneously enroll in the

Law and MDP programs. These students are particularly interested in the space where legal and development issues converge. Other programs have supported joint-degrees in public health, business, and various natural resource sciences.

Pedagogical innovation. Columbia University's MDP program, situated within the School of International and Public Affairs (SIPA) developed a novel pedagogical format to address the challenge of teaching practical skills through engagement with development industry actors. The Development Practice (DP) Lab is a two-semester requirement in the first-year curriculum that focuses on a different set of competencies each semester (SIPA, 2013). The lab consists of 10 workshops, taught by guest practitioners from the field who use cases drawn from or related to core courses, to train students in skills and techniques required for problem appraisal and program design. Students learn how to use the key tools, techniques, and approaches employed by development organizations when diagnosing complex problems. Among the skills that are taught are stakeholder and institutional analysis; problem mapping and causal analysis; geographic information systems; logical framework analysis; and social media, advocacy, and agenda setting. The DP Lab began as a series of ad-hoc skills workshops and evolved into a full-year, required course, because of the perceived value. In addition to analyzing real-world cases, students have to complete exercises and work in teams to apply these skills to an integrated, country-level diagnosis for an actual campaign. The DP Lab has proven to be particularly effective in integrating concepts and skills from across different disciplines and in integrating MDP network partners with the campus curriculum. Other programs in the network have adopted the DP Lab model or certain key features.

Within the field practicum

The field practicum is perhaps the one aspect of the MDP program with the greatest variability. Adaptations and innovations to the relatively straightforward and somewhat undeveloped original idea of field-based training can be found across the MDP network. One innovation to the typical student summer experience is the differentiation between internships and student consultancies, with the latter generally favored by most programs. Consultancy-style placements mirror the type of professional engagements typically encountered by development practitioners upon graduation. Consultancy-style placements favor the development of the client and project management skills and greater familiarity with project scoping and related negotiations.

Taking a team approach to the field practicum is another innovation and adaptation. Several programs require team placements. These placements mirror the professional project environment and foster the development of interpersonal professional competencies. Team placements are also an adaptive strategy, in that they permit teams with members having varied skills (e.g., language, evaluation) and experience (e.g., topical, geographic) to collaborate on a project that might be otherwise beyond the capacity of a single student. Moreover, team projects foster collaboration across programs; several schools have formed project teams using students from multiple MDP programs. Since the inception of the MDP program, the sustainable development focus has shifted from an international focus (e.g., MDGs) to a global focus (e.g., Sustainable

Development Goals (SDGs), the latter serving to better recognize the universality of sustainable development challenges and to balance the international and domestic considerations. The MDP field practicum requirement reflects this evolution. Programs increasingly encourage domestic placements to complement international ones. For example, both Winnipeg and Arizona encourage students to do one international and one domestic placement, often with nearby Indigenous nations. Likewise, many programs pair the *in-situ* field practicum requirement with an *ex-situ* capstone project, with the latter retaining a client-focused structure without an extended travel commitment. Additionally, most MDP programs partner with local organizations to enrich classroom-based learning experiences, bringing local challenges into conversations about global development and recognizing that the boundaries between local and global have blurred. Though the shift from MDGs to SDGs did not instigate this shift, it has certainly catalyzed it.

Market Positioning

Although the early vision for MDP graduates in the workforce was broad – reflecting the interdisciplinary nature of the program – it specifically focused on the integrative role of the professionals situated between policymakers and development actors in “the field.” This professional realm remains an important target for program alumni, but the experience of the previous eight years highlights the broader value of MDP training. The vision for program alumni has vertically expanded to include employees from the diffuse local to the (institutionally) more concentrated global. This expansion reflects two insights. First, over the last decade, sustainable development professionals have increasingly recognized that development is not a supply chain with ideas, finances, and effort emanating from central suppliers to dispersed consumers. So long as good work occurs at all points in the system, MDP practitioners have the potential to make valuable contributions everywhere. The graduates have discovered and shared that the integration of knowledge, skills, and professional behavior positions them well to take on a wide variety of professional challenges in the development field. Some graduates have opted to pursue work at the grassroots level with local community organizations and non-governmental organizations, while others have assumed the role of program officers in international organizations. To highlight the second insight, many MDP alumni have found opportunities in the private sector and at academic institutions. As private sector businesses have come to embrace sustainability and additional “bottom lines,” the skills acquired through MDP training have become increasingly valued by private industries, particularly those in partnership with public ventures. Likewise, as academic inquiry comes to focus more on complex, sustainable development challenges, the interdisciplinary, integrative skills found in the MDP program become assets to research teams. Increasingly, MDP alumni follow a path to doctoral research focused on complex, sustainable development challenges.

Fostering Strategic Evolution

With programs originating in different contexts and then innovating and adapting in response to different assets, opportunities, and challenges, the initial Commission report recognized the potential for programs to diverge to the extent that they do not retain functional commonality or compatibility. Several structures and systems were recommended to minimize this possibility and to strategically foster program co-evolution.

Mechanisms fostering strategic evolution

Since the inception of the MDP degree, programs in the network have had the option to meet annually, via the Global Summit. The venue for the Summit changes annually to encourage participation and representation. The Summit is the principal mechanism for establishing and strengthening cross-program relationships and partnerships, sharing of program successes and challenges, and introducing new institutions to the program and network. In 2013, the Global MDP Network became a co-sponsor of the inaugural International Conference on Sustainable Development (ICSD). Broadly, the ICSD provides a forum for academia, government, civil society, UN agencies, and the private sector to come together to share practical experiences and potential solutions to achieve the SDGs. For MDP programs, the ICSD provides another opportunity to connect across programs and regions and to share research completed by program faculty and students. Master of Development Practice faculty develop and moderate many of the ICSD research sessions. These events provide the principal means to operationalize the Global Network, via direct interaction between people and ideas. The MDP Secretariat plans and facilitates the Summit and ICSD meetings. The Secretariat also manages the process of recruiting new programs to the network and reviewing applications to ensure that they align with the MDP program's shared principles and essential elements outlined in the Commission report.

More recently, a desire to increase the sharing of resources and cross-program learning led to the emergence of regional meetings within the Global Network. Programs in the North American region have met annually since 2016 to discuss successes, challenges, innovations, and opportunities for collaboration. These regional meetings have driven strategic program evolution within the region and across the network as regional insights get shared through the annual summit meetings and the ICSD.

Examples of strategic evolution

This section highlights examples of intentional actions taken by MDP programs – working collaboratively – to retain functional compatibility. The first section showcases the benefit of communication and engagement for the purpose of sharing (or disseminating) innovations and adaptations across the network. The subsequent section provides examples of co-creation of innovations and adaptations resulting from the intentional creation of proximity, time and opportunity.

Sharing Innovations and Adaptations

The Development Practice Lab. Columbia University's presentation of its DP Lab (see above) at the 2016 Summit led to its adoption by the University of Minnesota in 2017. The DP Lab includes two important curricular pedagogical innovations. One is the pairing of real-world cases and guest practitioners to demonstrate the exploration of sustainable development concepts and methods. The other is the breakdown of the traditional course format into discrete, extended lab sessions, or workshops, that permit extended engagement and, when appropriate, community-engaged research. Both innovations present logistical challenges in the traditional university setting, but the sharing of ideas and experiences within and across programs has fostered the development of a successful, new course format.

Co-creation.

Program evaluation. University of Florida's MDP program provided early leadership within the North American region in the area of program evaluation. University of Florida's evaluation toolkit has been shared across the region and with the MDP Secretariat. Regional programs have used, adapted, and recirculated these tools and the results of individual program evaluations with the aim of improving overall degree quality through individual and shared program learning. In 2018, the North American region led an appreciative inquiry process (Cooperrider & Whitney, 2005) with members of the global network that focused on enhancing collaboration and affecting positive change. These efforts aim to facilitate the continued improvement of the degree program through intentional investments in collaboration across the network.

Professional competencies. Over the last few years, North America's MDP programs have endeavored to better understand the general and specific competencies necessary for success in sustainable development. While a set of competencies was presented in the original Commission report, nearly a decade of program implementation, plus a changing global context, provide ample reason to revisit those initial assumptions. Ongoing engagement on this topic has led to an evolution from the early understanding that successful development practice requires diverse knowledge and skills plus practical experience to a more sophisticated conceptualization of essential competencies. Figure 3 presents the integrated MDP competencies framework used by the Minnesota MDP program, one version of a core competency framework that has emerged through this shared dialogue. This, and related efforts within the network foster continuous learning and curricular adjustments that ensure the MDP degree remains relevant and on the forefront of sustainable development education.

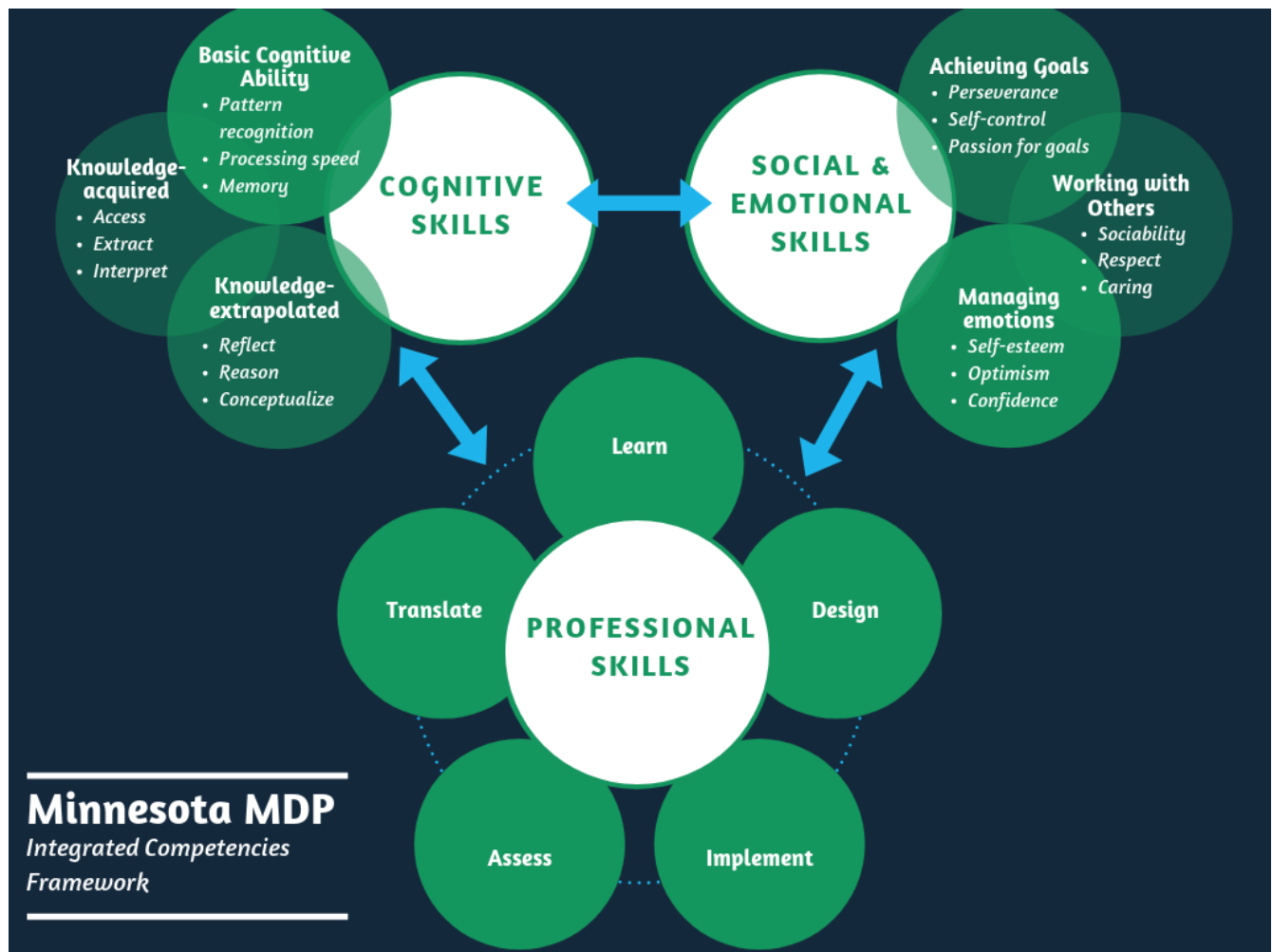


Figure 3. The Minnesota MDP Integrated Competencies Framework (adapted from Miyamoto, Huerta, & Kubaka, 2015; OECD, 2015)

Collaborations around field practice. Field practice collaboration has been another important way that programs in the network maintain linkages and common strategies. There are several examples that demonstrate the ways that programs have collaborated in the field. In 2013, MDP program student teams from Minnesota and Université Cheikh Anta Diop de Dakar (Senegal) collaborated to explore capacity building strategies for local sustainable development organizations in Senegal. In 2015, MDP program students from the University of Florida, Emory University, and Columbia University formed a team to work with a SABMiller subsidiary, Bavaria S.A., in Colombia. The project explored corporate social responsibility. In 2016, MDP program students from the University of Minnesota and Emory University formed a team to work with Rainforest Alliance in Guatemala. The project explored global markets and value chains for non-timber forest products from the Maya Biosphere Reserve. In addition to specific project collaborations, each year the MDP Secretariat supports the development of an interactive map of field practicum projects across the program network, a resource that fosters countless faculty and student interactions.

From program to network partner. In 2016, the Berkeley MDP program hosted a visiting professor from

the Institute for Food and Agricultural Development (IFAD). This partnership fostered IFAD's exposure to the MDP program model and, in particular, the field practicum, ultimately leading to an opportunity to fund MDP program students across the global network to work on projects that supported IFAD projects around the globe.

Advancing the Common Vision for Sustainable Development Education

Nearly a decade of experience with the MDP program model and network provides the necessary experience and perspective for reflection on strengths and challenges. While the five programs highlighted in this chapter are but a small subset of the total, nearly all have been engaged members of the Global Association since its inception. Most of the strengths and challenges highlighted below were identified or endorsed by all of these programs and discussed extensively by a larger program subset at regional and international meetings.

Strengths of the Model

Perhaps the most universally acknowledged strength of the MDP program is the *broad and integrated competencies framework* that supports development of the whole professional, one capable of leading toward and through complex, dynamic contexts. The program model fosters *investments in learning-across-disciplines and prioritizes engaged, experiential learning* for effectiveness, adaptability, and resilience. Curricular and field-based experiences developed to support this framework and approach generate *graduates with a breadth of understanding and the ability to work within and between areas of expertise*, with a commitment to learning through practice. Similarly, MDP program *graduates are capable of and comfortable with engagement and leadership from the grassroots to multinational organizations* and have the capacity to move up and down this development "value chain." Finally, the MDP Global Association and its member programs *invest heavily in continuous organizational learning*, investments that foster the very innovations and adaptations highlighted in this chapter.

Challenges of the Model

The MDP program model is not without its inherent challenges. As an interdisciplinary, practice-oriented degree, MDP *programs sometimes struggle to develop and maintain broad institutional support*, as the programs do not fit neatly into the disciplinary organization and incentive structure of the typical university (i.e., departments, faculty incentives, etc.). Similarly, programs within graduate schools that are principally organized around research often *struggle to retain a focus on practice*. Both of the preceding challenges also relate to a third concern for many programs: *financial considerations associated with operating as a professional*

degree program, which typically cost more than graduate school tuition while at the same time making students less eligible or ineligible for opportunities commonly used to support costs (i.e., teaching and research assistantships). This issue is of particular importance for new and/or small programs, where enrollment volatility can easily push programs in and out of financial feasibility. Finally, for all the curricular and competency merits highlighted in the preceding paragraph, *the degree sometimes seems more geared toward succeeding in a job than toward finding one*. Graduates encounter challenges engaging a job market that values interdisciplinary and integration skills but maintains human resources systems that fail to recognize interdisciplinary degree programs.

Strengths and Challenges of Strategic Evolution

Just as there are strengths and challenges associated with the program model, there are also strengths and challenges associated with collaboration that is oriented toward innovation, adaptation, and exchange. *The network effect is the most notable strength of the associated-program model*. With each new, or newly engaged, MDP program, the number of opportunities for connection, exchange, and collaboration increases. In most cases, *new institutions, programs, and faculty complement rather than compete with existing resources* due to the interdisciplinary nature of sustainable development. Finally, the *associated-program model fosters development of connections and relationships* which generate positive social effects such as trust and mutual support. Nevertheless, the *tension between collaboration and competition* remains an important challenge, especially for smaller programs struggling to attract sufficient numbers of qualified candidates. While all programs struggle in some way or another to overcome *time and other resource constraints associated with in-person collaboration*, these costs can be disproportionately higher for smaller or newer programs. This chapter highlights some of the advantages of program differentiation but, in some cases, differentiation relates to meaningful resource disparities that can limit the innovation, adaptation, and exchange necessary for strategic evolution. Finally, *structural differences between programs and their host institutions limit the attractiveness and feasibility of adopting ideas and innovations* or even collaboration. These include differences in admissions requirements, academic calendars, tuition, and other practical realities that govern higher education. Often, such barriers can be overcome in specific instances but prove difficult to fully remove for recurring activities.

Looking to the Future

Since 2009, the MDP experience has been characterized by learning at the program level and cooperation and co-evolution at the network level. The original Commission report led to the development of an educational model and global network to support the success and growth of that model. While much has been learned from the experience, the MDP program remains relatively young. As the network and its member programs look to the future, it will become increasingly important to remain engaged with professional organizations that employ MDP program graduates and with the rapidly growing community of MDP alumni, a group rapidly

approaching a critical mass in the sustainable development professional sector. Likewise, the educational “ecosystem” has changed since the publication of the Commission report. Other new degrees and degree variants feature attributes that once made the MDP degree novel. Retaining the focus on what happens outside the MDP degree and network is as important as focusing on what happens within. Just as we aspire to learn from and grow with our network partners, our network should aspire to do the same with other proponents of sustainable development education.

Over the first decade, it has been discovered that membership in an engaged, learning-oriented network confers benefits on individual programs and on the network as a whole. As new sustainable development programs emerge, established networks should strive to attract new members. Similarly, new programs should consider affiliation with existing networks or the creation of new alliances. Either way, the adaptations and innovations driven by unique program context and focus provide much needed insight in a field characterized by rapid and accelerating change in a complex world.

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SUPPORTING AND DEVELOPING COMPETENCIES FOR TRANSDISCIPLINARY POSTGRADUATE RESEARCH: A PHD SCHOLAR PERSPECTIVE

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“S/he who wants to walk fast, walks alone; s/he who wants to walk far, walks with others” ~ African proverb

There is a growing interest in transdisciplinary (TD) approaches to sustainability research (Stock & Burton, 2011). While TD research has merit, it is also challenging, particularly in the context of postgraduate research for degree purposes at universities (van Breda, Musango, & Brent, 2016). In this chapter, two scholars (Cockburn and Holden), who took a TD approach in their Ph.D. studies at two universities in South Africa, stories are shared. Their co-authors are two faculty members who have taught and researched TD contexts. For this work, the ability to address complex, social-ecological sustainability problems through research was an important consideration when choosing TD approaches. But what is TD research? Different fields have different understandings and definitions (Stock & Burton, 2011). When engaging the literature with scholarly intentions, it was determined that three key features of TD research are related and equally important in TD research (Figure 1):

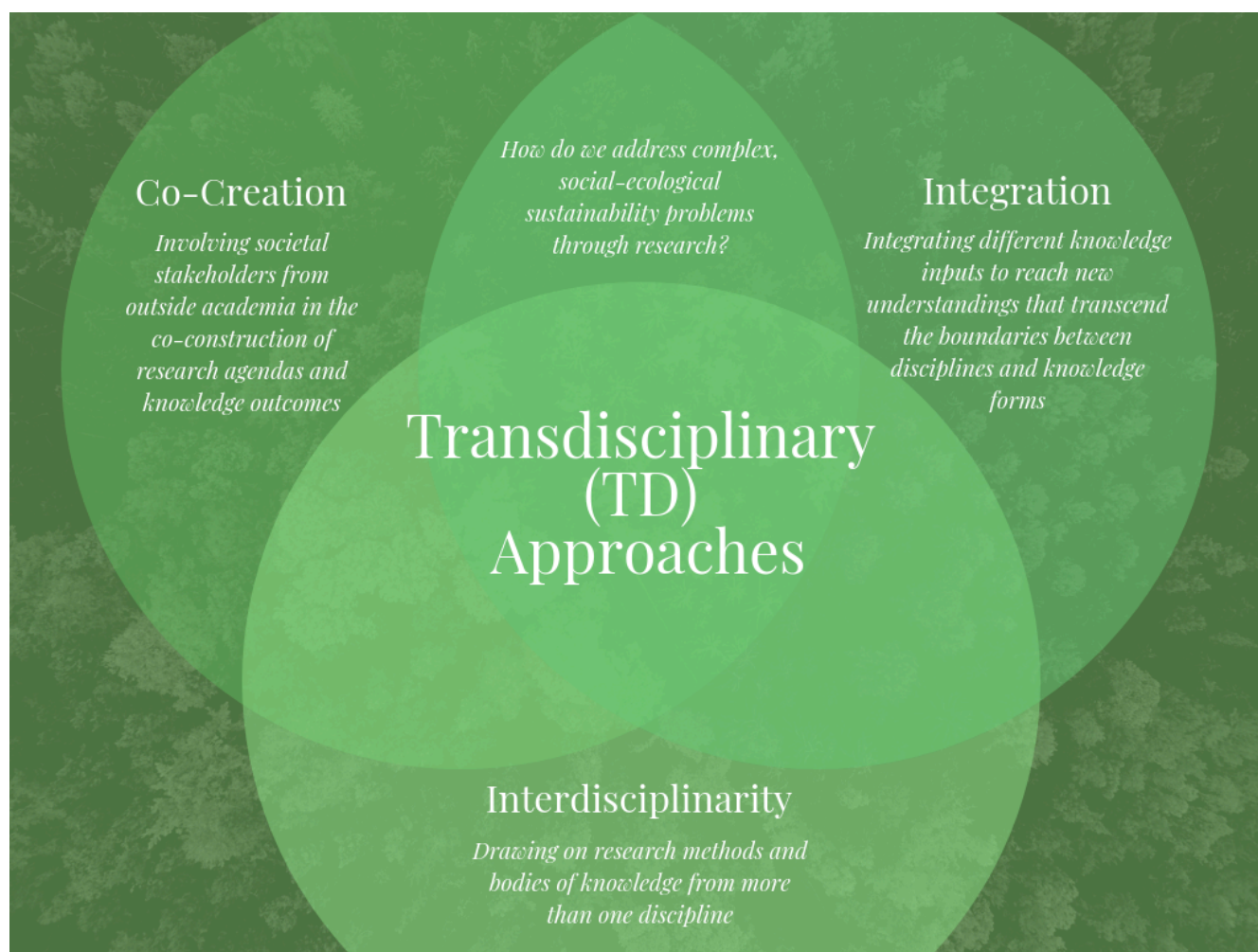


Figure 1. Three key features that are related and equally important in transdisciplinary (TD) research.

1. *Interdisciplinarity* – drawing on research methods and bodies of knowledge from more than one discipline;
2. *Co-creation* – involving societal stakeholders from outside academia in the co-construction of research agendas and knowledge outcomes; and
3. *Integration* –integrating different knowledge inputs to reach new understandings that transcend the boundaries between disciplines and knowledge forms.

This three-part framing is used to reflect on the research experiences shared in this chapter and investigate how conducting TD research within doctoral studies has the potential to develop scholars as change agents and leaders for sustainability.

This chapter also reflects on the competencies that the two Ph.D. scholars found they needed to undertake TD research and that others in the literature believe could support work in TD contexts, inside and outside of academia. Furthermore, the chapter shares the institutional challenges the Ph.D. scholars experienced and

reflects on what universities could do to better enable TD research as a scholarly undertaking that produces degree-earning change agents and as a transformative science that addresses complex sustainability challenges.

Transdisciplinary Research and Sustainability Competencies in Higher Education

Why are TD approaches to sustainability research increasingly popular? Much has been written about the need for the scientific community to produce knowledge that is of foundational value and can be immediately applied in addressing societal problems. In recent years, limitations that single, traditional disciplines have for addressing wicked problems like climate change, natural resource depletion, and managing landscapes sustainably for inclusive benefits have been recognized. This is a key reason for TD approaches, which are regarded as means of producing solution- and change-oriented knowledge (Hadorn et al., 2008; Lang et al., 2012).

While TD research creates a framework that enables the ability to conduct engaged sustainability research (Polk, 2014; van Breda & Swilling, 2018), it also poses challenges, particularly in doctoral research (Enengel et al., 2012; Mitchell, Cordell, & Fam, 2015; van Breda et al., 2016). Transdisciplinary research challenges described in the literature include the demands of disciplinary-based departments and examination requirements (Palmer, Fam, Smith, & Kent, 2018), inappropriate institutional research ethics requirements (Cockburn & Cundill, 2018), and failures to clearly define what knowledge types and outputs are recognized and incentivized (Park, 2006; Parker & Crona, 2012), leaving Yarime et al. (2012) and Dedeurwaerdere (2013) to conclude that existing academia institutional structures are not well-suited for TD research.

Despite the various TD research challenges, many scholars desire to conduct TD research. Actively and intentionally “doing TD” may be one of the best ways for scholars to develop the competencies needed to address complex sustainability challenges and become change agents. By competencies, we mean “a functionally linked complex of knowledge, skills, and attitudes that enable successful task performance and problem solving” (Wiek, Withycombe, & Redman, 2011, p. 204). Wiek et al. (2011) reviewed a considerable body of emerging work on competencies needed in the sustainability sciences and Scharmer and Kaufer (2013) documented leadership competencies that change agents addressing complex problems need. Drawing on these authors’ work, Rosenberg, Lotz-Sisitka and Ramsarup (2018) and Rosenberg, Ramsarup, Gumede and Lotz-Sisitka (2016), highlighted three kinds of competencies that change agents tasked with driving sustainability transitions need: technical, relational, and transformative.

While there is a large body of literature that broadly looks at implications of sustainability for training in higher education (Barth, Godemann, Rieckmann, & Stoltenberg, 2007; Wals & Blewitt, 2010), including a specific focus on competencies for sustainability (Barth et al., 2007; Brundiers & Wiek, 2011; Wiek et al., 2011), there is less literature discussing the implications of TD research for postgraduate training (but see Enengel et al. (2012), Kemp & Nurius (2015), Muhar, Visser, & van Breda (2013), Nash (2008), and Pearce et al. (2018)).

While some universities have seen a growth in team- and applied-based approaches to postgraduate training and education for sustainability (Callaghan & Herselman, 2015; Larsson & Holmberg, 2018; Westley, Goebey, & Robinson, 2017), there has been limited training in approaches and competencies for conducting TD research at higher education institutions. Furthermore, there is a lack of recognition and trust in TD modes of research. For example, in South Africa, and in many institutions across the globe, Ph.D. program requirements still consist entirely of a research project, with limited coursework and time for orientation (Schmidt et al, 2012; Wolhuter, 2011). Therefore, many doctoral scholars attempt TD research outside of dedicated TD research programs or TD teams and without exposure to TD research-type competency development during undergraduate or postgraduate studies. The experiences of these scholars have not been subjected to much research.

Two Ph.D. Journeys in Transdisciplinary Research

Since TD research is an ambitious undertaking, should scholars consider using it for degree purposes? This chapter looks at the personal experiences of the two authors applying a TD approach in their Ph.D. studies. Both authors wanted to use a TD approach for Ph.D. studies because of its applied, problem-oriented, and transformative value, and because of a desire to strengthen their ability to act as change agents. By examining the individual experiences, insights about the competencies required for conducting TD research and the institutional enabling conditions for supporting these competencies at the postgraduate level were developed. These insights may aid in developing stronger TD training programs.

Petra Holden: Navigating Trade-offs between Disciplinary Rigor and the Ideal Transdisciplinary Process

My Ph.D. involved using a transdisciplinary (TD) approach to investigate the impact of mountain protection on ecosystem services in relation to broader socio-economic and ecological drivers of landscape change (Holden, 2018). Prior to my Ph.D., my postgraduate studies limited me to hypothetico-deductive research. In contrast, my undergraduate studies were referred to as a management degree, including three years of “theory” (what I would call pragmatic theory) and one year of full-time experiential work. I did not pursue a professional career in conservation management after my undergraduate program because I felt that, to fully engage science in management, I had to be exposed to and gain experience in “the research process.” However, during my postgraduate years at a formal university, I experienced challenges linked to disciplinary differences and perceptions on facts, rigor, causal explanation, and research goals, which I struggled to align with the necessity of doing applied research.

It was largely in response to these limitations that my desire for building a place for socially relevant research at research institutions grew. I was interested in understanding interconnections and feedbacks between systems. I valued a range of methods and knowledge sources, but I wanted to tackle problems that were

meaningful outside of academia. I was frustrated with academia, therefore I left for a while to work in the field of climate change adaptation.

In this work, I noted the need for research information at multiple scales. For example, I needed information at both a water basin (larger catchment) and community or landscape (sub-catchment) levels to guide policy and implementation. I once again was frustrated because I felt that the projects within which I was working were not fully engaging with the complexity of the problems they were attempting to address. Therefore, when I started Ph.D. studies, I looked for funding that would support TD research and supervisors from various disciplinary backgrounds. I found a project with an ecologist, climate scientist/hydrologist, geographer, geomorphologist, economist, and a remote sensing expert (from five departments and three faculties at the University of Cape Town). My supervisors allowed me room to steer the project. At the outset, I engaged with landowners and managers to understand the situation and define the research focus.

Operationalizing TD research. Before writing my research proposal, I had interviews and informal discussions with conservation and fire managers, as well as local landowners. I matched their areas of concern, which were around land use, fire, and water, with appropriate literature, methods, and tools. I reviewed existing frameworks and concepts for understanding social-ecological change (Rissman & Gillon, 2017) including systems thinking (Kim, 1995; Meadows, 2008; Richmond, 1993), resilience thinking and theory (Folke, 2016; Folke et al., 2010), the Social-Ecological Systems Framework (Ostrom, 2009), and others (see reviews in Binder, Hinkel, Bots, & Pahl-Wostl (2013), Scholz (2013), and Cox et al., 2016).

I looked for a framework from sustainability science to integrate the different disciplinary results, however, none proved suitable (Shahadu, 2016). I, therefore, used the concept of pluralism (Isgren, Jerneck, & O’Byrne, 2017; Miller et al., 2008) to justify the use of various disciplinary aspects and to integrate the concepts of social-ecological systems, land use transitions, and ecosystem services into an overarching framework for protected area impact evaluation. Throughout the process, I engaged supervisors on a one-on-one basis regarding their specific areas of expertise. I also hosted three “workshops” that all the supervisors attended. Here, they focused on providing advice on how to reduce the workload to complete the Ph.D. within the expected time frame; there was almost no engagement of a TD nature. There was a concern that the Ph.D. program included too many approaches and aspects to fit into the expected Ph.D. time frame (three years). In these supervisor “workshops,” I presented detailed disciplinary methodologies and findings for all disciplines in the Ph.D. program and received detailed disciplinary insights from the supervisor who was a disciplinary expert in the respective field. In hindsight, I should have only focused on the TD aspects of the Ph.D. during these workshops and on how to integrate disciplinary aspects towards the central concerns in the landscape. It is likely that doing this would have required a focused methodology and efficient facilitation skills to bridge disciplinary epistemological differences.

Challenges to TD research. It was challenging to do all aspects of TD research (i.e., interdisciplinarity, co-creation, and knowledge integration) justice. I found it difficult to address all disciplinary requirements within the time and funding constraints, while also focusing on overarching applied research questions of a TD nature. I had to make trade-offs between achieving disciplinary rigor and achieving the “ideal” TD process.

In general, there was more pressure from my supervisors to obtain results separated out into their respective disciplinary domains than to obtain overarching, integrated results. A lack of all the supervisors having a mutual understanding of TD theory and methods limited the feedback that I could receive at a broader, integrated level. I struggled to consolidate the vast literature on transdisciplinarity and sustainability science into a succinct rationale for mixing methods. There were also differences between what landowners and managers viewed as interesting and relevant questions and results and what my supervisors and other academics viewed as necessary for doctoral research. Due to the emerging nature of the field, I also pre-empted that it was likely that my Ph.D. would be evaluated by disciplinary specialists rather than multi-method or TD researchers. This is because the notion of a “TD expert” is something that has not fully materialized in academia therefore individuals with these skills are often mixed in with disciplinary scientists.

In reflection, my efforts to achieve disciplinary rigor and to justify the various angles and approaches used for data, methods, and analyses side-lined other elements of the TD process. For example, although meaningful engagements with actors were achieved during the Ph.D. (e.g., co-design) and societal knowledge was integrated into the findings, there was a limited appraisal of the research findings in terms of relevance for actors in the landscape and a research management interface for driving change was absent.

Transdisciplinary research competencies. My modest positionality towards disciplines (i.e., believing that no discipline is in a better position than another to solve a problem or understand a situation (Augsburg, 2014)) enabled me to use and respect diverse disciplinary methodologies. However, I lacked insight and experience on how to trade-off disciplinary depth with integration and high-level systems thinking. I got lost in the details and struggled to integrate my empirical findings into novel and potentially transformative TD insights. I was also tied up with process-based stakeholder engagements and found it difficult to incorporate these informal processes into an examinable product (i.e., the dissertation). Although I had a supervisor with qualitative expertise, and I drew on these strengths for analyzing in-depth interview data, I was running out of time due to the magnitude of the work, as well as funding constraints.

I would have benefited from structured training opportunities in multi-method quantitative and qualitative case study research including a range of methodologies from “soft” to “hard” approaches for multiple fields. Guides to the basics of research methodology (such as epistemology, ontology, and associated methods) would have also been useful, along with guides for optimizing the use of disciplinary-specific methods for achieving transdisciplinarity and how to overcome the limits of compartmentalized research. Stronger systems thinking and exposure to the diagrammatic tools that systems thinkers use to communicate their research approaches, methods, and results would have been beneficial for me.

Box 1: Petra Holden’s Ph.D. research: A pluralistic-socio-ecological approach to understand the long-term impact of mountain conservation.

In this research, I used a TD approach to understand long term (> 60 years) change in the fire, water flow, land use, and vegetation cover in relation to mountain protection. The study area was a mountain catchment important for regional water supplies and of significant biodiversity importance in the Western Cape of South Africa. I built upon progress made in protected area impact evaluation (Ferraro & Hanauer, 2015), especially the use of counterfactuals (Epstude & Roese, 2008), with concepts from sustainability science, conservation biology, and land change science.

I used multiple disciplines including ecology, hydrology, geomatics, and environmental geography and tools such as vegetation surveys, repeat photographs, GIS (Geographic Information System mapping), mixed methods for social research, hydrological modeling, remote sensing, and scenario planning. I engaged with local actors to understand the situation (Mitchell et al., 2015) and to inform research design, and I used in-depth interviews to include landowner knowledge in research findings (Walter, Helgenberger, Wiek, & Scholz, 2007). I used pluralism (Isgren et al., 2017; Miller et al., 2008) to incorporate multiple epistemologies, philosophical viewpoints, and methodologies.

My findings showed that streamflow reductions and increased land fragmentation would have occurred without the protected area in the landscape. However, with increased water storage and fragmentation outside the protected area came socio-economic opportunities such as employment and local opportunities for ecotourism and sustainable agriculture. Interactions between global and local drivers were prominent causal mechanisms of socio-ecological change and defined protected area impact. Based on these findings, I highlighted the importance of maintaining various forms of land management in mountain ecosystems.



Photos: Left: Vegetation identification along surveys within the protected area Right: Informal meetings with landowners from the farming settlement outside the protected area.

Jessica Cockburn: Learning-by-Relating: Discovering New Competencies for Transdisciplinary Ph.D. Research

My Ph.D. research was a transdisciplinary (TD) inquiry on environmental stewardship and collaboration in multifunctional landscapes (Cockburn, 2018). Having worked as an environmental stewardship practitioner before starting the Ph.D., I wanted to conduct research that was relevant and useful to stewardship practitioners and that addressed important sustainability challenges. Transdisciplinary research enabled me to do science with society. Also, since sustainability science is a normative field of research (Wiek et al., 2011), it enabled me to be open about my values and my positionality.

To get started, I found a team of open-minded supervisors willing to support me and a nurturing ‘TD-friendly’ environment in the Department of Environmental Science at Rhodes University. Since I was not enrolled in a TD research postgraduate program, my supervisors and I were experimenting and acting as ‘bricoleurs’ to design and implement a TD study within the time and funding allowances of an individual Ph.D. project. We drew on the TD literature, on colleagues with expertise in supporting TD research (see Palmer, Biggs, & Cumming (2015), and on a TD community of practice at our university (see Wolff et al. (n.d.), and Cockburn & Cundill (2018)).

Operationalizing TD research. To guide the implementation of TD research, I drew on principles proposed by Lang et al. (2012) and on methodologies and theories across a wide range of disciplines and fields including natural resource management, biodiversity conservation, social-ecological systems and resilience, environmental governance, rural development, critical social theory, and environmental history. Guided by Price (2014), I used critical realism as a philosophical underlaborer and an analytical lens to strengthen and deepen knowledge integration across disciplines and contexts.

Transdisciplinary research requires building relationships with “societal actors” (van Breda et al., 2016, p. 156). I partnered with nongovernmental organizations that are facilitating multi-stakeholder collaboration for stewardship in rural landscapes. Through an opportunistic and iterative process (over ± 1 year), I developed three distinct TD teams (i.e., communities of practitioners working at different levels and in different areas on stewardship and integrated landscape management).

Challenges to TD research. Along the way, I experienced four key challenges. First, I was frequently challenged by the multiple roles I had to play: researcher, facilitator, knowledge broker, mediator, and friend. I was somewhat unprepared for this and had to quickly take responsibility for my actions and everyday research ethics challenges and appreciate my shifting identity within each of these roles. Second, reconciling

the, sometimes, mismatched purposes and demands of an academic research process with the expectations of practitioner partners was difficult and was compounded by time and budget constraints. Third, managing interpersonal relationships was personally and professionally challenging. I often wondered whether I had been communicating effectively with all the different partners, whether I had included all the right people in my emails, and whether I could find time and money to visit practitioners on-site and participate in their work. I often felt pulled in different directions and, at times, exhausted by the need to be everything to everyone. Fourth, I felt that I had to sacrifice depth for breadth. I worked ‘at breadth,’ across the knowledge divide between academia and practice, possibly trading off time to engage deeper in academic knowledge. I also worked across the knowledge divides between disciplines, covering a breadth of disciplinary knowledge, but not going into depth in any one discipline.

Transdisciplinary research competencies. In the process of building new relationships with practitioners, it became apparent that I needed to develop competencies and practices that conventional postgraduate research may not require. For my research to be societally relevant, I had to not only develop technical (academic) competencies related to critical thinking and systems thinking but also relational and translational competencies. This meant taking the time to build trust and manage interpersonal relationships with practitioner partners and mediate between different knowledge systems. I had to learn translational competencies by being a broker between academic and practice-based knowledge systems and by co-creating research questions with practitioner partners that were relevant in both practice and academic research. I spent time on non-research activities such as social events and practitioner meetings and workshops. I also had to manage expectations and communicate regularly with all three of my TD teams to ensure that we understood each other’s interests.

Along with developing relational and translational competencies, I also realized the importance of developing reflexive competence. I found that embedding reflexivity into my research practice helped me manage the balance between the demands of the academic system versus the often very different demands of working with practitioners. I learned reflexive habits of mind by not only reflecting (i.e., ‘looking into the mirror’ and thinking about what happened) but also considering the assumptions and conditions that underpin events and experiences (i.e., looking ‘through the mirror’ and reflecting on the nature of society and on my own value system and beliefs and responding accordingly (Bolton, 2010)). The practices that helped me embed these reflexive habits included disciplined personal journaling and connecting with others doing similar work through communities of practice (Cockburn & Cundill, 2018).

Developing new competencies to effectively practice TD research has helped me to think more carefully about what it means to be a change agent within academia that supports visions for sustainability. I have realized that we need to have a reflexive learning orientation. The world is changing quickly, and our roles, positions, and responsibilities are shifting. We need to navigate this rapidly changing world with an open mind, an open heart, and an open will (Scharmer & Kaufer, 2013).

Box 2: Stewardship and collaboration in multifunctional landscapes – Jessica Cockburn’s PhD research

The aim of my research was to conduct a TD investigation of the practice of stewardship and collaboration in multifunctional landscapes in South Africa. The research spanned social and ecological disciplines and integrated local practitioner knowledge to gain a grounded understanding of stewardship and collaboration. The methodology drew on transdisciplinarity, critical complexity, and critical realism which I integrated to develop a framework and a set of guiding principles. I first conducted a country-wide survey to investigate how practitioners put stewardship into practice. Based on this, I selected six cases of landscape-level stewardship initiatives where practitioners were working with local stakeholders to facilitate collaboration. In these case studies, I facilitated knowledge co-production processes, working closely with practitioners to develop a qualitative, place-based understanding of stewardship and collaboration. I then applied a critical realist methodology, developing a deeper TD understanding to explain my place-based research findings and reveal general trends applicable across contexts. I distilled the following key research findings:

1. Practitioners should refocus stewardship on stewards to enable human agency;
2. In multifunctional landscapes, a patchwork approach which recognizes diversity and values pluralism is necessary to support collaboration; and
3. Practitioners should focus on building new interpersonal relationships among diverse stakeholders to support collaborative stewardship.



Photos: Left: An on-site conversation with a stewardship practitioner. Right: The Langkloof case study is an example of a multifunctional landscape which is valued by different stakeholders for different functions such as water, agriculture, tourism, and biodiversity conservation.

Discussion and Recommendations

This section discusses an analysis of the two TD research journeys shared above, integrating the reflections of Cockburn and Holden with insights from the literature. First, the focus is on competencies needed for TD research using the three-part framing described in the introduction (interdisciplinarity, co-creation, and knowledge integration). Second, provisions that should be made in institutions of higher education to support Ph.D. TD scholars in enabling the development of sustainability change agents was considered.

Developing TD Competencies

Currently, doing TD research might be one of the best ways for scholars to develop TD competencies. The field of TD research is progressing as more scholars attempt individual TD Ph.D. studies, building an increasing understanding of the type of competencies required for doing TD research. This section reflects on the competencies that Cockburn and Holden found they needed to undertake TD research, building on similar experiences reported in the literature.

Interdisciplinarity. The first insight that scholars of TD research will need is that there is more than one way to do TD research (Mitchell et al., 2015). The approach chosen depends on the nature of the research question, interest, and scope as co-defined by the relevant stakeholders. Other features of the context include funding and time frames and the background, experience, and interests of the lead researcher (Maxwell, 2012). While there are many approaches to TD, this does not mean that ‘anything goes.’ Transdisciplinary researchers clearly need to know how to navigate and apply research methods suitable to TD studies with rigor and to an acceptable quality, a finding described elsewhere by early-career researchers following an ‘undisciplinary’ postgraduate research journey (Haider et al., 2018). For example, Holden needed to know what would be regarded as an appropriate, credible, and defensible approach to TD in her study and both scholars had to develop a coherent overarching framework within which to situate diverse theories and methodologies.

Intellectual and methodological creativity are arguably hallmarks of Ph.D. studies because of the need to make an original contribution to the field (Mullins & Kiley, 2002). However, TD presents scholars with additional demands for being intellectually and methodologically creative while still producing defensible research. The research stories reflect the vast swathe of literature that TD scholars need to engage with and the choice of what to include and what to leave out seems just as important as the ability to master the chosen content. Both scholars needed to be creative in juggling often conflicting demands and mediating how far to go into one area, whether literature or data collection or stakeholder engagement, before moving on to address another. Both Ph.D. scholars noted the challenge of mediating depth versus breadth, illustrating the importance of technical competencies, such as systems thinking (Wiek et al., 2011), to support the rigorous and coherent application of multiple and diverse methodological and theoretical approaches.

Cockburn mentioned the value of engaging with supervisors and/or other scholars who have experience with TD research. Some research decisions still need to be made by the individual, so it is significant that

Cockburn mentions reflexivity, the ability to start thinking of herself as a researcher and knowledge-producer and understand how her research decisions are being shaped by wider contexts and cultures by not only looking in the mirror and noting her own decisions but also looking ‘through the mirror’ into the long history that has shaped scientists’ decisions. This reflexivity is a high level of relational and, arguably, transformational competence because it allows people to see themselves in relation to a scholarly community and recognize historical, cultural, and ideological factors that shape decisions about how research should be done and valued. This enables researchers to transcend the boundaries of disciplinary decision-making, while still making logical and defensible decisions in the interest of credible knowledge creation.

Co-creation. Since TD research is an engaged process of knowledge co-production between academic and societal actors (Lang et al., 2012), building and maintaining relationships with a team of societal actors becomes a primary task in the doctoral research process (van Breda et al., 2016). This relational competency is needed to successfully conduct a TD study and, after graduation, to successfully function as a sustainability leader and change agent, particularly since sustainability transitions almost always involve collectives rather than individuals (Wiek et al., 2011). However, both scholars found stakeholder engagement difficult for different reasons.

Cockburn engaged extensively with stakeholders in various areas outside academia. She experienced several challenges in the process: managing stakeholders’ expectations, managing the contrasting interests of stakeholders and academia (also noted by Holden), and feeling poorly prepared for the interpersonal nature of the required engagements. She learned to play multiple roles in her work, operating as a broker, translator, and mediator. If well supported and well executed, navigating such challenges can build relational competencies that will help a scholar achieve good standing both inside and outside of academia (Scharmer & Kaufer, 2013).

Holden’s research journey illustrated that when a scholar is focused on juggling the disciplines in-depth, there can be little time and funding left for engaging stakeholders, especially at the end of the Ph.D. journey. While most research projects will have funding and time constraints, here the researcher had to make a call on whether to spend the time and funding on stakeholder engagement or on gathering further technical data. Cockburn’s example of worrying whether her email communications included all relevant parties suggests that details can be significant in stakeholder engagement and illustrates the kind of skill needed by change agents who intend to “walk with others” in addressing sustainability challenges. As an African proverb notes: “S/he who wants to walk fast, walks alone; s/he who wants to walk far, walks with others.”

Is it the role of supervisors to help develop relational competencies (Wiek et al., 2011) while also supporting scholars in gaining a deeper understanding of the literature and research methodology suitable to their studies (technical competencies)? What happens if they have not had such experiences themselves? Is there time for this? What suffers if attention is given to this – generally ‘new’ – dimension of scientific studies? Fortunately, some subfields in community development studies, adult education, and other social sciences have produced guidelines for stakeholder engagement and various forms of participatory research processes (Block, 2018; Bradbury, 2015). Even with guidelines, these processes are still challenging, but scholars do not have to design

them entirely from scratch. This is, however, yet another field scholars need to come to grips with, made even more difficult if none of their supervisors have related experience.

Knowledge integration. The case stories demonstrate how, in the quest to integrate and transcend disciplinary academic knowledge, scholars have to move outside their comfort zones (i.e., beyond what is familiar based on their prior studies). Doctoral scholars, as individuals, thus need to “be transdisciplinary in their own heads” (van Kerkhoff, 2014; Max-Neef, 2005).

The challenge of integration is clear from Holden’s research story. This pertains both to using multiple methods from different disciplines in an integrative manner and integrating knowledge with diverse origins. Supervised only by disciplinary specialists, and lacking a TD specialist in her supervisor team, Holden was concerned that her thesis would be examined exclusively by disciplinary experts. Because of this, she gave less attention to integrating knowledge that would span across the disciplines. A reduced focus on knowledge integration was also likely influenced by her not finding a suitable integrating framework.

In Cockburn’s case, a realist framing provided a common ontological and epistemological base where knowledge from different scientific disciplines, as well as non-scientific knowledge, could find its place in reflecting the layered nature of complex reality (Bhaskar, 2016; Sayer, 2010). Conceptual and philosophical frameworks that allow for a robust, defensible integration across different knowledge sources and knowledge forms seem essential.

Earlier it was noted that both Ph.D. scholars were challenged by trying to mediate between depth and breadth. This amounts to technical competence in one knowledge area (depth) vs. technical and relational competencies to integrate across more than one knowledge area (van Kerkhoff, 2014; Wiek et al., 2011). Rosenberg et al. (2018) and Rosenberg et al. (2016) showed that employers of scientists require *both* depth specialists and breadth specialists and that change agents value having in-depth knowledge about certain aspects, the ability to recognize and work with other depth specialists, and the ability to apply such specialist knowledge in contexts requiring a broad perspective. But, how should such agile, integrative, systems-thinking competencies be taught and examined at a university?

Institutional Provisions for TD Research

There are many institutional challenges that individual Ph.D. scholars striving for a TD approach to their research experience face. In response to the institutional challenges that Cockburn and Holden experienced during their TD Ph.D. studies, this section reflects on what universities could focus on to support the development of change agents through TD research. The focus is on communities of practice, training, supervision, and assessment.

1. **Company and structured training on the research journey.** The TD literature calls for team-based approaches to conducting research to cover the necessary breadth and depth and range of competencies required to address wicked sustainability challenges. This range of competencies is seldom, if ever,

present in one change agent (Rosenberg et al., 2016). This suggests that it would be wise to undertake TD research as a team activity (Kemp & Nurius, 2015). While the Ph.D. journey is, in South Africa at least, primarily an individual undertaking, this research recommends that universities explore other models that include cohorts of scholars working together in Living Labs (Callaghan & Herselman, 2015), Challenge Labs (Larsson & Holmberg, 2018), or Change Labs (Westley et al., 2017).

Holden recommends providing TD researchers with structured training relevant to TD research. Short courses (e.g., summer/winter schools) can address at least two identified needs. First, they can provide technical information about TD approaches, research methodology, analytic tools, and stakeholder engagement, thus complementing and extending the expertise of supervision panels so that they are able to provide the breadth of technical and relational input that a TD scholar requires.

Second, such courses – particularly if their delivery mode is face-to-face – could act as the start of professional networks of scholars who could continue to engage with each other long after courses have been completed (Rosenberg et al., 2018, 2016). Communities of practice noted by Cockburn and other researchers (van Breda et al., 2016; Rosenberg et al., 2018, 2016) provide TD researchers with a collegial community in which to share challenges, difficult decisions, reflections, new ideas, and resources.

Based on Cockburn and Holden's experiences, they agree with Kemp & Nurius' (2015) suggestion for a scaffolded, developmental approach to supporting and training TD scholars in higher education. Such an approach recognizes that doctoral scholars are on an incremental, personal growth trajectory and that TD learning should align with this developmental trajectory. This trajectory requires careful institutional, pedagogical, and interpersonal scaffolding (support), not only through formal training courses but also through carefully designed research experiences, mentorship, advice, and interaction with peers (Kemp & Nurius, 2015).

2. **Quality criteria for appropriate supervision and assessment of TD research.** Doctoral research is often fundamentally an individual endeavor and scholars are assessed according to their performance in the process of producing academic knowledge as independent researchers (Mullins & Kiley, 2002; Petre & Rugg, 2010). Yet, TD research is a collective endeavor. Therefore, is TD more demanding than mainstream scientific research? How should universities examine and value it? Scholars' uncertainty as to how their TD work will be examined should be reduced.

The newness of TD research in some institutions should not be a reason for scholars to assume that they are the first to undertake TD research. Supervisors have a responsibility to introduce them to the growing body of literature and to courses that help scholars gain in-depth insights into specific knowledge or methodological areas relevant to a study. Where supervisors lack the necessary breadth of knowledge, as they are likely to do, the supervision panel needs to be expanded. It is important to have at least one experienced TD researcher on a panel. Furthermore, ideally, TD research should be examined by experts in TD research. This makes

it doubly important to produce TD research academic quality criteria (Mitchell & Willetts, 2009), research ethics (Cockburn & Cundill, 2018), and stakeholder engagement (Reed et al., 2009) standards and guidelines that can be applied by examiners and supervisors, even if they are not experts in TD research.

It becomes apparent from the reflections and recommendations that the institutional changes required to support doctoral scholar TD research span the length and breadth of the academic system, from pedagogy in postgraduate teaching to assessment and examination to the professional development of supervisors and examiners to incentive structures and recognition of the value of diverse knowledge types and societal competencies. Another African proverb states that, “It takes a village to raise a child.” This research acknowledges that ‘it would take a whole system to enable TD research.’

Conclusion

In this chapter, two Ph.D. scholars shared their stories of pioneering TD research journeys for degree purposes. In reflecting on these journeys, insights into the kinds of competencies that scholars need to conduct TD research were gained. It became clear what competencies were relevant to their future work as TD researchers, practitioners, and/or research supervisors. The types of institutional arrangements that would make future TD research easier for other scholars, prospective change agents, and future sustainability leaders were also discovered.

The experience suggested that, in order to conduct TD research, one needs technical knowledge of and methodological competence in a number of disciplinary fields; knowledge of and the skill to apply one or more integrative frameworks; knowledge of and ability to use and defend methods, tools, and techniques that deal with a variety of data forms; high levels of relational skills to engage a variety of stakeholders and manage their expectations; project management skills including decision-making and prioritization with budgetary and time constraints; reflexive competence to understand the historical, cultural, and intellectual bases for decision-making; and communication skills to successfully convey and justify the research approach and findings.

While some of the knowledge necessary for sustainability science change agents and leaders is already in the system and can be accessed by new scholars, many of the skills and framings required cannot simply be learned from others. Many skills need to be developed and require scholars to be intellectually creative as well as be able to cope with high levels of uncertainty and complexity and be productive within those levels. Furthermore, they need to be able to ply their craft in the company of others since sustainability challenges are unlikely to be solved single-handedly.

Universities need to provide supervisors and examiners with TD experience, a range of courses that support TD and alternative models for the singular scholarly journey. An entire scholarly community is needed to work on frameworks and tools for conceptual and data integration; to provide collegial and intellectual homes for new TD scholars; and to determine credible quality criteria, research ethics, and stakeholder engagement guidelines for TD research.

The challenge of TD research is heightened by the constraints of existing Ph.D. timelines and current

academic incentive structures that focus on quick turnaround periods and academic outputs rather than process-based outputs which are important for collaborative TD research. Conducting TD postgraduate research requires more time to ensure inclusivity across all three aspects of the TD process: co-creation, interdisciplinarity, and integration. As noted above, this African proverb captures the spirit of TD as a collaborative, and therefore slower, process: “S/he who wants to walk fast, walks alone; s/he who wants to walk far, walks with others”.

At this time, TD research involves creating a newly made path. The experience of those who are operationalizing TD in an academic context is therefore invaluable. Transdisciplinary scholars who wish to work towards transformation in society through an innovative approach to research may – at least for the foreseeable future – also need to be change agents within the institutions where they undertake their studies.

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CLIMATE CHANGE AND HEALTH: AN INTERDISCIPLINARY EXEMPLAR

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For many, the word *crisis* connotes a negative or despair-inducing scenario, whether referring to human or environmental health. Curiously, the Oxford Dictionary (2018) defines a *crisis* as “the turning point of a disease when an important change takes place, indicating either recovery or death.” Guided by Oxford’s definition, it follows that recovery from planet Earth’s “disease” of climate change is possible. The Lancet Commission on Health and Climate Change (2015) maintains that climate change is both the world’s largest public health threat and a grand opportunity for humanity to overcome a colossal challenge by working together toward necessary societal change. Given the right leadership, crises can indeed prompt growth and bursts of creative solutions.

Framing language is imperative in developing the next generation of sustainability leaders and changemakers. Given that the Lancet Commission on Health and Climate Change (2015) views climate change as both a danger and an opportunity, it follows that climate change education, in the context of public health, should be similarly approached. However, there is evidence that suggests that, when people are faced with a challenge as daunting as the planetary health crisis of climate change, it is not unusual for them to feel confused about where to begin, too paralyzed to take action, or—worst of all—overwhelmed by despair (Heald, 2017). Thus, while the authors of this chapter recognize the urgent human, animal, and planetary health threats that climate change poses, this chapter is primarily written through the lens of opportunity. Approaching climate change via hopeful interdisciplinary partnerships prepares and positions emerging sustainability leaders for long-term success.

What follows in this chapter is an account of an interprofessional team of health educators at the University of Minnesota Academic Health Center who had a mutual understanding of the Lancet Commission on

Health and Climate Change's (2015) model; namely, that climate change is simultaneously a dangerous health threat and a unique opportunity for partnership, innovation, and joined forces.

The Connection Between Climate Change and Sustainability

First, it is necessary to clearly delineate the relationship between climate change and sustainability. According to the World Meteorological Society (WMO, 2017), climate change is defined as changes in the “average weather,” which include “temperature, precipitation, and wind” (para. 1). While weather changes continuously, climate change involves unpredictable, widespread regional or global fluctuations in weather over an extended period – usually over about three decades (WMO, 2017).

Furthermore, it is important to highlight that the greatest notable changes within the global climate have occurred since the beginning of the Industrial Revolution when there was a widespread introduction of fossil fuel-based energy use. This mode of energy production has resulted in a steep increase in global emissions of carbon dioxide and other greenhouse gases (Intergovernmental Panel on Climate Change [IPCC], 2013). Based on the direct positive correlation of human-caused greenhouse gas emissions and global temperature increase resulting in climate variability, climate change has widely been accepted as human-caused. In fact, in a recent survey of authors of nearly 70,000 published, peer-reviewed, scientific articles, there was over a 99.99% consensus that climate change is caused by human activity (Powell, 2016).

Globally, the unpredictable fluctuations in climate over the last few decades have contributed to extreme high and low temperatures, more frequent and more powerful precipitation and storms, a rising sea level, and ocean acidification. These changes have had both direct and indirect impacts on Earth's living organisms (IPCC, 2013). Bluntly stated, climate change endangers the sustainability of life on planet Earth. Moreover, given that climate change is primarily human-caused, it follows that sustainability on Earth is directly threatened by human actions. If we are serious about supporting future life on this planet, sustainability leadership is non-negotiable.

There are many strategies to address climate change through the sustainability lens, which is based on the principle that “everything we [humans] need for our survival and well-being depends, either directly or indirectly, on our natural environment” (Environmental Protection Agency [EPA], 2016). This same premise applies to all non-human life on Earth. Sustainability, therefore, is relevant and necessary in every discipline, for every scholar, and for every change agent. The EPA's definition of sustainability involves “survival” and “well-being” – both of which are deeply interwoven with health. Thus, by including sustainability and climate change efforts in their scholarship and practice, health professionals, in particular, have the opportunity – and responsibility – to lead.

'One Health' Impacts of Climate Change

In recent years, the term 'One Health' has been used to describe the connection between the health of living organisms and the health of the environment (Centers for Disease Control [CDC], 2018). The One Health framework expands upon the definition of sustainability shared earlier through the inclusion of non-human animals. Based on this relationship, it follows that if climate change threatens sustainability, it also threatens 'One Health' – the health of the environment, animals, and humans.

Climate Change and the Environment

Fundamentally, the increase in the consumption of fossil fuels has altered the composition of greenhouse gases in the Earth's atmosphere (IPCC, 2013). Earth's oceans, which absorb carbon dioxide, have warmed and become more acidic over time due to a greater ability to absorb gases (IPCC, 2013). This global oceanic warming has resulted in an average sea level rise of about $\frac{1}{3}$ of a centimeter per year. This rate is expected to increase dramatically in the coming century (IPCC, 2013). In fact, experts estimate an average sea level rise of 28-98 centimeters by 2100, depending on future greenhouse gas emissions (IPCC, 2013). Severe precipitation and storms cause massive damage to forests, bodies of freshwater, and soils. Oceanic changes and precipitation are not the only climate change effects that impact the environment; extreme heat has contributed to widespread droughts on all landmass continents, as well as an increase in forest fires (IPCC, 2013). Plant species are unable to migrate or adapt quickly enough, via seed dispersal and other methods of propagation, to outpace these geographic changes. Nearly 70% of plant species in the Amazon Rainforest are at risk of extinction by 2100 (World Wildlife Foundation [WWF], 2018). Furthermore, the plant adaptation challenges at hand have major implications for food security across the globe. Climate change has harmful effects on the very ecosystems that all living things rely upon.

Climate Change and Animal Health

Within the One Health framework, humans are considered separate from all other animals. However, non-human animal (including insect) health is drastically impacted by climate change in a myriad of ways. Based on a widespread literature review, Dr. Elizabeth Kolbert (2015) estimates a 20 to 50% reduction in *all* species on the planet by the end of the 21st century – citing climate change as one of the premier causes. The World Wildlife Foundation (2018) shares similar estimates, with even more specific and disturbing figures, such as 96% of tiger breeding grounds in the Sundarbans being submerged by rising sea levels and 60% of *all* species in Madagascar facing local extinction. Rising temperatures and fluctuating precipitation patterns lead to the emergence, re-emergence, and spread of bacterial, viral, fungal, and other diseases, both non-vector- and vector-borne, that animals have little or no protection against. In addition, ocean acidification results in physiological

assaults to animals whose bodies cannot adapt quickly enough. One only needs to momentarily think about the circle of life to understand the vast global implications of animal species extinction.

Climate Change and Human Health

Throughout the Anthropocene, humans have driven massive climate and environmental change. Over the past few decades, a quickly expanding body of research supports the premise that the relationship between humans and the environment is a two-way street (CDC, 2016; Kolbert, 2015; National Institute of Environmental Health Sciences [NIEHS], 2017; Planetary Health Alliance, 2018). Humans are harming the climate – and now the climate is responding. Local, regional, national, and global health agencies have identified a multitude of ways climate change is deleteriously impacting human health. Specifically, weather fluctuations due to climate change exacerbate chronic conditions such as respiratory and cardiovascular diseases (CDC, 2016; Medical Society Consortium on Climate and Health, 2017; NIEHS, 2017; World Health Organization [WHO], 2018). Climate change endangers human health via extreme heat, vector-borne diseases such as Lyme disease and Zika virus, extreme weather-related injuries and deaths, and changes in food and water supply (CDC, 2016; Medical Society Consortium on Climate and Health, 2017; NIEHS, 2017; WHO, 2018). In addition, the projected sea level rise does not bode well for nearly 50% of the U.S. population expected to live in high-density coastal areas by 2020 (National Ocean Service, 2018). Furthermore, indirect impacts such as mental health challenges, forced migration, and civil conflict are increasing in frequency (CDC, 2016). As with most other “health” issues, impacts of climate change are not felt proportionally across the human spectrum (WHO, 2018). The most vulnerable among us — the impoverished, the homeless, and the elderly, as well as children, women (Halton, 2018), and some communities of color — experience greater negative health effects of climate change (WHO, 2018).

It is known that health providers are widely viewed as trusted professionals. According to Gallup (2018), nurses have been ranked as the most trusted professionals in the U.S. for the last 16 years, with other members of health care teams not far behind. Therefore, educating health professionals about the health impacts of climate change so they can, in turn, share the information with their clients may be the most effective way to inspire individuals to take action.



As the authors of this chapter have argued in this section, climate change impacts *all* aspects of sustainability and ‘One Health.’ While it is critical for health professionals to engage in climate leadership, it is not enough to address climate change in a disparate fashion. When it comes to the health of the environment, animals, and humans, it is essential that multiple disciplines work together to collectively rewrite the climate change narrative and innovate solutions to address this global challenge.

Interprofessional Leadership in Addressing Climate Change

As previously mentioned, complex problems require complex solutions. One discipline alone will not be able to create viable climate change solutions. Instead, society needs to shift its understanding from old patterns of siloed research and fieldwork to new patterns of collaboration. ‘One Health’ is a start on this path, but even the aspirations of ‘One Health’ can be thwarted when adherents practice from a multidisciplinary, rather than a transdisciplinary, mindset.

Disciplinary, Multidisciplinary, Interdisciplinary, and Transdisciplinary Thinking

Disciplinary thinking has been the traditional approach to teach and scholarship within the academy. Each discipline obtains its own grants and funding, conducts its own research, and disseminates research findings through journals, conferences, books, and curriculum specific to that field. A multidisciplinary approach invites disciplines to apply knowledge from other fields to their own discipline. Essentially, one or more disciplines work to advance knowledge in a shared field, but they still apply knowledge gained from other disciplines within their own disciplinary boundaries (Choi & Pak, 2006). An interdisciplinary approach deepens levels of collaboration. One might see teams from various disciplines working on the same research project or co-authoring publications. There is a growing number of interdisciplinary journals such as the *Journal of Interprofessional Education and Practice* (JIEP) as well as interdisciplinary conferences such as the International Conference on One Medicine One Science (iCOMOS).

Ultimately, the most advanced form of collaborative practice is transdisciplinarity. “Transdisciplinarity integrates the natural, social and health sciences in a humanities context, and transcends their traditional boundaries” (Choi & Pak, 2006, p. 351). The World Health Organization underscores the potential of this form of collaboration:

Many health workers believe themselves to be practicing collaboratively, simply because they work together with other health workers. In reality, they may simply be working within a group where each individual has agreed to use their own skills to achieve a common goal. Collaboration, however, is not only about agreement and communication but about creation and synergy. Collaboration occurs when two or more individuals from different backgrounds with complementary skills interact to create a shared understanding that none had previously possessed or could have come to on their own. (WHO, 2010, p. 36).

Effective climate change mitigation and adaptation initiatives require educators to think beyond not only disciplinary boundaries but also geographical, political, economic, and social boundaries. The planetary health crisis calls for an “all hands on deck” approach, but change agents that adopt this level of collaboration and partnership will indeed “create a shared understanding that none had previously possessed or could have come to on their own” (WHO, 2010, p. 36).

The following case study illustrates a transdisciplinary approach to interprofessional climate change education. The result is that all health professional students at the Academic Health Center (AHC) graduate with a basic understanding of their role in climate change prevention and care for impacted populations.

1Health at the University of Minnesota Academic Health Center

For nearly half a century, the AHC at the University of Minnesota has been a significant leader of interprofessional education in the United States. In 2009, the AHC developed a 1Health vision and plan.

1Health is not to be confused with One Health – although they both promote interdisciplinary collaboration. The 1Health initiative at the University of Minnesota:

Prepares students in allied health, dentistry, medicine, nursing, pharmacy, public health, veterinary medicine and other related programs, such as social work, to develop the skills needed for success in interprofessional collaborative practice. 1Health challenges students throughout their academic careers to understand and value the importance of teamwork, communication, and collaborative care as they grow into their roles as health professionals. (University of Minnesota Academic Health Center Office of Education, n.d.).

There are three phases of 1Health:

- Phase I – Orientation: The Foundations of Interprofessional Communication and Collaboration (FIPCC) course provides students across the AHC with an introduction to interprofessional education concepts and teamwork skills.
- Phase II – Necessary Skills: This prepares students for rotations in the practice setting by providing them with additional skills and experiences.
- Phase III – Expertise in Practice: Real-world learning through authentic experiences builds on students' knowledge and ability to contribute to team-based care.

Interprofessional Climate Change Curriculum: A 1Health Initiative

The three-phase approach to interprofessional education highlighted above is an exemplary model used to respond to student-driven change and to transcend disciplinary boundaries related to climate change education. For instance, at the University of Minnesota, graduate and health professional students are leading the way in interprofessional action on climate change.

Background. In 2016, eight nursing and medical students learned of each other's passion for climate action. Borrowing from the vision and mission of Health Professionals for a Healthy Climate [HPHC, 2018], a community-based interdisciplinary health professional organization, the students formed their own official student group at the university entitled, *Health Students for a Healthy Climate* [HSHC]. Over the course of two years, *HSHC* burgeoned into a robust group consisting of health students from the schools of nursing, medicine, dentistry, public health, and veterinary medicine. Examples of *HSHC* activism include legislative letter writing, lobbying, and marching to support science and protest fossil fuel-based energy, as well as hosting monthly social "Climate Conversations" and student and public lectures.

While the interprofessional approach and climate focus of *HSHC* were both unique for health student groups at the university, the students believed they had the capacity to make a greater impact. In the spring of 2017, through the guidance of nursing and medical faculty, *HSHC* crafted a survey to inquire about students':

- Knowledge about the health impacts of climate change;

- Beliefs about the direct impacts of climate change on patient health;
- Experiences with health curricula including climate change content; and
- Levels of desire to see climate change content in health curricula.

One hundred and thirty-nine students from six health professions (nursing, medicine, dentistry, public health, veterinary medicine, and pharmacy) responded to *HSHC*'s survey. Students reported that they knew “only a little” (32%) or “a moderate amount” (47%) about the health impacts of climate change. However, the survey respondents also indicated that they believe climate change directly impacts patient health “a great deal” (53%) or “a moderate amount” (34%). Forty-six percent of respondents reported that only “a few” of their courses in their health program included content about the connections between climate change and health, whereas 53% of respondents reported that “none” of their courses included climate and health content. Finally, 43% of those surveyed indicated they had a desire for their curricula to address the health impacts of climate change “a great deal,” while 40% indicated they had “a moderate amount” of desire for climate curricula within their health programming (Demorest, n.d.).

The survey illuminated a major opportunity for University of Minnesota health programming. The consumers of health professional education had spoken – interprofessional health students wanted to learn about the health impacts of climate change. In a strategic effort led by *HSHC* and nursing and medical faculty advisers, the survey results were presented at an executive leadership council made up of the Associate Deans of each health program at the university. Following a discussion of the opportunities that climate change curriculum offered for innovation and leadership, the executive leaders unanimously agreed to authorize a team to use a phased 1Health approach to address the gap in climate change education (see Figure 1).

Phase I: Orientation. The goal of Phase I is to orient or introduce all AHC health profession students to climate change as a health issue. The preexisting FIPCC course is the ideal vehicle. The FIPCC course brings students from all the health care disciplines together for a series of six facilitated classes during the first semester of their professional education. The students are assigned to small groups with representation from each discipline. Discussions are designed to promote learning from and about each other so students will be better prepared for interprofessional practice. Topics include roles and responsibilities, health systems, teamwork, ethics, leadership, and other health system concepts shared across the disciplines.

Climate change content was specifically designed to be incorporated into the health systems module. One objective was modified to, “Use the complex health impacts of climate change as a case study to demonstrate the intersection of health and education,” (University of Minnesota Academic Health Center Office of Education, 2017) in order to address climate change content.

Facilitators prepared in advance by watching three short videos on climate change and reading four short summaries from climate change literature (see Table 1).

Table 1: Preparation for FIPCC Facilitators (University of Minnesota Academic Health Center Office of Education,

2017)

	Climate Change 101 with Bill Nye (National Geographic, 2015)
Videos	Climate Change: Our greatest health threat, or our greatest opportunity for better health?(Global Climate and Health Alliance, 2014)
	APHA’s Year of Climate Change and Health (American Public Health Association, 2017)
	Medical Society Consortium on Climate and Health’s (2017) Medical Alert: Climate Change is Harming our Health. Focus on pages 18-22 in preparation for the case study.
Readings	Let’s Talk Health & Climate, Communication Guidance for Health Professionals Guidebook (ecoAmerica, 2016, 6-7).
	What’s bad for the planet is bad for people: The health consequences of climate change. (Hellerstedt, 2017, 26-33).
	Minnesota Climate Change Vulnerability Assessment Report Executive Summary (Minnesota Department of Health, 2014, 5-6).

Foundations of Interprofessional Communication and Collaboration students were asked to prepare for the module by watching the video *APHA’s Year of Climate Change and Health*. They were asked to come prepared to discuss, “How can your profession impact climate change mitigation (prevention) and adaptation (treatment of consequences)” (University of Minnesota Academic Health Center Office of Education, 2017)?

On the actual day of the course, interprofessional student groups were asked to watch two videos then take part in an activity (see Table 2).

Table 2. Climate Change Activity (University of Minnesota Academic Health Center Office of Education, 2017)

Videos watched as a class	Climate Change 101 with Bill Nye (National Geographic, 2015) Climate Change: Our greatest health threat, or our greatest opportunity for better health? (Global Climate and Health Alliance, 2014)
Small Group Discussion	What can health care professionals do to promote climate change mitigation (prevention)? Assign a scribe and a reporter for your small group Using all of the professions represented in your small group, come up with a plan to reduce the health impacts of climate change (adaptation).
Small Group Activity	Be sure your plan includes all professions in your small group AND addresses all components of the Triple and Quadruple Aims: o Patient quality of care o Population health o Cost of care o Provider wellbeing

Foundations of Interprofessional Communication and Collaboration proved to be a very effective vehicle for orienting all the health professional students to the topic of climate change and health. Over 40 facilitators and 1,100 health profession students from 17 health programs on five different campuses learned basic facts about climate change and health.

Phase II: Necessary Skills – Development of Climate Change and Human Health Interprofessional Content (see Figure 1). The first step of Phase II involved recruiting ‘Climate Champions’ from every school and college in the AHC. Recommendations came from the Associate Deans, as well as the Director of Education, for the AHC. The ‘Climate Champions’ represented the following disciplines and departments:

- School of Nursing
- School of Medicine
- College of Pharmacy
- Veterinary Medicine
- Occupational Therapy, Center for Allied Health
- Public Health
- Medical Laboratory Sciences
- Dentistry
- The Center for Global Health and Social Responsibility
- AHC Office of Education

‘Climate Champions’ are respected thought leaders in their units. Their primary responsibilities are to assess the curriculum for their unit to determine the best place(s) for the addition of climate change content, to co-create climate change curriculum and provide advice on the learning needs of their students, to disseminate

the climate curriculum in their schools once it has been created, and to be a resource to faculty and staff as the climate change curriculum is implemented.

Within a year, the curriculum was created, reviewed, revised, copy-edited, and approved for dissemination. The final product is entitled *Climate change and health: An interprofessional response* (University of Minnesota Academic Health Center Office of Education, 2018). It consists of an introductory slide deck and eight focused slide decks on climate-related issues and their associated health impacts. Some of the focused slide decks include increasing severe weather, increasing allergens and air pollution, and the rise of extreme heat, all of which impact safety, exacerbate cardiopulmonary illnesses, and threaten food and water quality. These decks are designed to be implemented throughout the AHC by the ‘Climate Champions.’ The decks are also available to the general public through the University of Minnesota Center for Global Health and Social Responsibility under a Creative Commons license.

Phase III: Planning and Project Examples. Orienting and teaching health professional students about the health impacts of climate change are important steps in increasing awareness. However, knowledge alone is not enough. Without actions to adapt to or mitigate the health effects of climate change, change cannot occur. At the University of Minnesota AHC, the goal is to prepare students to lead climate change action which requires students to develop the skills needed to implement climate change-related projects while they are in their health programs. This implementation occurs in Phase III of the 1Health climate change curriculum, which is currently in the development-pilot stage (see Figure 1).

One approach health professional students can use to address climate change is to focus on reducing the carbon footprint of health care and health education. Formalized student environmental sustainability projects involve a deeper level of collaboration, one beyond the University AHC. ‘Climate Champions’ leading the Phase III initiative connect students who self-identify as having an interest in environmental projects with environmental leaders in local health organizations at a community level. Typically, environmental sustainability in health organizations falls within the scope of directors or managers who were trained in traditional health profession roles or otherwise. Therefore, students who participate in sustainability or climate action projects have the opportunity to learn from leaders in their own fields or outside their health disciplines – many of whom are not currently practicing health professionals. Thus far, students have participated in Phase III pilot projects that have focused on implementing the following environmental sustainability initiatives:

- Forming Green Teams in health care and health education settings
- Reducing the use of fossil fuels in health care and health education settings
- Developing carbon footprinting protocols for hospitals and clinics
- Reducing waste in patient care, organizational, and educational settings via increasing re-using, recycling, and composting rates
- Reducing unnecessary use of anesthetic gases with high global warming potentials
- Educating staff and leadership about regional impacts of climate change

- Developing patient education on climate change and health in Minnesota

Over time, the aim of Phase III is to support community-based projects for students who present a penchant for environmental or climate action in each health program. By carrying out these real-life projects in interprofessional teams comprised of health students and current health professionals, students learn the value of cross-sector collaboration. Connecting students and practicing health professionals around the issues of climate and health has the unique advantage of preparing students to transition to professional practice with a holistic understanding of the health impacts of climate change along with their disciplinary knowledge. Furthermore, students who work on projects with the goal of adapting to or mitigating climate change contribute to the ultimate global goal of reducing the effects of climate change.

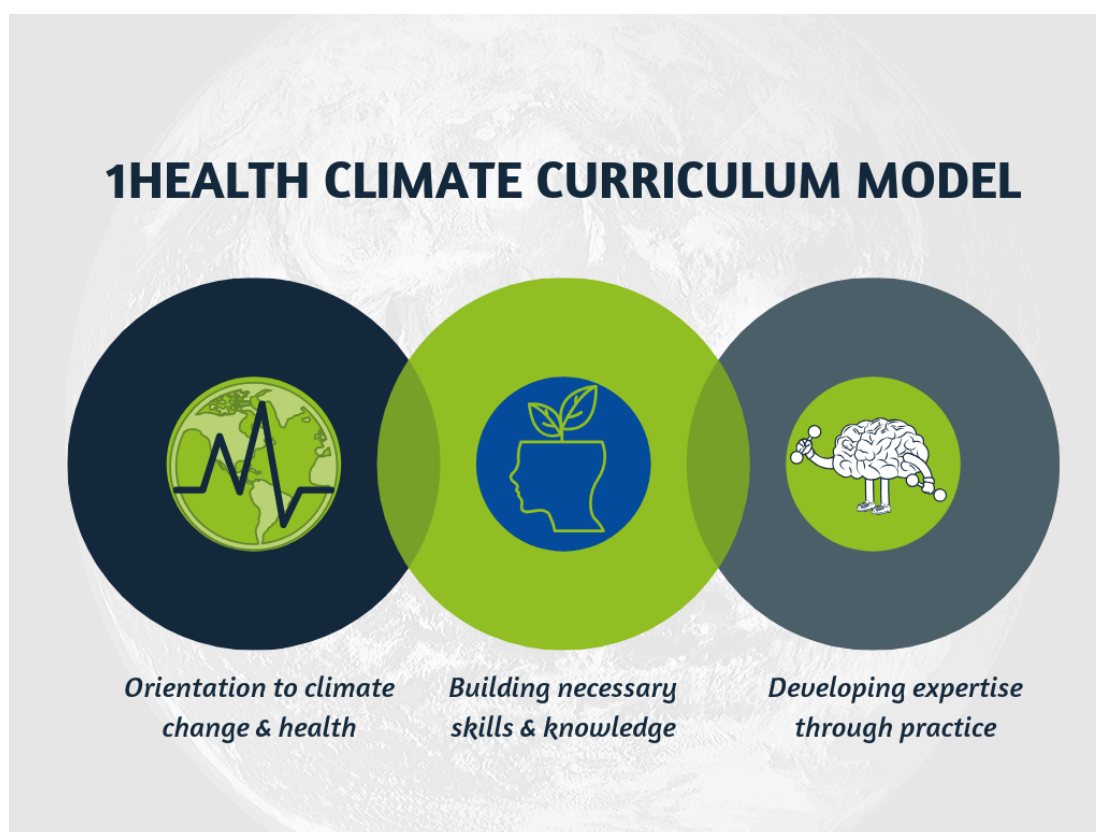


Figure 1. University of Minnesota 1Health Climate Curriculum Model (Based on 1Health: The University of Minnesota Interprofessional Education Program)

Lessons Learned

To date, the team has only received student evaluations regarding Phase I work. Of the over 1,100 students who participated in the orientation about the health impacts of climate change and the relevance to interprofessional collaboration, nearly 800 responded. It is important to recognize that the delivery of the orientation's content varied and was impacted by the skill levels of 40 different facilitators. A student in public

health nutrition commented, “This session was my favorite because in some way we were able to relate every professional role to having a part in climate change” (Sick, n.d.). Additionally, a speech-language pathology student shared, “I had never really considered the effects of climate change on health before, and I thought our discussions in small and large group were really informative” (Sick, n.d.).

On the other hand, there are further opportunities for ‘Climate Champions’ to refine the work, such as preparing facilitators to be more inclusive of all health professions. One audiology student commented that the climate change case was “not related to [their] field. What impact does climate change have on the auditory or vestibular system?” (Sick, n.d.). Furthermore, the debate of the existence of anthropogenic climate change remains. As one medical student stated, “Incorporating climate change, while important, seemed forced to certain students who deny the process or fail to recognize the severity” (Sick, n.d.).

While the survey results will inform work moving forward, this process is generalizable for multiple contexts. The following lessons learned from this experience may help inform others implementing similar initiatives:

- Never underestimate the power of students’ voices. When students mobilize and coordinate their requests, they can drive change. Therefore, working with student leaders to measure their interest in an initiative is an essential first step.
- Once students see a need for change, it is important that they directly work with leaders who have the authority to authorize that change.
- The next step is to create a diverse team to design the initiative. Effective change is not mandated nor does it thrive in hierarchies. Effective change occurs when people from diverse disciplines with diverse knowledge and experiences work in partnership to co-create solutions to our grand challenges.
- Effective change also requires a commitment to iterate. The first model is bound to require modifications based on feedback. Each new iteration can improve the effectiveness of the model.
- Be sure to keep stakeholders (i.e., students and administrators) informed of progress on the initiative. People want to see movement so they can support movement.
- Keep things as simple as possible. Layers of complexity are rarely necessary for an initiative to succeed.
- Share! Climate change is an “all hands-on-deck” issue. If you develop a best practice or create an effective model, pass the knowledge on to others.

This interprofessional climate work presented new challenges and opportunities that the faculty had not previously encountered. It required a great deal of patience and commitment to find dates and times when representatives from all the professions could meet. However, once ‘Climate Champions’ had been designated, one of the greatest take-aways was the sheer joy of working across boundaries. Not only did educators walk away with a better understanding of the incredible work being done across the AHC; they also came to recognize that transdisciplinary interprofessional collaboration makes things that previously seemed impossible possible. When leaders collaborate on transdisciplinary projects, siloed and hierarchical thinking is no longer palatable.

Next Steps

Knowing that during development and implementation of the curriculum challenges would be encountered, the ‘Climate Champion’ team deliberately incorporated the two I’s: Innovation and Iteration. In fact, innovation and iteration are the two primary components of design thinking (Brown & Wyatt, 2010). Specifically, “design thinking taps into capacities we all have but that are overlooked by more conventional problem-solving practices” (Brown & Wyatt, 2010, p. 33). Thus, the authors of this chapter used the design thinking approach during each of the three climate change curriculum phases to foster an unconventional and flexible process with valuable results. All three phases will continue to undergo further iterations in response to emerging trends and new climate change mitigation and adaptation knowledge.

In addition, the authors plan to use this experience to move closer to true transdisciplinary collaboration. While the value of sharing this story in academic journals of respective professions is understood, the authors aim to find dissemination opportunities that challenge disciplinary thinking. The authors hope to stretch, or even break, traditional boundaries that have, thus far, thwarted progress on climate change. They aim to weave the health sciences together in the context of humanity and nature (Choi & Pak, 2006). Support for transdisciplinary collaboration on climate work is steadily growing as evidenced by organizations such as WHO (2010) and the Planetary Health Alliance (2018). Through the dual lens of hope and opportunity, the ultimate aim is to transcend disciplinary boundaries to find effective and sustainable solutions for climate change.

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STUDENTS AS DRIVERS OF CHANGE: ADVANCING SUSTAINABILITY SCIENCE, CONFRONTING SOCIETY'S GRAND CHALLENGES

Carla Carlson

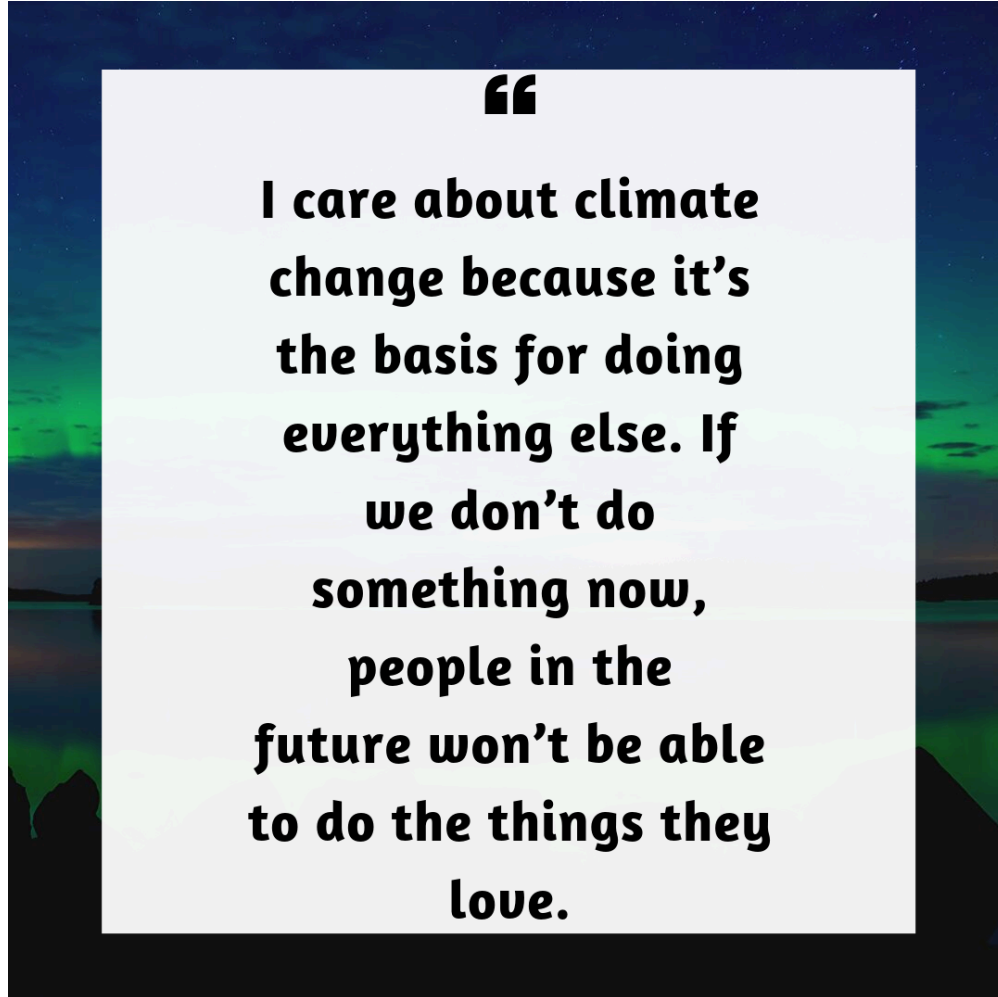
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Rising sea levels and untoward outcomes from levee and dam construction have reduced the home of a community of Louisiana's Native Americans from a 22,000-acre island to an isolated and disappearing 320-acre spot of land. Isle de Jean Charles, about 80 miles south of New Orleans, is now distinguished as the location of the first climate refugees in the United States (Isle de Jean Charles Band, 2018; the State of Louisiana, 2018). The reality of this human-induced assault on the bayou environment and the people who live there is fraught with tensions across federal, state, local, and tribal governments. The tensions from a systems-thinking perspective are complex and include cultures, ecosystem distress, geography, money, power and politics.

Moving up the Mississippi River from New Orleans to the Minneapolis, Minnesota suburb of Saint Louis Park, a high school student organizer says, "I care about climate change because it's the basis for doing everything else. If we don't do something now, people in the future won't be able to do the things they love." Katie Christiansen is a leader of the Saint Louis Park High School's Roots and Shoots Club (Yarger, 2018), an affiliate of the national student-based iMatter campaign (iMatter-St. Louis Park, Minnesota, 2018). The club is credited with the Saint Louis Park City Council's February 2018 adoption of a climate action plan that has the goal of achieving carbon neutrality by 2040. The City Council action was based, in part, on a climate change report card issued by the student club two years earlier.

Many of the students who worked on the climate change report card are now well into their undergraduate studies. Their hands-on research on sustainability issues, articulation of steps to take to mitigate problems such as greenhouse gas emissions, and creation of strategies to address renewable energy and waste management

options for the city provided them with real-time experience in contributing solutions to the complex grand challenges facing society. Will their higher education degree programs prepare them for a future as active citizens or researchers? Will their graduate programs narrow their focus to a single discipline or provide the interdisciplinary and transdisciplinary foundations needed to confront the interrelated environmental, social, and economic issues of sustainability represented by Isle de Jean Charles?



Sustainability and Students

A generation has passed since the concept of sustainability debuted in the 1987 United Nations report, “Our Common Future” (World Commission on Environment and Development, 1987). Sustainability science, more recently defined as “use-inspired research” that promotes goals of sustainability (Matson, Clark, & Anderson, 2016), is in the early stages of evolving as a new field of science. Sustainability science was first described in a 1999 report of the National Research Council and was further advanced in a 2001 article in *Science* (Kates et al., 2001). Early descriptions focused on ways that sustainability science can help to ensure the health of the planet and its future generations. At that time, reports did not explicitly address preparing future generations of problem solvers and leaders – students. Nearly 30 years prior to the 2001 *Science* article,

Griffith and Mullins (1972) emphasized the importance of specifically engaging graduate students in research and training opportunities so they can take part in emerging fields and teach the next generation. Griffith and Mullins (1972) summarized, “The importance of these activities is clear: Groups without students die” (p. 962). Today, the emphasis applies to the emerging field of sustainability science.

To fully appreciate the influence that students wield today, it is important to consider interrelated elements that contribute to their position as agents of change. This chapter focuses on the emergence of the sustainability science field, the structure of higher education institutions, the role of faculty members, and the direct influence that students have on faculty members who engage in sustainability and sustainability science-related work. The chapter concludes with examples of efforts being made by higher education organizations, sustainability networks, and institutions to create sustainability and transdisciplinary learning experiences that best position students in their careers, and as future leaders, in sustainability.

The Field of Sustainability Science

One activity that helps advance sustainability science is transdisciplinary research analyses. Transdisciplinary research is a new, but growing field, that is essential to sustainability science but, as of yet, has no common terminology or shared research framework (Brandt et al., 2013). Descriptions of integrated, cross-disciplinary processes generally rest on two terms: *interdisciplinary* and *transdisciplinary*. Vincent and Focht (2011) described interdisciplinary processes as those pursued by scientific and technological experts to better understand complex environmental systems and phenomena. Their definition of transdisciplinary processes expands to include environmental practitioners, policymakers, economic sector representatives, and public stakeholders who participate in the policies and governance that guide the management of complex human-nature systems. Transdisciplinary work – integrating scholarly research expertise with other ways of knowing – is foundational to sustainability science and the type of experiential learning that students are demanding.

Developments that are associated with sustainability science – evolving communications and research networks, conferences, and new journals – are consistent with what has been called “the invisible college” (Crane, 1969) and the emergence of new scientific fields (Griffith & Mullins, 1972). Social mechanisms that result in a response to scientific problems and advocacy around an issue can develop among groups of researchers (Griffith & Mullins, 1972) – in this case, sustainability. In some cases, scientists that coalesce around a scientific issue might have effects on their respective, traditional disciplines. Based on an analysis of the literature on sustainability, Bettencourt and Kaur (2011) found that the sustainability science research network has a broad geographical footprint that includes both developed and developing countries. The network also includes small universities, as well as well-recognized national centers, from around the world and a disciplinary array that includes the social sciences, biophysical sciences, health sciences, engineering, law, public policy, and increasingly, the arts and humanities.

As described later, from the perspective of faculty members, graduate students increasingly come to the classroom and the laboratory with an understanding of the complexities of the vexing, big problems of today.

They are eager to work with others from a variety of disciplines and with external community partners to drive toward solutions that require diverse ways of knowing and expertise from multiple disciplines. Students are motivators. They press faculty to include interdisciplinary components in courses and question requirements in degree programs that do not better position them for interdisciplinary expertise – possibly making them the most effective change agents within academia today.

Institutions of Higher Education

Since the inception of sustainability science in 2001 (Wiek, Withycombe, & Redman, 2011) and the subsequent literature contributions, scholars have been exploring implications for higher education's role in sustainability. Scholars have also been emphasizing ways to balance social and natural science research approaches and to integrate citizens' local knowledge.

Higher education is well-positioned to serve as the change agent for sustainability (Stephens, Hernandez, Román, Graham, & Scholz, 2008), particularly with the emergence of sustainability science. Stephens, Hernandez, Román, Graham, & Scholz (2008) suggest that the new science of sustainability could indeed spur change and subsequently transition society, via a new, integrated approach, to address the complex and long-term challenges of sustainability. Academic researchers recognize the structural impediments within higher education institutions that can inhibit progress in addressing sustainability and that the inception of sustainability science signals interest, on the part of researchers, to break down institutional barriers.

A key challenge to integrating sustainability research and community engagement into colleges and universities is inherent in the organization and leadership structures of higher education institutions. Cortese (2003) concluded that the vertical rigor of the disciplinary focus (commonly referred to as a “silo”) in higher education encourages compartmentalized and competitive views that are contrary to the interdependent nature of sustainability. He suggested a structure and culture where an equally strong lateral rigor draws students and faculty across disciplines together, encourages systems thinking, incorporates sustainable operations and facility design, and engages communities. Using the University of Michigan as a case study, Shriberg (2003) addressed the consequences of a lack of sustainability leadership at the highest levels of an institution. Shriberg (2003) argued that activities across an institution are piecemeal greening efforts and concluded that, without leaders at the top who identify sustainability as a priority, there is no driving force to coalesce the many scattered pockets of sustainability activities and disciplinary knowledge into a cohesive whole. Velazquez, Munguia, and Sanchez (2005) also reported that decentralized management, bureaucracy, student and faculty turnover, and many non-standardized processes are also barriers to achieving institutional sustainability goals. Other scholars have concluded that there are few examples of strong institutional leaders who make an active commitment to achieving their institution's sustainability goals and an alternative leadership model is required (Thompson & Green, 2005). They argued that, within an institution, proponents of sustainability must develop strategies that do not assume a top-down approach (Thompson & Green, 2005).

The Role of Faculty

Some scholars emphasize the importance of faculty members when it comes to motivating people to make changes related to sustainability within their institutions. Pittman (2004) argued that, within institutions of higher education, top-down approaches to strategic initiatives and transformational change are largely ineffective. He noted that institutions are slow to change their use of mechanistic “command and control” (Pittman, 2004, p. 202) strategies to manage their scientific endeavors. Pittman described the importance of the relationship between the individual faculty member and the institution through the lens of whole systems design. Whole systems design is a design-based strategy for organizational change that begins with individuals – faculty, students, and partners outside of the university – who work together toward a shared and collective vision to address complex problems such as sustainability. Pittman (2004) emphasized that it is individuals within an institution who will make change.

Student Influences on Faculty Members

The observations of faculty members are a testament to the change-making leadership that students are demonstrating in classrooms, labs, and community partnership projects. During dissertation research data collection (Carlson, 2017), 20 faculty members at the University of Minnesota were interviewed about the ways factors related to sustainability science influence their work. Seven factors consistent with the emergence of new fields of science were analyzed: new journals; associations, organizations, and networks; funders’ priorities; colleagues from other disciplines; stakeholder and citizen interests; international arrangements; and student interests. Student interests, more specifically those of graduate students, was one of three factors that had a very strong influence on faculty – all respondents indicated the ways that students positively influence their research, teaching, and community engagement (the other two factors that strongly influenced faculty were colleagues from other disciplines and stakeholder and citizen interests). The faculty interviewees were affiliated with a University-wide interdisciplinary center and represented 16 disciplines. They had all conducted sustainability research to varying degrees.

Today, students exhibit a level of global awareness, including both scientific and social awareness, of complex issues beyond that of students a decade ago, according to the faculty interviewees referenced below (Carlson, 2017). The savviness that students have for employing sustainability science methods to address societal grand challenges affects professors’ research and how they incorporate sustainability issues into the curriculum. Scholars described the strong influence of their students with enthusiasm and pride. One professor compared the students’ growing interest in the interaction of humans and nature with the emergence of sustainability science:

[The influence of students] is constant in the sense that they’ll come in and ask really good questions. They oftentimes bring in new and fresh perspectives. I get exposed to students who are really interested in issues about

where we are headed – what's happening in the environment and what's happening to the environment and society.

Students appear to be pushing for a cultural change that is recognized by faculty members. Some professors are meeting the interests of students through research opportunities and class curriculum. A biologist described the change in student interests over time as aligning with sustainability science and the concomitant influences of sustainability science on research projects:

Students have changed tremendously in my career. When I was a graduate student and then shortly after that became a faculty member, we paid almost no attention to whether our work was relevant to sustainability of the planet. In fact, quite the contrary, there was an attitude when I started my career – quite a pervasive attitude – that basically looked down on any projects that had social relevance. The thinking was, if you're doing something socially relevant, it's because you aren't good enough to come up with an idea that's saleable otherwise. And today, the pendulum has swung so far that almost every project, almost every student who comes to me, starts with an idea of, even in general terms, 'We're increasing carbon dioxide, and the climate's changing, and therefore we have to know X, Y, or Z.' I would have to think very long to remember the last student who expressed an interest to me that was disassociated with social forces and sustainability science broadly defined. Every student says they want to work on biology or ecology or limnology today because they care about people of the planet. There has been a tremendous cultural shift.

Students influence their professors by utilizing the mentor, adviser, or teacher relationship to introduce them to related areas of research. An engineer described a new area of investigation and the learning that the scientist experienced through advising a student:

I've had a few [students] come in from the get-go with a really strong idea of what they wanted to work on, and that's been really fun because over time you can see how it connects to your other work, too. And I had one [student] who was really interested in stormwater treatment and rain gardens, which is not something that I've thought of myself as doing. I co-advised this [student], and he was so smart, and it was a really nice three-way partnership. I learned just a ton from him, and I think about stormwater now, where I never would have bothered to think about it before...When I first started [teaching], the students seemed not very engaged in the political world and social enterprises. They seemed pretty focused on themselves and their other activities. Now, I see a change; the students are really engaged and want to save the world. They're much more politically aware – and not just necessarily Washington politics – but in general, the movements going on, Black Lives Matter, and various equity and social justice things going on. I think they're much more aware of developing world issues.

The genuine receptivity to student ideas and research findings that many respondents described was articulated by a public health researcher:

Students bring new ideas that are not my area of expertise but are around my area of interest or my area of application. I have an excellent Ph.D. student who actually proposed to me a new method. I was very skeptical at the beginning, but we evaluated that method with other previous methods that we used, and her method is much more efficient. So, I love when these things happen because they open my mind.

An entomologist described an instance where a student researcher had a major impact on an aspect of the respondent's ongoing research:

...Sometimes [students] find out things that I never would have thought. I have an example of that with a student doing what he was supposed to be doing, but then he found something really different that really changed everything. So that can happen. [The student's finding] made us think differently about the [work]. That was a case of a student just doing a regular experiment and finding out something that really sort of blew our minds.

Students may be a factor in deepening interdisciplinary interactions through their work with scientists and other students in multiple disciplines. A big-data researcher reflected on the influences of students from various disciplines, using an example that included post-doctoral researchers:

I have seen that a few of my students, while they were working with a postdoc coming from the science domain of ecology and climate science, get locked into the problem, and then they start teaching me. One of my students is studying how plants adjust their various properties in different biomes, and she knows more about this than I do. And she educates me. She understands what I know and understand, and she'll bring it down to my level and explain to me what we are trying to do. I learn more from the [students] than I would get from [reading] a Nature or Proceedings of the National Academy of Sciences science paper...And the post-docs in other disciplines teach me a lot, a lot. I do serve on the committees of various students, somebody working on leaf venation structures – how leaf veins work. Somebody working on plant species that are going extinct...they often need a sounding board on the mathematical and computing ideas. I think this is a fantastic use of my time...This stimulates your brain; this person unfolds this whole new world. I find that fascinating. And, in some ways, I believe I can help them.

Students were strong motivators for the professors who were interviewed. The give and take between a student's interests and the expertise of a scientist can result in changes in the way a scientist approaches a research question and encourages a student to pursue a research direction. A chemistry professor addressed students' passion for working on the wicked problems facing society and the challenges of addressing their curiosity and creativity:

Graduate students who come into our program are very keen on, to be a little bit flip, saving the world. They want to work on sustainability initiatives whether or not it's in energy or water or food or green chemistry. That transition is evident since the last decade or 20 years since I've been here. The student population is changing so much. They really are passionate about solving these practical problems, so they push me in that direction. It's really kind of synergistic. I pitch it, but they're already committed to it, and so they give me more motivation to continue along those lines. If the students are coming in with a particular interest in a framework of sustainability, how can I work my science and research projects to connect to the students? Can I emphasize and grow the sustainability aspect on the basis that this is what the students want to work on? I like the latitude of letting the students take the projects in the directions they think are most important.

The Academic Organization

Student interests strongly motivate faculty behavior. The desire of both students and faculty to apply sustainability science methods – interdisciplinary and transdisciplinary approaches, among others – will likely drive change within academic institution structures. Institutions, in general, strive to meet student needs in the classroom and through graduate education experiences but lag in providing the high-value interdisciplinary and transdisciplinary opportunities that students desire. Interviewees expressed their goals for addressing student interests and also described opportunities and challenges for graduate education.

A professor described the pervasiveness of sustainability and student interest as the impetus to incorporate sustainability approaches in the classroom:

I think that students are definitely interested in sustainability. Most students who come to the field of urban planning know what it is, know how to use the term, and refer to things that they're doing as sustainable or not, and have some basic understanding. They're often motivated in saying, 'You know, I really want to do sustainability planning. What opportunities for me are there in sustainability?' What I try to do in the class that focuses on it most totally is to think about tools and ways that sustainability is implemented – take a set of ideas and a set of aspirations and some sort of ideal concept that we can get to, which is sustainability, to think about, for planners or for people in public policy, what are the tools that they have to get to [do sustainability]?

New approaches to graduate student training and interdisciplinary work could be developed using a sustainability science lens. A scientist commented on the benefits of education from both a disciplinary and interdisciplinary frame:

I've had a few students, and I could see having a growing proportion of students, who are doing work that is essentially informed by sustainability science. I had one student who did a mix of applied economics and ecological modeling to create the scenarios of land use, and that work is increasingly being subsumed under sustainability science...If you could get the graduate students inured to an interdisciplinary sustainability focus, then they will carry that forward. The [graduate students] would be trained in that way – have a home discipline in which they are experts, but get used to playing with other folk.

Within the current configuration of higher education institutions, students pursuing sustainability science or other aspects of interdisciplinary work will likely find barriers. An interviewee focusing on geographical information systems-based research expressed concern for students who seek interdisciplinary expertise in educational systems constrained by the disciplines. The interviewee posited that a strong disciplinary focus might better position students for the future, given the current structure and reward system of academia.

When you have a graduate program like conservation biology or sustainability studies, I worry that [the students are] going to be undercut when they go on the job market. Say you want to get hired into a sociology department; most sociology departments would rather hire a straight up sociologist than someone who did a sustainability science degree with a sociology focus, which kind of speaks to the tyranny of the discipline.

The majority of faculty members in academia conduct disciplinary research, following the traditional

structures of higher education institutions. However, as young academics with sustainability science or interdisciplinary expertise move through the tenure process, the mix of disciplinary and interdisciplinary focus might change over time. An ecologist described enthusiasm for working with students compared to working with peers:

The students haven't been beaten down by disciplinary pressures for decades, so it's much easier to do interdisciplinary work with them than it is to do it with senior faculty. And [the students] also bring lots of energy.

Student interest in sustainability can better inform the public as graduates with sustainability science and interdisciplinary expertise move into the workforce. This expertise can benefit young learners in kindergarten through 12th grade classrooms, as well as the general public. A professor with interest in science education said:

[University students] tend to come in [now] having had a few more, I would say very loosely, interdisciplinary experiences or different experiences in learning. They're more likely to have seen examples of how to use sustainability as a way to teach their disciplines. Sustainability has been a way for me to bridge that [interest in science by students who do not intend to become scientists]. For me, it's really: How do you get the public in any way, sense, or form, to care about scientific issues? Sustainability just becomes one of those drivers [of interest in scientific issues].

The interviewees addressed, in a variety of ways, the burden of the disciplines in the promotion and tenure policy, departmental expectations, and the standard advice to young, non-tenured faculty members and students not to stray from the narrow, disciplinary focus. They expressed concern for their students who are passionate about working on interdisciplinary grand challenges, noting, in particular, academic employers' expectations for an intellectual base in a discipline.

Results from the analysis of the faculty interview data emphasized the importance of individuals – faculty members and students – as change agents within higher education institutions. Change agents are necessary for the expansion of sustainability science-based approaches to research, teaching, and community engagement. The dedication of the faculty to pursue solutions to complex sustainability problems, coupled with the students demanding transdisciplinary experiences through sustainability science, might be increasingly strong drivers for institutional change.

Encouraging Institutional Change

Advancing higher education organization networks is one strategy that can be used to encourage institutional change that results in increased opportunities for graduate students in sustainability science and interdisciplinary and transdisciplinary scholarship.

Higher Education Organizations

Three key higher education organizations that specifically include a focus on graduate students are the American Association of State Colleges and Universities, the Association of American Universities, and the Association of Public and Land-Grant Universities. Although the focus on graduate student opportunities in sustainability and interdisciplinary and transdisciplinary scholarship could be more straightforward, each of the three organizations highlights preparing students to address societal grand challenges to varying degrees.

The American Association of State Colleges and Universities (2018a) has 400 public college and university member institutions in the United States, Guam, Puerto Rico, and the Virgin Islands. Student attendance at these institutions ranges from 1,000 to 44,000 students. The organization's sustainability and sustainable development programs include emphases on education and the establishment of minors in sustainability (2018b).

The Association of American Universities (2018a), with 62 research university members, has launched a doctoral education initiative that includes a goal to "influence the culture and behavior at the department level to provide Ph.D. students with the knowledge, skills, and abilities to be successful in careers both within and beyond academia" (2018b). Neither sustainability science nor interdisciplinary/transdisciplinary scholarship, however, are specifically addressed.

The Association of Public & Land-Grant Universities represents 238 members in all 50 states, the District of Columbia, four U.S. territories, Canada, and Mexico (2018a). It has undertaken two initiatives that have the potential to advance opportunities for graduate students wishing to enhance their interdisciplinary and transdisciplinary learning experiences to pursue careers in sustainability. The "Challenge of Change" initiative focuses on sustainable solutions to feeding the world, specifically noting the role academic institutions have in training future generations of leaders who will continue to address the health of people and of the environment (2018b). The Highly Integrative Basic and Responsive (HIBAR) Research initiative is a network of research leaders grounded in collaborative work engaging academic institutions, corporations, and governmental agencies. The Association states that "HIBAR research builds upon other conceptions of engaged science and technology, such as research on societal grand challenges" (2018c). The Association lists 21 criteria for evaluating HIBAR research. Criterion 17 is: "Are there opportunities to involve and mentor students?" (2018d). This criterion suggests that there is some level of attention being paid to enhancing opportunities that emphasize the value of external partners for students who wish to gain experiences in collaborative research.

In addition, in October 2017, the University of California-Los Angeles convened representatives from more than 20 universities and other institutions to discuss the creation of a community of practice for university-led grand challenges initiatives. University-Led Grand Challenges (Popowitz & Dorgelo, 2018), the report from the workshop, highlights the efforts of 18 universities that are leading grand challenges programs that engage students, faculty, and external partners to solve major societal issues. The institutions are pursuing varying approaches to research, teaching, and public engagement to advance solutions-driven science. The report addresses the need to position students to be future leaders in addressing grand challenges. Among

these institutions, the University of Minnesota is somewhat unique, since the five grand challenges that the institution continues to address were developed through a campus community engagement model that involved faculty, students, and staff members. Competitively funded interdisciplinary teams include graduate and undergraduate students as well as external partners (University of Minnesota, 2018).

Sustainability-Focused Organizations

Organizations that focus on action agendas related to sustainability and sustainable development are also increasingly viewing the preparation of future leaders in sustainability as a priority. A number of colleges and universities have indicated their commitment to sustainability through membership in the Association for the Advancement of Sustainability in Higher Education (2018a). The association offers action steps and documentation that institutions can use to shape a sustainability strategy. It also offers self-reported information on sustainability courses, certificate programs, concentrations, and sustainability-related minors (2018b). The data are informative but are not described in a way that allows for easy comparisons across institutions or opportunities for graduate students.

Even before the United Nations Decade of Education for Sustainable Development concluded in 2014 (United Nations Educational, Scientific and Cultural Organization, 2018), the Sustainable Development Solutions Network (2018a) was launched in 2012 to support the achievement of the 17 Sustainable Development Goals. Universities represent 500 of the more than 800 network members (Sustainable Development Solutions Network, 2018b) that are working toward the Sustainable Development Goals objectives of ending poverty and hunger, ensuring access to education and healthcare, and protecting the environment worldwide (United Nations Development Programme, 2018). In addition, the University Partnership Program of the Sustainable Development Solutions Network (2018c) assists universities and other educational institutions in incorporating sustainability materials into course development and delivery.

The definition of sustainable development from the classic Brundtland report (World Commission on Environment and Development, 1987) emphasized a long-term perspective: “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (chapter 2, point 1). An essential component of this long-term view is the education and training of sustainability scientists and practitioners who are skilled in interdisciplinary and transdisciplinary approaches to the big, intractable problems facing societies globally. Organizations and networks are indeed collaborating to support the integration of sustainability into the curriculum and degree programs at academic institutions. However, to what extent is the education of graduate students as future leaders in sustainability a priority for individual institutions of higher education?

Advances in Higher Education Institutions

In general, the concept of sustainability has gained traction in recent years, supported by increasing

institutional momentum. European institutions have led the way (Gardner, 2011), but both Arizona State University and Harvard University, among others, are cited as prominent examples of institutional accomplishment and leadership in the field of sustainability (Rowe, 2007; Wiek, Withycombe, & Redman, 2011).

Arizona State University president Michael M. Crow describes the reconceptualization of his institution based on commitments to academic excellence, inclusiveness, maximum societal impact, and quality operations and organization – with sustainability at the core (Arizona State University, 2018a; Crow, 2010). Transdisciplinary schools within the university have been created and some traditional academic departments have been eliminated including biology, sociology, anthropology, and geology. In envisioning the “New American University,” Crow (Arizona State University, 2018b) urges that “scientific research conducted with application and social context in mind – outcome-driven science, or science with purpose – should be granted equal accord with fundamental research” (Crow, 2010, p. 488). Since the inception of the School of Sustainability in 2007, one of the outcomes has been that the current portfolio of graduate sustainability degree programs includes masters and Ph.D. degree programs (Arizona State University, 2018c).

George Washington University offers another strategy for sustainability education that takes a step beyond interdisciplinary scholarship. The Academic Program in Sustainability resides in the Office of the Provost at George Washington University, consistent with a pan-university vision for courses open to all students and faculty (Benton-Short & Merrigan, 2016). The George Washington Faculty Committee on Sustainability considered four approaches for structuring sustainability education: a unique sustainability degree, the creation of a degree-granting sustainability institute or center, the establishment of a school of sustainability, and organizing existing sustainability-related degree programs into a matrix. The matrix approach has been pursued with some success. However, Benton-Short and Merrigan (2016) noted the ongoing challenges for organizational structures that create barriers for many higher education institutions intent on advancing sustainability and interdisciplinary and transdisciplinary opportunities in research and education. Traditional barriers continue to be disciplinary silos, promotion and tenure processes, and governance issues, among others.

Arizona State University and George Washington University are just two examples of institutions that are innovating to ensure that graduate student education best positions students for their careers, whether in academia or in public or private sectors. It is important to emphasize the tendencies of institutions toward isomorphism, the process that causes, in this case, a higher education institution to become more like other colleges and universities (DiMaggio & Powell, 1983). Isomorphism can potentially contribute to a more coordinated approach to graduate education and training — and to sustainability solutions – across an increasing number of higher education institutions.

Making Change

Students will continue to be drivers of change within institutions of higher education. Through sustainability

science and transdisciplinary approaches, the faculty and students within their institutions can reach beyond the campus to work with stakeholders and citizens' organizations to confront sustainability challenges together. Colleges and universities need to continue to assess how best to tailor scholarship and experiential learning opportunities – whether designated as grand challenges or interdisciplinary, transdisciplinary, or sustainability scholarship – to best prepare the sustainability leaders of the future.

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DEVELOPING LEADERS IN PLACE: GRADUATE LEADERSHIP EDUCATION FOR A SUSTAINABLE AND PEACEFUL FUTURE

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Society is in an era of rapid change. Political and social environments are fraught with fear, uncertainty, and division on a global scale; war, conflict, and human rights abuses are widespread; democratic norms are strained; and society bears witness to, and is frequently complicit in, unprecedented degradation of the environment and natural world. In this time of accelerated change, society naturally seeks comfort in control and familiar structures; “we reach for old maps, the routine responses, what worked in the past” (Wheatley, 2010, p. 39). In doing so, society frequently looks for leadership that comforts or confirms rather than that which helps it grow, more effectively navigate, and make meaning of the challenges it faces. In this “Age of Disruption” (Scharmer & Kaufer, 2013, p. 3), educators’ understanding and practice of leadership is deeply challenged and must adapt. As the frame of what constitutes effective leadership evolves, so must leadership education and development. Educators need to better prepare citizens, organizations, and communities to co-create a shared future in ways that center peace, justice, and sustainability. With such goals in mind, we perceive leadership as engaged citizenship and community participation rather than, or regardless of, the presence of authority; leadership can and should be practiced by all who seek to participate in creating their own future. As educators in this time and place, we are called to better equip graduate students with competencies that prepare them for effective leadership in a time of upheaval and change. This means preparing them to participate

in constructing and enacting new ways of leading, whatever their discipline or career trajectory, in order to generate more sustainable organizations and communities.

Supported by conversations unfolding about the competencies necessary for students engaged in the academic study of sustainability, this chapter builds upon the argument that sustainability and peace are fundamental frameworks that will shape how educators in all disciplines teach and equip graduate students for leadership and creating change (Satterwhite, McIntyre Miller, & Sheridan, 2015). Bolstered by emerging paradigms of leadership that highlight systems thinking, human development, criticality, and complexity theory—as well as sources beyond the Western leadership canon that better illustrate our relationship with self, others, and the natural world—we call for graduate education programs of any discipline to integrate the following three key leadership development competencies: systems thinking, time and boundary navigation, and challenging normative constructs. As this chapter will demonstrate, these competencies help students develop the habits of mind, practical skills, and resiliency needed to thrive today, while helping to ensure that future generations will have similar opportunities. Further supporting these competencies is the emergent dialogue that has taken place within the academic field of sustainability about key competencies students need to be effective problem solvers and change agents.



Wiek, Withycombe, and Redman (2011) identified key competencies critical to the academic study of

sustainability including systems thinking, anticipatory competence (temporal and spatial acumen), and normative competence (the ability to question and reconcile competing values, ideas, and frameworks). This alignment indicates an important confluence of the fields of leadership and sustainability, reinforces the complexity of theory and practice in these two interconnected arenas, and reminds us that multiple disciplines are engaged in addressing society's most pressing global challenges.

While still new and in need of validation, competency-based education in institutions of higher education has increased significantly over the past decade (Cunningham, Key, & Capron, 2016). Such approaches to curriculum development integrate broad professional skills with technical and context-specific knowledge and abilities to prepare students for success within their fields and the overarching landscape of organizational and professional life. This chapter argues that graduate education is the most fertile context in which to integrate such complex, developmental approaches to learning and illuminates the deep connection between the study and practice of leadership with concepts of sustainability. Each of the three critical competencies are discussed and further defined through the lens of emerging leadership constructs with nods to sustainability, ecology, and environmental science. Following the discussion of each competency, pedagogical considerations for integrating competency development into academic programs are introduced. Finally, several practical and applied ideas for addressing and developing these competencies in graduate education are offered.

A Call for Leadership Development in Graduate Education

The broader social and environmental contexts in which educators are preparing graduate students to work, live, and thrive, are shaped by emergent, wicked challenges that cross traditional boundaries and cannot be solved by existing knowledge or processes (Grint, 2010). In order to engage in this environment of increased complexity and interconnectedness, educators must ensure that graduate students are “equipped to synthesize and bring together ideas from a variety of perspectives” (Stedman & Andenoro, 2015, p. 145). Additionally, graduate students should be capable of participating in the process of deconstructing and reconstructing oppressive narratives of leadership so that leadership can squarely “be placed...in service of justice and sustainability” (Bendell, Little, & Sutherland, 2018, p. 26). The challenges faced cannot be addressed by an individual leader or a privileged few; rather, “the human dynamics of how we operate socially must play a role in how we solve these problems where a singular response is no longer adequate” (Stedman & Andenoro, 2015, p. 146).

Preparing students to enter into shared and rapidly changing social and environmental contexts requires integrating intentional leadership development with a lens of reflective adult development. Multiple lines of inquiry into how adults continue to develop throughout their lifespans have yielded relevant insights for leadership development, including the need for attending to developing ecocentric perspectives over egocentric ones (Plotkin, 2008; Scharmer & Kaufman, 2013), first and second tier consciousness (Beck & Cowan, 2006), and a self-transforming mind (Kegan & Lahey, 2009). These insights, briefly discussed below, prepare graduate students to effectively confront the wicked challenges shaping our shared future.

In 2008, Plotkin explored a developmental path that requires a balance of the demands of nature and culture and a shift in human consciousness as society matures into “people who are citizens of the Earth and residents of the universe” (p.7). In work that emerged from Clare Graves’ research, Beck and Cowan (1996) located a shift between first and second tier consciousness where individuals develop a worldview that is multidimensional and complex, with a focus on flexibility, inevitability, collectivity, and openness. Finally, Kegan and Lahey (2009) identified the self-transforming mind that can “step back [further] and reflect on the limits of our own ideology or personal authority; see that any one system or self-organization is in some way partial or incomplete; be friendlier towards contradiction and opposites; seek to hold on to multiple systems rather than projecting all but one onto the other” (p. 17).

Taken together, these explorations of adult developmental trajectories point towards an adult mind that is increasingly capable of complex and dialectical thinking with a notion of self that arises from dynamic relationships and being in community with one another. While this may not be achievable in the short period that most students engage in graduate studies, graduate programs should nonetheless seek to actively accelerate this developmental process. One way to do this is through leadership development guided by the three competency areas discussed herein.

Ultimately, integrating leadership development into graduate education also meets Fink’s (2013) call for embracing a new paradigm in college teaching that is characterized by active forms of learning and a constructivist epistemology shaped by inquiry and invention where knowledge is jointly constructed by students and faculty. Each of the three competencies advance this educational paradigm by strengthening under-utilized categories of Fink’s (2013) taxonomy of significant learning: integration, human dimension, caring, and learning how to learn. Building competencies in systems thinking, time and boundary navigation, and challenging normative constructs requires students to connect ideas, learning experiences, and realms of life (integration); become self-directed learners (learning how to learn); develop new feelings, interests, and values — in this case regarding our shared responsibility for a just, peaceful, and sustainable world (caring); and learn about oneself and others (human dimension). As presented here, leadership development is inherently about finding identity and agency in communities and in integrating knowledge, experience, and structure in a way that inclusively co-constructs a better future. Fink’s (2013) larger critique about the state of U.S. higher education — namely that there are significant limitations in providing significant and transformational learning experiences — indicates that if graduate programs were to embrace these competencies (and support faculty in delivering such an educational experience), this work would go a long way towards enhancing the overall educational practice.

It is for these reasons that educators need to prepare graduate students to engage in leadership, both in their respective fields and, more broadly, in their workplaces and communities. While leadership studies education has arguably become a distinct discipline, it is one relevant to and essential in any industry, field, or area of shared human activity. The authors of this chapter believe that leadership development should increasingly be seen as a fundamental outcome of graduate education, not simply by virtue of acquiring specialized

disciplinary knowledge, but through an intentionally designed curricular experience that develops skills in systems thinking, time and boundary navigation, and challenging normative constructs.

Existing efforts to prepare graduate students for the complex work they will be called to do largely fail to adequately prepare them for leadership within the world they will be operating. With only 11% of the U.S. population holding advanced degrees – and a much lower percentage of the global population – graduate students are an influential subset of the population who are equipped with specialized knowledge that is increasingly needed to address the complex challenges society faces (Ryan & Bauman, 2016). However, specialized knowledge and the ability to employ it in collaborative ways that center peace, justice, and sustainability in our communities and workplaces are needed even more. Regardless of the type and nature of their roles in organizations and communities, it is critical to prepare graduate students to be changemakers and learners that engage in leadership that creates solutions to the global community’s most pressing issues while building resiliency to new challenges as they arise.

Critical Competencies for Graduate Education

To explore the competencies of systems thinking, navigating time and boundaries, and challenging normative constructs and how they serve as a framework for leadership development within graduate education, it is important to establish a working definition of competencies and understand their use in an educational context. For this chapter, competencies are defined as “complexes of knowledge, skills, and attitudes that enable successful task performance and problem solving” (Wiek, Withycombe, & Redman, 2011, p. 204), specifically with regard to sustainability challenges and opportunities, including issues of peace. The development of competencies is meant to progress over time, so rather than equipping students with expertise in these areas, competency development should be concerned with establishing a foundation and planting seeds that will continue to grow as students immerse themselves in professional, community, and organizational life. Competencies themselves are not outcomes to be achieved; rather, they serve as thematic guides for the establishment of measurable outcomes that demonstrate their application.

The remainder of the chapter will explore these three graduate education leadership development competencies. The chapter will discuss the literature that supports each competency and explore practices that actively support their development. While these three competencies will be explored separately, there is significant interplay between them and overlap among them. It is critical for graduate students to integrate these competencies into a cohesive leadership practice.

Systems Thinking

Systems thinking – the ability to recognize interconnectedness, see wholeness from the parts, hold the one and the many, and value emergent properties, among other things – is increasingly called upon as a necessary capacity in emergent notions of leadership. Ideas presented by Senge, Smith, Kruschwitz, Laur, and Schley

(2008), Wheatley (2006), Allen and Cherrey (2000), Scharmer (2013), Scharmer and Kaufer (2009), and Satterwhite et al. (2015, 2016) emphasize nurturing a comfort with uncertainty and ambiguity, collaborating across perceived boundaries, and engaging multiple perspectives as critical to effective leadership.

Senge et al. (2008) discussed how systems thinking can be integrated into all aspects of organizational life. They identified organizations as systems of relationships both within and beyond the organization itself and introduced the concept of “systems citizenship,” characterized by the capacity to see and operate within systems, collaborate across boundaries, and create desired futures. Further, they characterized organizations and institutions as living, dynamic systems with the capacity to grow, learn, and evolve. That capacity can be enacted through leadership that is conceived of and engaged by the system in order for it to adapt and evolve.

Emerging knowledge in the field of teaching and learning provides a rich lens for transforming leadership education into something that challenges graduate students to think beyond the self, consider deeper timelines, and integrate multiple perspectives — all of which are critical in order to operate from a systems perspective. Owen (2015) implores leadership educators to not only adopt new pedagogies but also new frameworks that increase the effectiveness of the learning experiences they create. Fink’s (2013) taxonomy of significant learning, discussed at length above and prominently featured in this chapter, places particular emphasis on the categories ‘integration’ and ‘learning how to learn’ and suggests that they are critical to leadership practice. When done effectively, intentionally integrating these categories into learning environments allows graduate students to move toward a capacity for continuous learning, perspective taking, and seeing more complex issues more holistically.

Practices that allow students to gain and integrate new perspectives are encouraged, and sometimes even required, in graduate university programs. These opportunities include campus and community engagement that incorporates critical service-learning, community involvement, co-op or internship opportunities, and international study, to name a few.

Problem-based learning is another technique that has gained traction over the past several decades. It allows students to employ research, theory, and practice as a means of greater understanding, sense-making, and problem-solving (Savery, 2015). Such experiences, when facilitated well, provide a starting point for expanding one’s worldview and understanding different perspectives. Oftentimes, opportunities to integrate new perspectives fall short, allowing students to maintain distance and “otherness” between themselves and their experiences. Senge, Scharmer, Jaworski, and Flowers (2004) encouraged learning environments in which educators shift from looking at the outside world – the other – to looking at what happens internally as a result of external stimuli. Such opportunities “dissolve the boundaries between seer and seen” (Senge, Scharmer, Jaworski, & Flowers, 2004, p. 43), allowing people to sense their connection to the whole, and to see their part in creating their reality. Not only do exposure to and engagement with new ideas and different perspectives allow for greater self and systems awareness, but these experiences also open new lines of inquiry and scientific investigation that can develop new knowledge and more sustainable practices (Wiek, Withycombe, & Redman, 2011).

Wheatley (2006) used systems thinking as a basis for understanding organizations through the lens of

the natural world to illustrate the deep order and resilience that can arise from chaos and complexity. Her research and observations implore everyone to work with the natural flow within organizations; to understand themselves as a function of larger, dynamic systems; and to better understand the various ways that individuals and organizations are activated by different systems and contexts. Modeling the learning experience after natural systems is a central objective of the Burns Model of Sustainability Pedagogy (2011). This pedagogy is an ecological teaching design that integrates content, perspectives, process, context, and design to engage learners in the process of constructing solutions to persistent, complex challenges. This model promotes transformative learning, a style of learning that is ultimately concerned with challenging established frames of reference and expanding learners' worldviews. It also calls on learners to engage systems thinking "to solve complex problems and make changes that regenerate and sustain places and communities" (Burns, 2011, para. 10). Systems thinking then becomes both a learning outcome and a guiding principle for instructors who are encouraged to thoughtfully weave together all aspects of the model and that allows learners to help shape their unfolding learning.

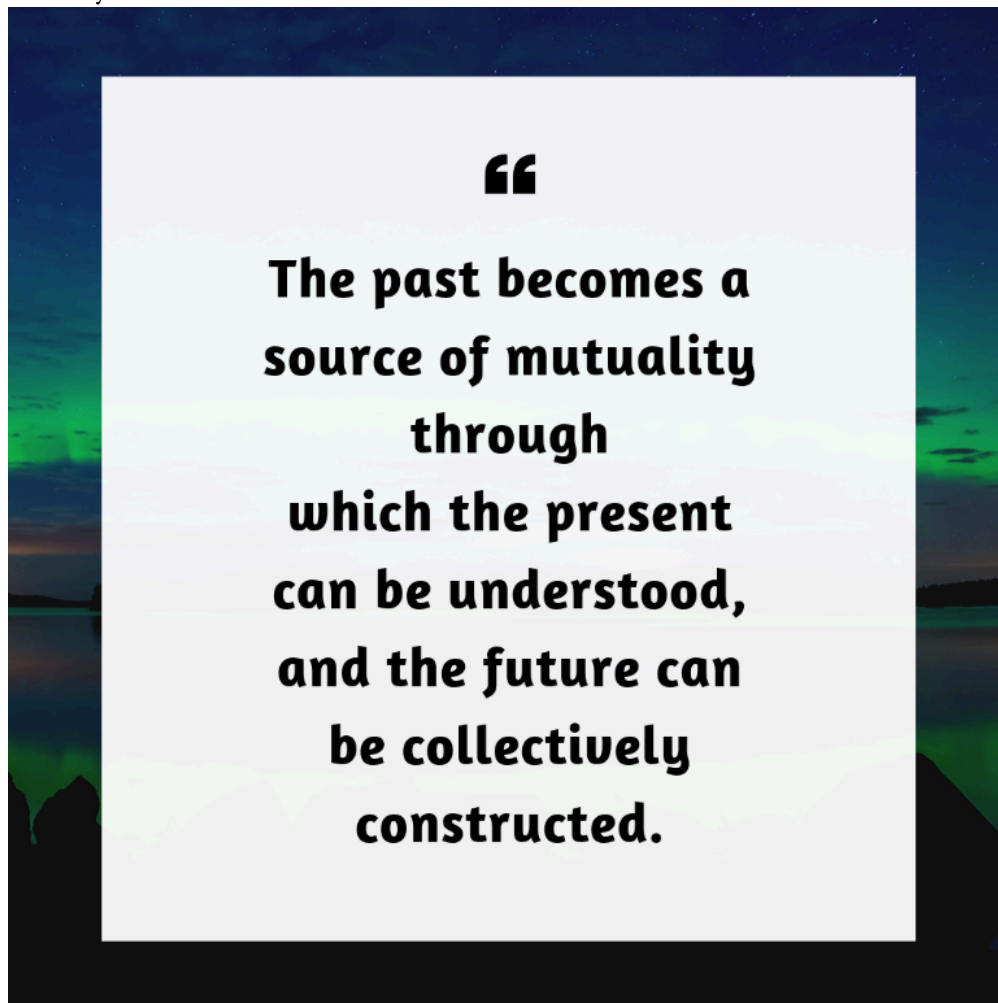
Time and Boundary Navigation

Discussions of systems thinking within the leadership canon often integrate salient insights about the nature of time and boundaries. Constructs of leadership that use a lens of systems thinking not only attempt to help students see beyond the self and the immediate cause-and-effect nature of their actions; they also call their attention to the artificial boundaries they create, of which time is one (Meadows, 2008). These frameworks further instruct that they cannot effectively operate in short-term, isolated contexts when faced with deeply rooted and interconnected challenges that have expansive implications for everyone's shared future (Allen & Cherrey, 2000; Satterwhite et al., 2015, 2016; Scharmer, 2009; Wheatley, 2006).

Organizations that can effectively hold the emerging future in mind are also better equipped to lead in the present moment, creating approaches that not only address immediate challenges but also attempt to mitigate potential future issues (Scharmer, 2009; Scharmer & Kaufer, 2013). Satterwhite et al. (2016) identified the lack of time constructs as being a significant oversight of leadership literature to date, noting that "not only do we fail to look at distant and deep time in the future, we frequently fail to learn from the past, especially the distant and deep past" (pp. 48-49). The lack of time constructs has profound consequences for effective leadership and how society understands and experiences the challenges faced. Without a deeper understanding of deep and distant timescales, society limits its capacity for systems thinking and its ability to make decisions that nurture and benefit systems. The authors of this chapter suggest that expanding both the individual and collective abilities to relate to distant and deep timescales and operate beyond immediacy is a core outcome of effective graduate leadership education.

Learning environments that integrate collectivism and inclusive leadership may provide the most fertile ground for integrating time dimensions into graduate leadership development and education. It is within these spaces that time dimensions have a particular impact and influence since such environments are concerned with

the impact of leadership development on a broader collective and create greater consciousness of and a deeper connection to the distant and deep past. Bordas (2012) identified Sankofa (learning from the past) as the first principle of multicultural leadership, noting that many cultures view the past as “the ‘wisdom teacher,’ and the source from which culture flows” (p. 27). She continued on to state that “understanding and healing the past” (p. 28) can create an inclusive future and allow for the integration of individual and collective identity. The past becomes a source of mutuality through which the present can be understood, and the future can be collectively constructed.



As Bordas' (2012) perspective illuminates, viewing deep pasts and futures as fixed points on a linear time scale creates significant limitations when educators seek to help graduate students see themselves as part of these timeframes. If educators can effectively integrate the deep past into an understanding of the present, they can begin to make meaning of shared histories and help graduate students do the same. With regard to the future, Senge et al. (2004) stated that “the core capacity to access the field of the future is presence – being open beyond one’s preconceptions and historical ways of sense-making, (p. 13),” going on to say that as society integrates and better understands its past it can then move into “manifesting or realizing the emerging future” (p.13). Rather than focusing on a fixed point in time that people are always anticipating, they have the opportunity to

envision the future as a field – “an open space with vague boundaries” (Senge et al., 2004, p. 14), a field that people are not destined to encounter but are collectively responsible for creating.

One concept that may help graduate students grasp their connection to deep pasts and futures is Elise Boulding’s notion of the 200 year present which frames the present moment by the effects of past actions and potential future consequences. Through the consideration of the life spans of the oldest and youngest living individuals at a given period of time across past, present, and future, a time span of roughly 200 years is generated. This mental exercise reminds people that the past is always represented and will act upon the unfolding future. As described by the Metta Center for Nonviolence (2018), the 200-year present “demands that we shift from a materialist view of human beings to a consciousness-based view that embraces the unity of life across time.”

The pattern of falsely dividing our world, “making a division where there is tight connection, and seeing separateness where there is wholeness” (Senge et al., 2004, p. 190), is an epidemic in modern organizational life. Meadows (2008) reminds us that “there are no separate systems. The world is a continuum. Where to draw a boundary around a system depends on the purpose of the discussion” (p. 190). Dividing reality into component parts – maintaining a binary “subject/object” worldview – masks, perpetuates, and exacerbates complex organizational and community challenges. In doing this, people make decisions based on limited information and apply technical solutions that may temporarily solve a problem for one part of the system, only to create new problems for other parts of the system.

As patterns like this persist in organizations and communities, people’s behavior becomes habitual and unconscious and they begin to blame the patterns that they created for their failings (Senge et al., 2004). According to noted theoretical physicist David Bohm and co-author Mark Edwards (1991), “fragmentation in our view of the universe and of ourselves as separate from one another and nature – [is] ‘the hidden source of the social, political, and environmental crises facing the world’” (as quoted in Senge et al., 2004, p. 190). Systems thinking is largely concerned with developing the capacity to see beyond artificially and arbitrarily created boundaries and sensing both the singular and the many. Pedagogies and practices that engage graduate students in developing systems thinking will allow them to also navigate, question, and see beyond boundaries that restrict peace, justice, and sustainability.

Challenging Normative Constructs

The final critical competency is challenging normative constructs. Two sources of academic literature provide significant support for the need to challenge normative constructs of leadership: critical theory and non-dominant leadership perspectives. Critical theory:

The final critical competency is challenging normative constructs. Two sources of academic literature provide significant support for the need to challenge normative constructs of leadership: critical theory and non-dominant leadership perspectives. Critical theory:

questions the hidden assumptions and purposes of competing theories and existing forms of practice... [it] insists

that thought must respond to the new problems and the new possibilities for liberation that arise from changing historical circumstances. Interdisciplinary and uniquely experimental in character, deeply skeptical of tradition and all absolute claims, critical theory was always concerned not merely with how things were but how they might and should be (Bronner, 2011, pp. 1-2).

Similarly, the multidisciplinary nature of the unfolding challenges global communities face has created a strong call for prioritizing interdisciplinarity in academia (Holley, 2009). Significant limitations in providing structures and support that facilitate interdisciplinary research and scholarship at the faculty and institutional level and create limitations in teaching and preparing students to think and operate from an inter- or multidisciplinary lens remain. As Pfeferman (2011) noted, “many important research questions require integration of multiple perspectives... and an interdisciplinary approach” (p. 8).

Embedding a culture of interdisciplinarity within graduate education and engaging graduate students in projects, coursework, and experiential opportunities where they must consider complex issues from a range of disciplines and approaches can support the framing, naming, and solving of problems in ways that would not be possible if the issues were looked at through a solitary lens. For graduate students to be effective in their work in the complex world we now live in, they must be guided to bring new and untapped perspectives to address the deep challenges that cannot be solved through the narrow analysis and singular disciplinary approach to problem-solving.

Critical studies of leadership have exposed limitations in prevailing constructs of leadership that perpetuate habits of constructing artificial boundaries. Alvesson and Spicer (2012) call attention to the binary nature of common notions of leadership which, no matter how inclusive or fluid, still tend to draw distinctions between positions of leadership and followership. This places those who are responsible for various aspects of organizational life into an informal and yet powerful hierarchical structure, even if these roles are not themselves hierarchical. “Leadership,” they point out, “is studied in splendid isolation” (Alvesson & Spicer, 2012, p. 43), and these studies often perpetuate a dominant, normative leadership ideology.

When students hold the idea of leadership, in all its nuances and multiple meanings, as a pinnacle for individual and organizational behavior, they construct their expectations for ‘good leadership’ through their own lenses and biases. “Recent forms of leadership discourse push issues of personal identity to the fore” (Alvesson & Spicer, 2012, p. 43), meaning that when organizations and groups must negotiate the definition and purpose of leadership in their context, they are also doing so through the lens of their own self-concept and may give added weight to skills and abilities they believe they already possess. Through this process, students perpetuate the idea that it is their own individual ability that is responsible for leadership when it is, in fact, the product of a series of complex variables, of which an individual is only a part.

Despite this general critique of the field, several authors have begun to employ a critical lens to examine leadership. Dugan (2017) offered an integrated model of critical leadership development, highlighting three critical elements or meta-themes: stocks of knowledge, ideology/hegemony, and social location. Dugan and Humbles (2018) explained that critical perspectives

...represent meta-themes or distillations from the complex and expansive body of knowledge that comprises critical

social theories. These meta-themes are topical or content areas that can be drilled down into as a means to examine taken-for-granted assumptions, power, and inequity. The depth of knowledge and skills with which a person engages critical perspectives is directly related to human development” (p. 11).

Graduate education should increase students’ ability to dive deeper into these challenging meta-themes. Experiences that promote metacognition and create the conditions in which learners can progress to increasingly higher developmental stages of sense-making will allow them to view the world and their place in it in more complex and inclusive ways (Petrie, 2014). The perspectives domain in the Burns Model of Sustainability Pedagogy also supports questioning assumptions and dominant ways of making sense of the world. By reflecting on systemic causes and “questioning and examining dominant attitudes and behaviors, learners may recognize that many aspects of sustainability crises are cultural” (Burns, 2011, para. 16), and thus challenge underlying cultural assumptions, economic structures, and power dynamics. This process allows graduate students to unpack persistent narratives and shift mental models to create new possibilities for action.

Much of the aforementioned leadership discussion has arisen from Western discourses and ways of understanding. It is essential that graduate students also understand perspectives of leadership that are non-Western in nature, including those that extend further beyond the practices and skills of working in global contexts (Cohen, 2007; Mendenhall et al., 2018), to fully understanding the contexts and cultural norms of individuals and groups from other cultures (Kessler & Wong-Mingji, 2009). This also includes understanding the diversity that permeates the Western context, thinking beyond the dominant discourse to include discourses that speak to Latinx, Black, and native communities in Western spaces (Bordas, 2012). “Multicultural leadership has broad relevance and application to our diverse world...and offers practices and tools that [are] effective with many populations” (Bordas, 2012, p. xi). It is essential that graduate leadership understand and embrace these non-Western leadership discourses to further enhance their practice and efficacy.

Multicultural and indigenous leadership and ecology teachings, such as those discussed by Bordas (2012) and Berkes (2008), remind educators that wisdom and practices in these areas have ancient roots that are passed down through vast networks of culture. These frameworks connect with broader and more complex perspectives than the dominant Western constructs that inform many existing approaches to leadership and scientific ecology. Bordas (2012) invited educators to investigate the origins of many dominant leadership teachings, noting that many prevailing constructs embrace dominant cultural values at the expense of deep and ancient wisdom. Berkes (2008) brought together knowledge and practices of indigenous and remote populations regarding caring for natural resources and conserving land. Collectively, traditional ecological knowledge (TEK) can inform and support scientific ecology and conservation practices and serves to inextricably link humans and nature. Integrating these perspectives with pedagogies that allow graduate students to awaken to new ways of meaning-making, unlearn old assumptions, and integrate new ways of being will create powerful learning environments that support the exploration of critical perspectives and new ways of effecting change. Just as the theories and frameworks discussed in this chapter move beyond old notions of leadership, programs that prepare graduate students to be change agents must engage them in the collective

process of leadership, equip them with the capacity to let go of old ways of thinking, and encourage them to develop new practices that evolve as they engage in co-creating the future (Scharmer, 2009).

Practical and Applied Applications within Graduate Education

While this chapter has offered a theoretical basis and pedagogical practices that can be incorporated to develop the three critical competencies in graduate students, it is also useful to supplement these approaches with practical experiences and exercises that may be more readily applied. For graduate students studying ecology, environmental science, and sustainability, steps can be taken to integrate these critical competencies into existing research and fieldwork. Engaging students in collaborative and sustained applied research and incorporating resulting learning into classroom dialogue can move knowledge-building and discovery out of individual silos to generate collective learning. Dekay (1996) noted that, “Intelligence and learning are thought to be the province of individual will and talent. In truth, learning is almost always a collaborative event” (p. 4). Extending these opportunities into local communities builds in another layer of perspective-taking and further engages systems thinking. Applied research projects that allow students to employ technical skills and knowledge and engage multiple disciplines while also developing an understanding of how their work affects real people and communities further contextualizes and gives meaning to the scientific process (Atalay, 2012). One such project, that is currently underway within a graduate school of sustainability, employs students with varied specializations within the field, including business, urban development, and natural resources, to conduct research on local streams and runoff areas to assist a nonprofit serving an impoverished area to develop a stormwater management plan and improve the water quality in the community. This requires students to integrate multiple and sometimes competing perspectives, understand cultural and historical considerations that impact their work, and work across multiple disciplines (Atalay, 2012).

Moving into the Unfolding Future

In a speech accepting the John Burroughs Medal, Rachel Carson said:

“Mankind has gone very far into an artificial world of his own creation. He has sought to insulate himself...from the realities of earth and water and the growing seed. Intoxicated with a sense of his own power, he seems to be going farther and farther into more experiments for the destruction of himself and his world” (as cited in Lear, 1999, p. 94).

Carson’s insights emphasized the danger of artificial boundaries and people’s separation from each other and the natural world almost 70 years ago. Given the increasing complexity and volatility of our unfolding present, it is safe to say that, collectively, we have failed to heed Carson’s warnings. The work of unlearning these deeply

ingrained patterns of behavior to find new ways of being and leading that align with desired visions of the future is difficult but necessary. Incorporating this work into graduate education will help to ensure that those who are equipped with critical technical knowledge and expertise are also able to use that knowledge to create solutions to problems that require input from multiple disciplines.

In conclusion, we are hopeful about the possibility of re-conceptualizing the delivery of graduate education to include leadership development that creates change-makers in all disciplines but challenges exist and more work is needed. Singular, stand-alone leadership courses do not allow for sustained, context-driven learning or the development of the critical competencies discussed here. Beyond this, there are real program design constraints that make adding a new course an unrealistic expectation. Because of this, we advocate for broad integration of the three critical graduate education competencies covered in this chapter. Through the practical applications suggested here, these competencies provide a framework for effectively weaving together disciplinary/technical knowledge and the engaged learning practices that will help graduate students grasp the complexity of the world they inherit and develop the ability to create just, sustainable, and peaceful communities through their collective work.

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POLICY ENGAGEMENT FOR SUSTAINABILITY LEADERS

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The world needs scientists to discover new knowledge and deepen society's understanding of grand sustainability challenges. Now, more than ever, society also needs scientists to connect knowledge to action, evaluate solutions, and contribute to sound policy. The ability of society to navigate sustainability challenges depends more on the application and use of scientific evidence than on the accumulation and publication of research (Evans & Cvitanovic, 2018; Sutherland, Pullin, Dolman, & Knight, 2004). Fortunately, today, many scientists are eager to do research that impacts policy. However, there remains a sizeable gap between wanting to impact policy and having the knowledge, skills, and support to effectively engage with policymakers and policy processes.

Below are two short stories that demonstrate how early career scientists can become sustainability leaders who meaningfully impact policy. In 2015, Kathy Zeller was an environmental conservation Ph.D. student at the University of Massachusetts. She attended a policy workshop through her Switzer Fellowship and learned about a potential federal bill to support wildlife corridors. She saw policy relevance in her own research, worked with professionals at the non-profit COMPASS to connect her research with policy conversations, and contributed to an effort to establish a national system of wildlife corridors. Kathy engaged in dialogue with federal policy staff about her science and the proposed bill. In meetings with the office staff of a congressman, Kathy delivered compelling science messages that linked her research with what the policymaker cared about by describing how wildlife corridors are good for biodiversity as well as agricultural productivity and recreational industries. While the ultimate outcome of the proposed legislation is uncertain, Kathy's efforts shed light on the need to protect broader, interconnected areas of public land rather than only isolated patches.

In the same year, Aerin Jacob was a postdoctoral fellow in geography and environmental studies at the University of Victoria and the Wilburforce Fellowship in Conservation Science. As part of her fellowship, Aerin attended a workshop and set a goal to do something about the lack of attention being paid to science

in an upcoming national election in Canada. Aerin planned an all-candidates' debate and worked with the host of a popular Canadian science radio program to be a guest moderator. Three leading political candidates participated in a unique public discussion that gave science and technology a prominent role in policy. The debate received positive news coverage and included remote listeners and participants from around the world. One year later, Aerin led a national effort that engaged over 1,900 early career researchers and encouraged them to address the government's environmental assessment law, policy, and practices.

Aerin's initiative encouraged policymakers to recognize the value of science in public policy and also influenced her fellow citizens' thinking about science, society, and the environment during an election. Kathy's awareness of her research's policy implications and her ability to effectively communicate with policy staff transformed a federal policy dialogue to include broader, more impactful solutions. Yet, neither of them woke up one day and knew how to engage with policy processes. They received training and support in key aspects of connecting science and policy. They took time to develop goals, a sense of whom to engage, and effective action plans.

This chapter focuses on what it takes for emerging leaders to engage with the policy world and impact policy. In doing so, the importance of training, support, and connections between being a good communicator and being a sustainability leader who transforms public dialogue are emphasized. The ideas in this chapter draw from applied work that connects science and policy as well as diverse theoretical perspectives on science communication and the science-policy interface.

This chapter was written with a particular audience in mind: university faculty and staff who support early career scientists and emerging sustainability leaders. A related audience includes leaders themselves. The main goals for these groups are to 1) see policy engagement as an important way for academic scientists to address complex sustainability challenges and 2) understand key factors for successful policy engagement. The aim of the chapter is to encourage graduate students, faculty, and staff to change academic systems and institutional cultures to better support scientists in connecting their research with policy.

While emerging sustainability leaders can play key roles in linking knowledge with action when they take opportunities to engage and receive effective training and support, the incentive systems for higher education professionals do not always align with policy engagement. Thus, cultivating the next generation of sustainability leaders involves developing the capacity of programs to adapt and meet societal needs. Institutions and programs that support emerging leaders' engagement with policies can become more relevant and integrated with their surrounding social contexts (Cvitanovic, Lof, Norstrom, & Reed, 2018; Posner & Stuart, 2013). Strengthening connections between research and policy will inspire the creation of science that is more relevant to decision making and more responsive to complex societal challenges.

What Is Policy Engagement and Why Is Supporting Emerging Leaders' Engagement Important?

What does policy engagement mean? Any institution or program that supports emerging leaders' engagement

would benefit from defining key terms and building a common vocabulary. This chapter uses the following terms in the following manner:

- Policy means the “sum total of government action, from signals of intent to the final outcomes” (following Cairney, 2016, p. 19).
- Engage means to participate and interact in a deliberate, meaningful way that opens and advances dialogue and facilitates mutual learning between scientists and policy actors.
- Pathway describes an opportunity for scientists to engage.
- In combination, a policy engagement pathway refers to an approach or opportunity available to scientists who aim to impact policy.
- The term ‘policymaker’ is used in a general sense to refer to the official, elected policymakers, as well as other actors who ‘make policy happen.’ This includes policy staff, such as schedulers and legislative assistants, and others who influence policymakers, such as directors and senior advisors.

In general, an important quality of a sustainability leader is the ability to connect with diverse audiences beyond their peers. Leaders who are more advanced in their careers often have well-developed networks. Emerging leaders may have an appetite for broader impact, but often need support to skillfully navigate subtle aspects of the policy world. Such support could have an enduring, positive influence in the early stage of their professional careers.

Policy engagement can fundamentally affect how emerging leaders view and conduct their science. When scientists develop the ability to interact with policymakers in meaningful ways, they learn to create a more inclusive, iterative knowledge exchange (Bednarek et al., 2018). Creating more dynamic relationships between scientists and policymakers throughout the research process can foster opportunities for scientific evidence to be useful in decision making (Alberts, Gold, Martin, & Maxon, 2018; American Association for the Advancement of Science (AAAS), 2017; Posner, McKenzie, & Ricketts, 2016). Scientists can benefit from engaging with policymakers by being informed about the very research questions they ask. Ultimately, policy engagement can lead to scientists and policymakers co-producing knowledge and research and further alignment of the knowledge that scientists produce and the knowledge that policymakers need (Smith et al., 2013).

Emerging leaders may have concerns about engaging with policy, such as how policy-related activities could affect their scientific objectivity. As described later in this chapter, there are many different roles for scientists to play in policy processes. Some roles involve advocating for particular solutions while others hinge on remaining more neutral. With support and guidance, individuals can thoughtfully define a role for themselves that aligns with their own personal interests, beliefs, and comfort.

Other legitimate concerns include whether engaging with policies would distract from scientific career progress or cause tension with supervisors or colleagues who have different views on policy engagement. However, many scientists agree that people with a strong science perspective are important contributors to

solving societal challenges. In addition, engaging with the public sphere can improve scientific skills such as explaining complex ideas or analyzing data to answer a specific question. Policy engagement can also unlock exciting career opportunities beyond academia. For emerging leaders, a discussion with colleagues about broader impacts and the difference they would like to make in the world could demonstrate how policy engagement contributes to professional and personal goals.

While there is no guarantee that engaging with policymakers will result in better or more informed policy decisions, it could be the difference between science being part of a decision or being left out of consideration (Rowe & Lee, 2012). Cultivating the next generation of sustainability leaders to link knowledge to action is critical for the inclusion of sound science in decision making.

Planning for Policy Impact

It is not always clear to emerging leaders how to effectively work across the professional, cultural, and institutional boundaries between academia and the policy world (Bernstein, Reifschneider, Bennett, & Wetmore, 2017). Engaging with policy processes often means navigating new and unfamiliar terrain. Emerging leaders would benefit from a supportive framework for policy engagement.

A framework for institutions that value broader impacts would support emerging leaders in 1) articulating their policy goals, 2) evaluating progress toward their goals, and 3) envisioning specific actions they could take and roles they could play. In this section, these components are described in more detail. In the following sections, the importance of institutions and programs providing opportunities for emerging leaders to develop the civic competencies and communication skills that are essential to effectively engaging in policy conversation is also emphasized.

Articulating policy engagement goals lays the groundwork for success. As Aerin from the beginning of this chapter put it: “I set a goal to get Canadian political candidates to publicly discuss science, which metamorphosed into Canada’s first all-candidates’ debate on science.” Her goal of having political candidates publicly discuss science was ambitious, yet doable. Achieving her goal provided something important that the world needed: a more public debate about the role of science in society. A key dimension of the Wilburforce Fellowship that Aerin received was supporting emerging leaders in articulating and refining their goals. Unfortunately, some academic programs do not support emerging leaders in aiming for ambitious goals that have a broader impact, in part because they deem broader impacts as tangential to, or distracting from, academic research. Programs’ lack of support for setting policy impact goals leads to missed opportunities for institutions and scientists to affirm their relevance to society. A co-production model of science, whereby scientists and policymakers (or other stakeholders) jointly define goals, research questions, methods, and actionable outputs is one promising way to link research knowledge with action (Beier, Hansen, Helbrecht, & Behar, 2017).

The second component of planning for policy impact, measuring progress toward goals, is essential but often overlooked. Supporting emerging leaders in identifying indicators of successful policy engagement and

evaluating their efforts helps leaders sharpen their thinking about goals. Evaluating progress requires leaders to be specific and strategic about their objectives and facilitates continuous learning (Posner & Cvitanovic, in review). Programs can provide guidance that aligns measures of individual progress with measures of institutional or program-level success.

The third component, envisioning actions and roles, is an exciting aspect of implementing policy engagement plans that deserves special attention. In the case of Aerin, she noticed a window of opportunity in an upcoming election cycle and strategically thought about pathways to accomplishing her goal. Her willingness to engage motivated her to have conversations with key people, who in turn, helped her to come up with the idea of holding a debate. She put together a team of like-minded individuals that helped do the work necessary to see the vision through. She drew support from different sources, including peer relationships that were strengthened in workshops provided by her fellowship.

In many cases, the actions of an emerging leader will define their role in a policy system. A scientist who organizes a group of people to raise awareness of an issue (such as public debate about science) serves in a convener role. A scientist who shares research findings that suggest new solutions can fill a role as a technical expert. A technical expert can also help policymakers navigate the scope of expertise that exists for an issue and point out others with relevant expertise. A scientist who analyzes possible solutions or describes what would likely occur if a particular solution were implemented plays an important evaluator role. In these ways, scientists can empower decision makers by clarifying choices, accessing expertise, and framing the scope of possible solutions.

A scientist who promotes a particular policy solution or encourages a decision maker to take a specific course of action assumes the role of advocate. Advocacy can be impactful, and the degree to which one advocates for a particular solution is a personal choice. It is important for scientists to be aware of the risks (e.g., risks to one's reputation as a more neutral stakeholder), rewards (e.g., a goal might be to sway policy outcomes), and constraints (e.g., university rules about lobbying) involved in advocacy or efforts to directly influence decision-making outcomes.

Much has been written about the roles of scientists in policy processes (Baron, 2016; Cairney, 2016; Pielke, 2003). Some feel that scientists should contribute policy-neutral information and avoid advocating personal positions (Lackey, 2006). Emerging leaders benefit from reflecting on how they would like to show up. Programmatic support that provides opportunities for self-reflection through facilitated group discussion, writing prompts, or individual advising can help leaders appreciate their own growth and evolution as they plan for impact and engage with public issues. After organizing the public debate, Aerin reflected on how, "More broadly, I see my contributions now more as part of long-term processes and less as one-off events."

Self-reflection can also help emerging leaders understand how their personal preferences, values, and strengths shape whether they are a good fit for any given opportunity. While planning for policy impact, reflective processes can also help leaders overcome barriers that may limit access to opportunities. For example, an engagement pathway may be more or less accessible depending on career stage (i.e., early career, mid-level, senior) or individual or social characteristics (i.e., gender, race, or other forms of diversity). Supportive

institutional cultures based on inclusion and representation of diverse populations enrich the scientific enterprise and make it easier for individuals to navigate social barriers to policy engagement (Puritty et al., 2017).

Core Competencies

A framework that supports sustainability leaders in articulating goals, evaluating progress, and envisioning actions and roles is a useful start but is incomplete. To deliberately impact policy, an emerging leader needs to understand key aspects of government, policy, and politics. Scientists who know how policy is made can identify opportunities for change and effectively engage with influencers, partners, and decision makers. The following suggested topics help graduate students, faculty, and staff develop the core competencies necessary to successfully engage.

Civics 101

Leaders who understand the fundamentals of government and how it works at different levels (e.g., federal, state, county, municipal) are more prepared to impact policy, navigate policy systems, and work in whatever levels are most appropriate for their goals. Each country has its own government structure that has a significant bearing on how a government functions. For example, in the U.S., at the federal level, it is important to be familiar with the three branches of government (executive, legislative, and judicial), what happens within each branch, and how the different branches interact. These insights allow a leader to navigate the system to find levers of change. An institution or program can train emerging leaders to be able to make sense of the networks, hierarchies, and “rules of the system.” Understanding authority and jurisdiction in terms of who can do what, in which order, and why, empowers emerging leaders to effect change. It is important to note that there are also many pathways to impacting policy that are beyond government. These involve working with non-governmental organizations, civil society groups, and others to engage with policy processes.

The Role of Scientific Evidence in Policy

Policy processes are complex and messy. Scientific evidence is just one of many different types of information that policymakers acquire, scrutinize, debate, and use (or not) as a basis for decisions. Emerging leaders who appreciate how and why policymakers use scientific evidence will be less surprised by the realities of policymaking and more skillful in how they engage (Akerloff, 2018; Bipartisan Policy Center, 2018; Kenny, Rose, Hobbs, Tyler, & Blackstock, 2017). Generally speaking, policymakers often use scientific evidence to frame ideas and shape the way people see issues, build support for ideas or plans, and provide a basis for specific decisions or courses of action (McKenzie et al., 2014). Timing is a key determinant of the role that scientific evidence plays in policies. A policymaker may use scientific evidence differently throughout policy

processes depending on whether people are identifying a problem, considering options for what to do about it, or implementing solutions.

The Role of Scientists in Policy

Earlier, the importance of individual leaders reflecting on the roles they can play in working towards a policy engagement goal was described. In this section, the general roles that scientists can play in policy processes are elaborated upon. A program that supports policy engagement makes it easier for emerging leaders to:

- Frame the dialogue and find out which questions policymakers are asking and seeking answers to;
- Define a problem and signal the need for action (for example, the distribution of a species is shifting, there are follow-on impacts to people, and current management tools are inadequate to address the situation);
- Raise awareness and expand the range of options for policymakers or managers to consider; and
- Clarify specific options that meet policy, management, and stakeholder needs as policy conversations shift to exploring solutions that can be implemented.

Again, timing can be a key factor. “Policy windows” are discrete windows of time that offer an opportunity to influence policy. Policy windows are frequently unpredictable, and scientists need to be able to act on short notice to take advantage of strategic opportunities to engage with decision makers. Institutions and programs can help emerging leaders respond to policy windows by foreseeing opportunities, supporting communication and framing that aligns with appropriate windows and creating new windows (Rose et al., 2017).

How Policymakers Perceive Scientists and Scientific Evidence

Science is most effective in shaping discourse and informing decisions when policymakers see it as credible (based on rigorous technical expertise), legitimate (fair, unbiased, and representative of different viewpoints), and salient (timely and relevant to the issues at hand; Cash et al., 2003; Posner, McKenzie, & Ricketts, 2016). The reputation and skill of a researcher contribute to the perceived credibility, legitimacy, and salience of the scientific evidence they produce. Personal relationships, apparent motivations, and other social and political factors also affect how a policymaker perceives scientists and scientific evidence. Effective policy engagement requires trust among science ‘producers’ and ‘users’ (Lacey, Howden, Cvitanovic, & Colvin, 2017). Institutions and programs can encourage emerging leaders to become trusted resources that policymakers turn to for information and analyses.

Long-term, Trusting Relationships

Sound, scientific evidence is necessary for policy impact but is insufficient by itself. Impact arises from people's relationship with scientific evidence. Thus, it's important for programs to support strategic thinking about whom to engage with and how. Beyond policymakers themselves, it is essential for scientists to build relationships with policy staff and entrepreneurs who track conversations and facilitate policymaking because these people can help navigate new networks, anticipate trajectories, and provide on-the-ground insights and guidance. Building relationships with people who make policy happen helps align research with policy needs, increase trust, and increase the likelihood of policymakers using sustainability research in their decision making. In this way, emerging leaders who engage with policy people can build a richer and more effective community of practice while working on complex sustainability issues.

Focus on Communication

An emerging sustainability leader will be well-equipped to make changes if they have a policy engagement plan and a solid understanding of core science-policy concepts. Adding communication skills, confidence and enthusiasm will significantly boost their capacity to impact policy. Thus, a central aspect of support for sustainability leaders is cultivating good communication.

Communication is not an add-on to science; it is central to the enterprise (Baron, 2010a; Smith et al., 2013). Effective communication enhances knowledge exchange between scientists and policymakers (Cvitanovic, McDonald, & Hobday, 2016). Honing communication skills improves an emerging leader's ability to engage with diverse audiences, articulate a vision, and "talk about their science in ways that make people sit up, take notice, and care" (Baron, 2010b, p. 1032).

Institutions and programs play an important role in cultivating good communicators. They can provide opportunities for emerging leaders to practice and hone their ability to communicate sustainability-related research to audiences beyond academia. They can also facilitate productive dialogue among faculty, staff, and graduate students about which audiences are most important to engage. Better communication of sustainability topics across traditional disciplinary boundaries in academia (including between social and natural sciences) can increase the impact of research by making it more accessible to people of all backgrounds.

The following five practical guidelines can help sustainability leaders develop top-flight communication skills. These tips and insights draw from decades of organizations such as COMPASS studying, developing, and testing science communication approaches. While these guidelines are primarily based on communicating a message to an audience, it is important to emphasize the value of two-way communication. Simply providing information to policymakers in a "linear transaction" does not necessarily lead to it being used (Beier et al., 2016). Listening to policy audiences is vital for relationships that strengthen, expand, and diversify the networks of people that emerging leaders work with to advance sustainability and coproduce solutions.

Know the Audience. Understand what the audience cares about. What matters to the policymaker that is

being engaged? What is most important to them? What do they value? What are they concerned or worried about? Who are their constituents?

Frame the Message. Align and connect the message with what the audience cares about (COMPASS Science Communication, Inc., 2017). For a policymaker, this could be their agenda, their policy priorities, or the interests of their constituents. Build common ground, get to the point, and make it clear why the audience should want to pay attention. Learn to effectively frame how research can advance a particular policy conversation.

Limit the Number of Ideas. People's working memory stores a limited amount of information. Thus, any audience is likely to only remember a small number of key points that are made. Bombarding them with evidence or data can distract from the core message. Communication about complex sustainability topics is more impactful if the number of ideas focused on is limited to three to five key points.

Avoid Jargon and Distill Complexity. The message will be more impactful if the audience understands what is being said. This is especially true for written policy briefs that may only receive seconds of a policymaker's time and attention (Balian et al., 2016). Communicate at the level of expertise of the other person. Make things easy to understand for the audience. Share ideas with language that is clear, jargon-free, and simple (but not simplistic).

Tell a Story. This story would preferably be one that features people who live at an address within the jurisdiction of the policymaker. Stories can define issues, provide evidence, and describe solutions in compelling ways (Cairney & Kwiatkowski, 2017). A well-crafted story can add rich layers of meaning to data and research. For example, a story can show how the spread of an invasive plant species impacts people in surprising ways and has implications for issues a policymaker might care about such as increasing tourism, growing food, or hunting and fishing. Stories can also cultivate trust and signal positive intentions by allowing the leader to share why they do what they do.

A Supportive Framework for Policy Engagement

The emerging leaders featured at the beginning of this chapter received key support that helped them develop clear policy engagement plans, science-policy know-how, and effective communication. Institutions and programs that provide such support will foster sustainability leaders who are well-equipped to create change. Leaders can be successful in policy engagement without having a supportive framework, but they are more likely to realize broader impacts on the world if institutions provide scaffolding for policy engagement planning, science-policy proficiency, and strong science communication.

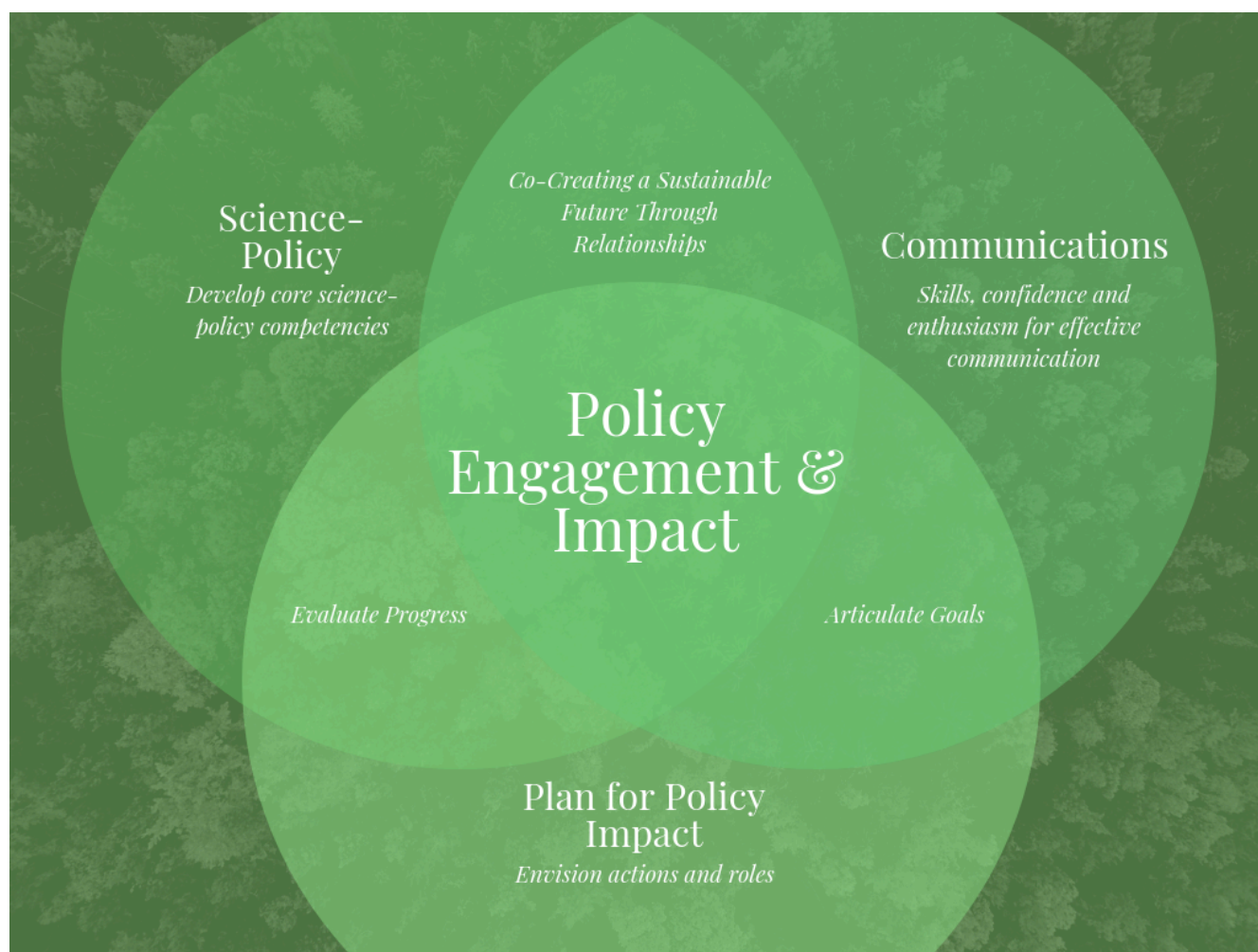


Figure 1. The Policy Engagement & Impact Process

Institutions can provide practical leadership development opportunities by partnering with organizations that specialize in this field such as COMPASS, The Alda Center for Communicating Science, The American Association for the Advancement of Science (AAAS), and professional societies. These groups provide hands-on communication and policy workshops that enable scientists to learn new approaches and hone their skills. Such experiences can provide peer support and mentorship opportunities with other leaders outside the typical academic system. Organizations such as COMPASS also work on the ground to span boundaries between science and decision making and facilitate knowledge exchange (Bednarek et al., 2018). In addition to partnerships with external organizations, many universities have robust legislative affairs offices or institutes that can provide opportunities for policy engagement at the local, state, and federal levels.

Programs that build a framework (see Figure 1) for early career scientists to engage with policymakers and policy processes show that they value public engagement and that it is important for students, faculty, and staff to think more broadly about the impacts of their research. Identifying, challenging, and supporting students who have strong qualities for successful policy engagement could, in turn, help shift the institutional culture around what is valued and supported. With better and more deliberate support for policy engagement,

emerging leaders will advance both the knowledge and the action needed to overcome today's grand sustainability challenges.

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CHALLENGES AND OPPORTUNITIES FOR TRAINING AGENTS OF CHANGE IN THE ANTHROPOCENE

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The scope and nature of sustainability education is evolving. Notably, sustainability education is increasingly spanning disciplines in response to challenges that undermine the well-being of natural systems and human societies including climate change, biological invasions, food and water insecurity, and emerging diseases. In an environment with these increasing global challenges, graduates with advanced degrees have much to offer, provided they have meaningful leadership training. Recent data suggest that half of Ph.D. graduates gain employment outside of the academic sector in private corporations and government and not-for-profit organizations. The half that stay in academia can—and should—engage with diverse stakeholders if they want to affect positive social change. Thus, for graduate students to contribute meaningful solutions to today's sustainability challenges they are not only required to have research capabilities but also policy-savvy communication skills and cross-sector capabilities in collaboration and engagement. Graduate training that predominantly focuses on disciplinary skills cannot meet the needs of these students or our planet. This chapter addresses the leaders of graduate programs and explores how graduate education—primarily focusing on the Ph.D.—can make a stronger contribution to sustainability outcomes through improved skills development and careful reflection on what sustainability leaders need in diverse work settings.

Background

Our planet is facing a new era—the Anthropocene. In this era, all ecosystems are dominated by humans and

all natural systems are affected by human activity. To ensure a future for humanity, economic externalities must be addressed, and healthy ecosystems restored. This requires creative and engaged work conducted by environmental scientists. Fortunately, scholars across the social-natural sciences and the humanities are working together to grapple with pressing planetary challenges. These scholars are calling for even greater disciplinary integration and engagement of researchers in the quest for sustainability (e.g., Clark & Dickson, 2003; Keeler et al., 2017).

This book explores several compelling examples of graduate training programs that are working to transform the academy so that it can be a more effective force for environmental sustainability. These case studies showcase some of academia's most innovative institutions and individuals who are experimenting with new ways to build the human capital necessary to create a better future. The past decade of graduate training experimentation has revealed the importance of developing leadership and communication skills to create a new kind of Ph.D. graduate. Effective communication and strategy development allows graduates to reach new and diverse audiences and articulate why their work is important. New additions to graduate education also reinforce the call for interdisciplinarity (Brandt et al., 2013; Weiler, 2007). These new programs recognize that many graduate students seek employment outside of the academic sector and help them to be successful in alternate paths.

Despite the apparent efforts and progress made, the case studies in this book are a reminder that institutions of higher learning have more improving, growing, and evolving to do to fully realize their collective potential to steward the world through—and even reverse—the catastrophic consequences of environmental change. Despite new curricular approaches, the preceding chapters point to enduring, unmet needs in graduate training. We recognize that traditional departments, funding streams, and academic reward structures still have the potential to fail to generate graduates who are prepared to work alongside practitioners, able to cross community boundaries to test the social significance and validity of their scholarly work, and able to translate their ideas into practical business or action plans.

In this chapter, the leaders of graduate programs, namely the faculty and administrators who are responsible for teaching and learning in universities and who have within them the capacity to make further change, are addressed. From the perspective of teachers, scholars, and leaders of boundary-spanning organizations, how the products of graduate education—primarily focusing on the Ph.D. in the environmental sciences—can contribute to an evolving workforce in sustainability, the workforce needed to make meaningful change, is explored.

Eight Challenges and Opportunities in Sustainability Graduate Education

In this section, the eight current trends (see Figure 1) that we see in an outcomes-oriented sustainability practice with the potential to produce effective and engaged environmental scholars are described. Through

the identification of these eight trends, it is hoped that future evolution and experimentation in graduate education will build upon them in interesting and transformative ways.

1. Sustained Interaction with the Public

Despite the emphasis placed on publishing in traditional graduate education, scientists must go beyond publishing in journals and academic books if they want their research to be relevant to society. Recent research demonstrates that the production of environment-relevant research alone does not lead to social or technological change (e.g., Evans, 2006). Failure to implement recommendations from academia is not only due to lack of awareness (Sturgis & Allum, 2004) but is also complicated by other factors such as trust and ideology (Nisbet & Scheufele, 2009; Zia & Todd, 2010).



Figure 1: Eight Challenges and Opportunities in Graduate Education

Academic training rarely prepares future scientists to communicate with the press, the public, policy makers, and other relevant stakeholders. More importantly, it does not train students to engage in sustained, two-way

relationships with non-scientists around scientific issues, especially those who disagree with them (Rosenau, 2012; Sherman & Howarth, 2016).

The current era that the world is in, the Anthropocene, is an era where the future depends on knowledgeable people who have innovative ideas about sustainability solutions and graduate programs that train students to communicate science in clear, accessible language. To increase awareness of how science is used in the broader world, students must be empowered to descend from the “ivory tower.” They need training and support to cultivate the skills and relationships necessary to be effective in science engagement. It is no longer enough to merely produce science; rather, students must be trained in conveying science to relevant stakeholders and forging relationships that keep diverse stakeholder communities at the table when scientific information is being discussed in a social-political setting. This requires skills in leadership, communication, and relationship-building. Along with these skills, students should gain an understanding of how the public forms opinions about science and science-policy and how stakeholders reach decisions and take action when presented with scientific information. For example, understanding how to connect decision-makers in business and government with scientific researchers and knowledge remains a critical challenge. While academic publishing should remain an important way to convey scientific information, partly because of its intellectual rigor, communicating with diverse stakeholders must become just as important if recipients of advanced degrees are to become helpful members of a sustainable society.

2. Securing Funding in an Insecure World

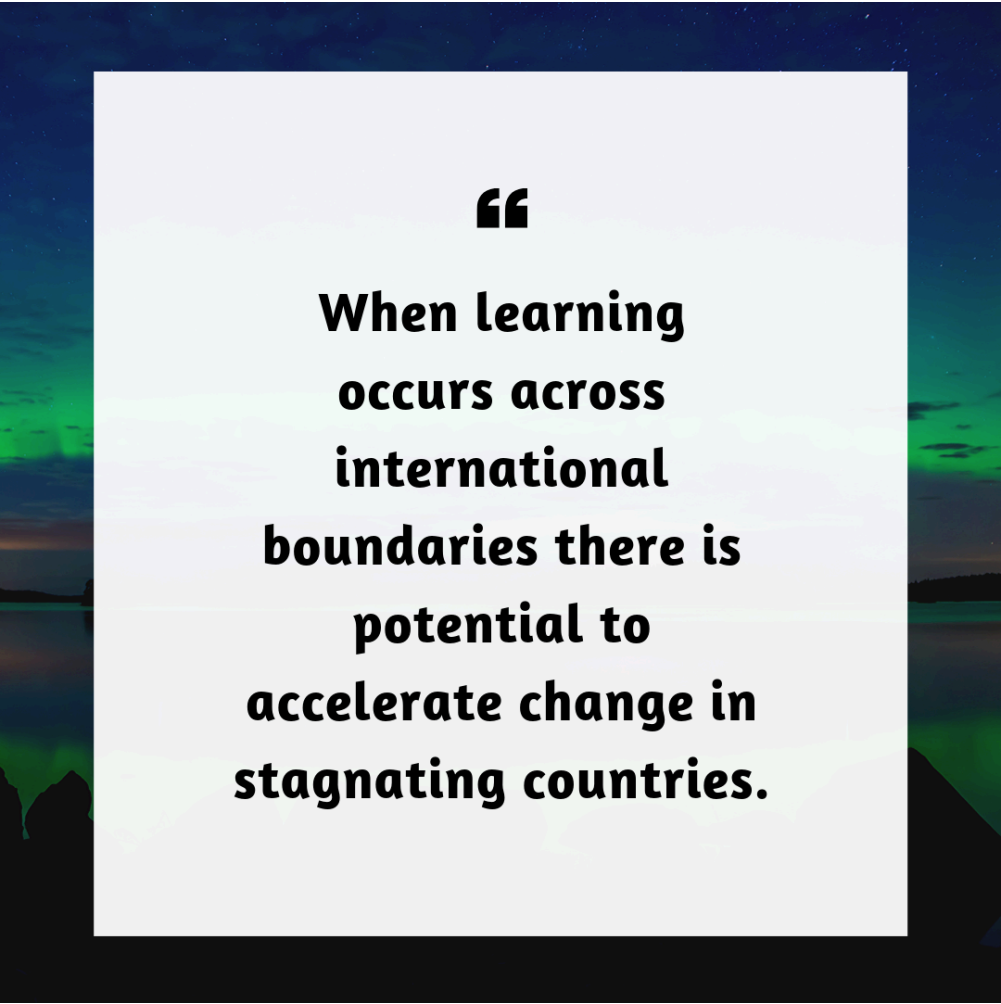
Ph.D. graduates working in academia or other grant-driven industries face a dynamic and uncertain funding environment (Blume-Kohout, Kumar, & Sood, 2015; Bromham, Donate, & Hua, 2016). In a tenuous funding landscape, leadership requires prowess in financial management, a set of skills needed for growing and sustaining a research enterprise. With federal support for research and development declining since 2004 (excluding the American Recovery and Reinvestment Act; National Science Board, 2018), an increasing number of grants are coming from non-traditional sources including mission-oriented agencies, private foundations, and individual philanthropy (Grant, 2017; Murray 2013). These sources often require cultivation, substantial reporting, and outreach. Even federal grants are evolving, with a substantial portion of funding committed to large, multi-investigator grants that require just as much project management as experimental design. Still, scholars’ ability to make progress in environmental and sustainability research—an essential ingredient to building a sustainable future—depends on the best scholars’ abilities to attract financial resources. Thus, success in this area must extend beyond the traditional, federal sources and requires an ability to express purpose and passion to a diverse group of potential funders.

3. Seeking New Points of View

In a rapidly changing biophysical, institutional, and cultural landscape, diversity in scientific and

sociodemographic perspectives is essential to navigating pathways toward sustainability. Most of the sustainability science literature still views humans as external agents acting upon the environment, but humans are not a unitary force. They have diverse viewpoints, histories, and capabilities that affect change. Failing to recognize this diversity limits understanding of the causes and potential solutions to environmental problems. Successful sustainability implementers also will understand the legacy of history and power structures and how structural bias affects science and scientists (Puritty et al., 2017). The world needs a diverse workforce that understands that cultural arrogance and supremacy, as well as unchecked consumption by the wealthy, are important drivers of the environmental problems we confront today (Ivanova et al., 2015).

This need for diversity extends to geography as well. Many of the most important sustainability decisions that will affect the future will take place outside of the U.S. and western Europe. For example, in the last several years, some of the most innovative approaches to ecosystem management have occurred in China (e.g., national ecosystem service accounting) and Latin America (e.g., changes to the legal standing of nature; Pacheco, Barry, Cronkleton, & Larson, 2011; Ren et al., 2015). Meanwhile, biodiversity laws in developed countries like the U.S., Canada, and Europe have remained largely stagnant since the protection of endangered species. When learning occurs across international boundaries there is potential to accelerate change in stagnating countries.



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potential to
accelerate change in
stagnating countries.**

4. New Twists on the Academic and Research Career

One reason students lack support and training in engagement is the persistent idea that the primary goal of graduate education is to reproduce its faculty. While mentors and advisors train students like they were trained, with the goal of preparing them for the academic job market, students have limited opportunities for success in the broader sustainability landscape. Not all academic jobs are the same. Some graduates head into more research-intensive settings while others head into more teaching-intensive settings. In addition, the academic market is changing. Today, more than 50% of life science graduates gain employment outside of the academic sector (Xu, Gilliam, Peddada, Buchold, & Collins, 2018), pursuing careers in government, non-profit, and the business sector. Graduate programs and mentors need to empower students to consider careers outside of academia, emphasizing the need for scientists in all aspects of professional life and showing that careers outside of academia can be meaningful and fulfilling. Graduate research that works towards practical outcomes offers a promising approach to training future sustainability leaders for a variety of careers. Training that offers students the opportunity to engage with practitioners in solving real problems may also help prepare students for a diverse workforce.

Even Ph.D. graduates that stay in higher education will occupy a variety of positions (University of Toronto, 2017). While there is little to no growth in the number of tenured faculty within U.S. universities, new Ph.D.s continue to be produced at a significantly higher rate than tenured faculty are retiring (National Science Board, 2018). Considering institutional, linguistic, and cultural barriers that constrain traditional tenure-track faculty (Gerber & Raik, in press), just to name a few, many institutions are exploring non-traditional faculty appointments. There is a long history of hiring “applied” faculty as part of extension programs and institutions are increasingly engaging translational scholars or “professors of practice” (Weerts & Sandmann, 2016). Cross-fertilization between academics and practitioners is necessary to address sustainability challenges in a rapidly changing world, and professors of practice do this more effectively than many traditional faculty. However, in many cases, emerging forms of these positions do not have the hard support that disciplinary, teaching-based tenure positions have. The professionals entering these jobs will be creating and molding the workforce from within and require a high level of creativity and resourcefulness—gained during their graduate training—to break the traditional mold.

5. Making it on Wall Street, Main Street, and at the Capitol

Think about the scale of environmental problems confronting the world today and the lack of political and economic action being invested into addressing those problems. The lack of appreciation for environmental issues, as well as the lack of problem-solving abilities and skills needed for evaluating credible information, are a few of the reasons for inaction. Imagine having legislators, small business owners, and corporate executives with Ph.D.s. Imagine scientists not on the edges looking in with their published papers in hand but instead occupying professional roles and titles and using their experiences and talents directly. These professions are realistic possibilities for Ph.D. graduates. In fact, 20% of students entering graduate school are not interested in academic employment and that number grows during Ph.D. studies (Roach & Sauermann, 2017). If students were empowered to consider non-academic employment, the diversity of professions available to advanced degree recipients could expand further than has ever been imagined before.

Consider the elementary fluency in business concepts, including incentives, corporate language, and the decision landscapes, that are required to work in the private sector. The semantic and cultural divide between academic scholars and business leaders hinders progress in fully accounting for biodiversity in the business sector (Gerber, Bakker, Bonini, & McCormick, 2017). In general, the corporate sector does not currently have access to the ecological knowledge or data necessary for decision processes that consider the value of nature or the consequences of their activities on natural systems. Environmental Ph.D. graduates need business training to generate future leaders who consider this value and the consequences of environmental, social, and financial activities.

Why are holders of Ph.D.s relatively rare in legislature and the boardroom? The answer could be twofold. On one hand, employers outside of technical fields may not recognize the value of advanced degrees. On the other hand, higher education may not be producing advanced degree recipients that are attractive

in policy making or less technical industries. While economic forces dictate the uptake of advanced degree recipients, graduate mentors may not sufficiently emphasize these career paths while students are in graduate school. Changing the latter is well within our control. Professional experience obtained through internships or external collaboration can build appreciation and preparedness for alternate careers.

6. Training the Trainers in Interdisciplinary Collaboration

Those who stay in the academic sector and choose to work on sustainability challenges and outcomes will find themselves interacting with multiple, competing stakeholders in diverse social, political, and economic contexts. Yet, faculty are often not equipped to facilitate cross-sector collaboration and keep stakeholders at the table through contentious scientific deliberation. Many interdisciplinary collaborations fail due to differences in epistemologies, norms, and reward structures (see Ledford, 2015). When collaboration extends outside the academy, there can also be further differences in ideology, strategy, and the priority placed on empirically-based decision-making. In nascent research, trust appears to be a core issue affecting effective collaboration and teamwork (Harris & Lyon, 2013). Since obtaining real-world outcomes necessitates interdisciplinary and translational collaboration, problem analysis and systems thinking skills are urgently needed by the next generation of science practitioners. Science is not the only ideology that matters in discussions of sustainability; the ability to bring together a group of diverse individuals to achieve a common goal is a skill that can and must be taught.

7. Understanding the value of Knowledge Production and Knowledge Outcomes

An understanding of knowledge transfer is needed to bring data into relevant decision-making processes. To make the best use of primary data, there needs to be a pathway through which decision-making informs the design and application of models and guides the design of data discovery tools. Students are often motivated to do research because they think it is important, but their research is not necessarily aligned with what decision-makers need. Differences in social priorities, modeling questions and methods, and background theories represent important contextual variables that influence linkages between knowledge production and knowledge outcomes. For example, what makes people use decision tools in a policy context? What makes sustainability scientists effective at translating their research into changes in decision-making? Encouraging students to engage with decision-makers (e.g., through policy fellowships or internships) provides a mechanism for students to learn how research actually informs policy on the ground.

Furthermore, the way stakeholders view the fairness of decision-making processes is of importance because equitable decisions are known to be more durable (Klinsky et al., 2016; National Research Council, 2005). The inclusion of underrepresented voices and the social viability of action plans also influences how successfully

plans are implemented. Understanding the factors that determine knowledge uptake and use is necessary to identify intervention strategies that increase equity in biodiversity decision-making.

8. A need for New Institutional Models

The need to replicate, scale, and build upon case studies described in this book represents a call to action for those within higher education to make the world a better, more sustainable place. There are critics who say that there is not enough time in a graduate education to learn disciplinary skills and capacities argued for above. These critics suggest that, even if academic programs could be transformed to offer new curricula and forge new practical experiences for graduate students, the graduates would still be missing something. We disagree. Instead of pointing out limitations regarding what students can absorb, the authors of this chapter point to present-day limitations regarding what institutions deliver.

Among other possible solutions, we have seen the proven value of investing in “boundary organizations” within academia to provide consistent support to future sustainability leaders and the places that develop the skill sets needed to advance outcome-driven research (Gustafsson & Lidskog, 2018). These boundary organizations do not supplant traditional or disciplinary education but offer innovative and ambitious students a place to engage like-minded colleagues, meet helpful role models, and develop practical skills.

Partnerships with non-academic entities, jointly-funded fellowships, and opportunities for life-long learning within the academy represent promising examples of institutional structures. Many graduate students seek hands-on experiences to better understand how to make conservation knowledge actionable. Cultivating partnerships with “end users” who can co-create solutions and collaborate in research activities produces a promising approach to providing hands-on applied research experience. A number of universities have made substantial investments in these activities (e.g., the Institute on the Environment at the University of Minnesota and the Center for Biodiversity Outcomes at Arizona State University) and are committed to furthering institutional growth and evolution around collaboration and co-creation.

Conclusion

This chapter shares insights about the challenges and opportunities that exist in the development of advanced sustainability scientists. We think that these insights are critical to developing an evidence-based and flexible theory of change for sustainability education and we are asking other university administrators and leaders to join us on this journey. The future of our planet requires future leaders to have a variety of skills that are currently lacking in most graduate programs. Let us commit to turning the tide by placing greater emphasis on leadership and communication. Focusing on these concepts can help us address the complexity of systemic problems, determine viable sustainability solutions, and assist in managing and collaborating with—and working for—diverse stakeholder groups. We look forward to the next decade of transformation in graduate education for both sustainability scholars and practitioners. Advanced degrees have an essential role to play in

developing the leaders needed for a sustainable future. The question is: Are we doing what is necessary to train these leaders?

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THE KEY CAPACITIES NEEDED TO DEVELOP CHANGE AGENTS

“You must unite behind the science. You must take action. You must do the impossible. Because giving up can never ever be an option.” — Greta Thunberg

This book charges higher education administrators, faculty, and students with an immense task. We are charged with responsibilities that are great and that require rising to the challenge of some serious calls to action such as transforming programmatic practices, transforming curriculum, transforming academia, and transforming ourselves. A willingness to rise to these challenges is a vital step toward not only developing change agents but addressing rapidly changing, large-scale sustainability problems. In short, a revolution is needed to address the gap between knowledge and action. In this concluding chapter, key strategies to revolutionize the way administrators and faculty train, support, develop, and reward students, faculty, and staff to ensure that the next generation of change agents are equipped to be proactive on the frontlines of climate and social change are outlined.

Rethinking Programming and Practices

Throughout this book, strategies for developing change agents, whether through programs, practices, or otherwise, are presented as frameworks for action for practitioners. These strategies and frameworks are, therefore, vital to transformative practices that build competencies for developing graduate student change agents and future leaders. Instead of a catalog of skills or topics, the emphasis of this book is built upon the premise that administrators and faculty must utilize diverse strengths, opportunities, and experiences within our multiple roles and positions to transform graduate sustainability leadership education. To do this, we must examine the status quo in every sustainability graduate education space we engage in. This may include rethinking what education looks like both programmatically and in practice. More importantly, we must recognize that there will never be a point where this reflexive process is complete. As new societal, environmental, and sustainability challenges arise, leadership is required and training for the next generations of leaders will need to continually evolve. The enterprise of pulling together this edited volume has already illustrated that there are just as many extremely diverse experiences aimed at addressing challenges and outcomes as there are extremely diverse challenges and outcomes. It is an asset that no two programs are

the same. Instead of encouraging conformity, experimentation and providing space for the exchange of information to learn from one another should be encouraged.

It is only recently that the academy shifted away from the disciplinary silos that dominated the 20th century. At most universities, this shift has been limited to particular areas of inquiry, such as sustainability. Likewise, graduate education has typically focused on training the next generation of faculty who are siloed away from the public, only occasionally providing scientific insight that may be useful to the public if communicating with them at all. In order to conduct relevant scientific studies and incorporate a variety of knowledge (such as indigenous, local, and non-academic), academics need development in areas like leadership training, soft skills, respect for diverse understanding, and more. Because sustainability challenges require engagement with varied publics and local and global communities, both scientific studies and potential conclusions need to be tailored to the respective audiences by transforming the education enterprise at-large.

Transformative Training for Change Agents

If administrators and faculty want to develop change agents, they must provide transformational training. All of us, both individually and collectively, have a role in this transformation. This transformation cannot occur simply by changing the content; the entire enterprise must be transformed. In addition to thinking beyond the classroom, traditional programmatic practices can evolve by interweaving learning and experience for an intentional and seamless development of transdisciplinary competencies among future sustainability leaders and change agents. A shift in identity must be cultivated through real-world experience and engagement. Experiential learning provides the capacity for tangible and practical action development that translates into real change. However, planning, practice, and impact are mitigated by the fact that real and meaningful change takes time. By taking the necessary time needed to develop transformative change agents, the investment promises to yield a tremendous return, especially given the problems that challenge the world both now and in the future.

Traditional perspectives need to be questioned in order for traditional hierarchies to be transformed. While the importance of developing critical thinkers through education may never have ceased to have value for the academic landscape, when contextualized against the problems faced by sustainability leaders, there is a palpable urgency to ensure thoughtful solutions are intentionally carried into practice. This step from theory to practice, from inaction to impact, from problem to solution, requires that students, instructors, practitioners, and beyond re-evaluate hierarchies that stymie the collaborative possibilities excluded by an aging hierarchical structure that prioritizes ‘publish or perish’ competition or that enforces any boundaries that hinder unforeseen partnerships. The idea that a graduate education serves the purpose of reproducing faculty, as noted by Hellmann and Gerber (2019), does not allow a space for pedagogical innovation to flourish in the manner that this book deems necessary. What could transforming academia look like? Global problems require global solutions, so what better way to challenge traditional hierarchies and perspectives than to leverage a global network toward transdisciplinarity and supporting innovation, co-design, co-development, and multi-

modal and faceted programming. Networks provide an opportunity to harness the tension between global and local communities by marrying information exchange, co-learning with other entities, and tailoring lessons for particular individuals and entities.

To advance this agenda, all of us must embrace the role of a change agent. In this concluding chapter, we explore 1) what it takes to be a change agent, 2) three key strategies that can be used to transform graduate training and the larger university enterprise, 3) future directions required to advance this agenda, and, based upon the rich empirical work in this volume, 4) guiding questions designed to inspire concrete action for developing change agents at your program or institution. We caution readers about the tendency to replicate success without careful self-reflection. Each place, program, and person have unique strengths that will not be fully utilized if a formulaic approach is taken to develop and support change agents.

What Does it Take to be a Change Agent?

Let us begin by understanding what needs to change. The sustainability “tent” is quite large but with emerging programs, degrees, and interdisciplines, there is danger that critical disciplines deemed outside of sustainability, such as the health and medical fields, will be excluded (Demorest & Potter, 2019). Instead of falling into the gatekeeping role that is all too common within academia or, conversely, arguing that everything is about sustainability, we argue that more attention should be paid to expanding the domain for interdisciplinary scholarship or, more importantly, transdisciplinary scholarship, where the bounds are training, and research spaces set within relevant communities. If we are truly going to develop agents of change, we must recognize that domains of needed change are not static and will require novel collaborations both inside and outside of the academy. This might require changes to, for example, what supports a case for tenure, but, more fundamentally, our students must be equipped and trained to work in these domains, develop new partnerships with people with very different ways of thinking, and work to collectively affect and scale change.

It is our premise that we can change ourselves, the planet, and our future through our practices, our investments in leaders, and our willingness to try things that are experimental, intentional, meaningful, and focused on solving the wicked problems we face. Graduate education in sustainability confronts two critical challenges. First, it must address problems that are embedded in increasingly complex and rapidly changing social, technological, and economic systems (Clayton & Radcliffe, 2018; Steffen et al., 2018). To meet this challenge, education must prepare future researchers to work across disciplines; build collaborative teams; integrate research from the sciences, engineering, social sciences, and humanities; engage with external stakeholders effectively, and co-create solutions with communities (Miller, 2010).

The second challenge is diversity. To date, a failure to recruit and train a diverse community of scholars that represents the larger society has undermined our ability to address deepening social, economic, hegemonic, and political inequalities (Hackl, 2018; Temper, Walter, Rodriguez, Kothari, & Turhan, 2018) and has decreased the academic enterprise’s responsiveness to the many pressing problems in poor and disenfranchised communities (Cozzens & Thakur, 2014). To effectively change our world, we must build the collective capacity

to engage in transdisciplinary and community- and policy-embedded team science and meaningfully develop and support diverse communities of scholars and practitioners.

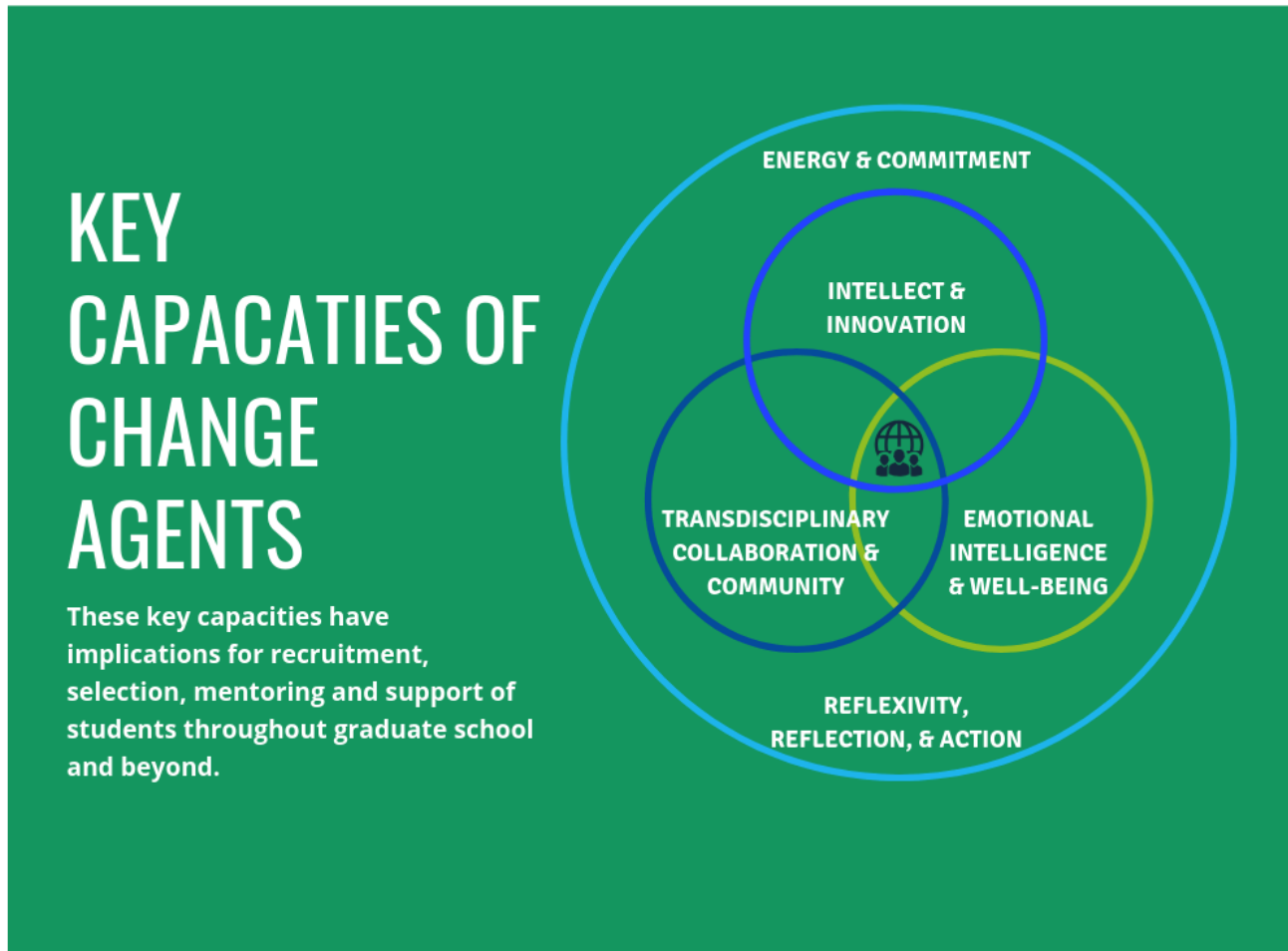


Figure 1. Key Capacities of Change Agents. This figure illustrates the importance of aspects, including intellect and innovation, that are already valued in the academy and challenges us to also value, support, and reward transdisciplinary collaboration and community, emotional intelligence and well-being, energy and commitment, and finally, reflexivity, reflection, and action.

There are numerous lists of competencies (Lozano, Barreiro-Gen, Lozano, & Sammalisto, 2019; Wiek, Withycombe, & Redman, 2011) used to develop sustainability graduate education programs, but a fundamental transformation of higher education that goes beyond competency is required (Gosselin et al., 2016; Vincent & Mulkey, 2015). We embolden the entire higher education enterprise to become change agents in order to deal with today's sustainability challenges at multiple levels of agency: as individuals, communities, organizations, networks, and systems. With that in mind, we identify five critical change agent capacities that embolden the transformative aspects of developing change agents: transdisciplinary collaboration and community; intellect and innovation; emotional intelligence and well-being; energy and commitment; and reflexivity, reflection, and action (see Figure 1).

Transdisciplinary Collaboration & Community

Prior chapters recognize that, to address sustainability challenges, there must be a focus on both transdisciplinary science (Holden, Cockburn, Shackleton, & Rosenberg, 2019) and team science (John, Harsh, & Kennedy, 2019). Team research of complex, transdisciplinary problems faces challenges that are just as much sociological as technical (Anbar, Till, & Hannah, 2016) and soft skills are required to resolve them. Recent research hints at the importance of cultural identity over science literacy in basic information handling and risk analyses on culturally-loaded topics like climate change highlight the depth of this challenge (e.g., Drummond & Fischhoff, 2017; Kahan, 2012). Simply conveying the technical substance does not lead to correct and effective comprehension of a given topic. Learning how to effectively communicate is critical to conducting team science, advancing the co-production of transdisciplinary science with diverse publics, and informing critical policy questions. Effective communication is also critical for both conducting innovative interdisciplinary research and engaging diverse audiences. Communication without engaging with these diverse audiences and communities is ethically problematic both in terms of efficacy of interventions and in that it lacks incorporation of relevant local knowledge. For these reasons, knowledge co-production has emerged as one of the most significant new tools for global environmental change research (Miller & Wyborn, 2018). Communication across disciplines (Holden et al., 2019) is essential to impacting real world problems, but without embedding research within communities or policymaking (Holden et al., 2019; John et al., 2019) scientists may miss the most critical questions and much-needed solutions. Furthermore, effective communication is not simply about learning how to produce or translate science but also the soft skills needed to build trust with communities, publics, and teams (see John et al., 2019).

Sustainability decision-making occurs at many levels and in overlapping jurisdictions such as individual households, companies, local municipalities, utilities, states, and federal agencies. Change agents need to navigate these varied policymaking domains. Anticipatory and strategic governance and decision-making strategies are all key for participants in decision-making and for researchers seeking effective research interventions (Wiek et al., 2011). For example, the concept of anticipatory governance is becoming an increasingly valuable tool in a variety of socio-ecological systems and sustainability work (Armitage et al., 2009; Bates & St. Pierre, 2018; Wiek, Ness, Schweizer-Ries, Brand, & Farioli, 2012). In line with navigating those domains, chapters from this book highlight the nexus spaces between the university and the critical roles of developing capacity to communicate with policymakers (Posner, 2019) and the public (Weller, Wall, & Barron, 2019). In general, change agency in academic institutions is further catalyzed by involvement in institutional initiatives, whether by the top-level leadership driving them or by having all stakeholders seated at the table, where institution-wide collaboration is made possible.

Promising practice. An example of transdisciplinary collaboration and community is the Participatory Field Modeling School, which provides a 3-day training for graduate students, faculty, community members, and policymakers to engage in co-creating solutions to complex problems with members of the Detroit and Flint, Michigan communities. This is one example of how participatory-based modeling is being used

by Eastside Community Network, the city of Detroit, and Michigan State University (see Figure 2). This community organization purchased abandoned lots and transformed them into a rainscape (which helps with the increasing flooding in the area) and an outdoor learning lab. Through this revitalized space, residents have access to both job training and education while, at the same time, a beautiful solution that works towards climate resilience has been created.

In Detroit, there are 70,000 abandoned properties and there has been a push to revitalize the land through farming. But, if you speak to many older black residents who remember the Great Migration from the South (1916-1970), the last thing they want to do is farm. For many, farming represents a trauma-filled life in the South that they escaped. This human perspective is something a “well-intentioned” academic could easily miss. Without knowing the history of an area and, more importantly, not knowing how the people that live there are impacted by policies and solutions created in the ivory tower, effective change cannot occur. <https://modeling.engage.msu.edu/>



Figure 2: Orlando Bailey, Chief Development Officer of the Eastside Community Network, speaks to participants of the Participatory Field Modeling School.

Intellect & Innovation

Harnessing the intellectual and innovative talents of the gifted has been a driving force for leadership development throughout history. Approximately 2000 years ago, Plato devised an educational program for the most gifted to be future leaders known as ‘men of gold.’ These men were separated from their peers of lesser intellect who were known as ‘silver,’ ‘iron,’ or ‘brass’ men (Freeman, 1980). The role of higher education in developing the infant nation’s leadership was on the mind of the founding fathers and was most clearly articulated through Thomas Jefferson’s vision when he developed the University of Virginia. Jefferson believed that higher education should create leading scientists, researchers, and leaders (Brubacher & Rudy, 1997). Today’s sustainability change agents need strong intellectual and innovative acumen to navigate the vast complexity of the entangled issues that are endemic to sustainability.

To address these challenges, graduate education should provide students with skills that facilitate collaborative, use-inspired research that contributes to effective community solutions to complex systems problems. Sustainability challenges require novel research frameworks and approaches that are: (1) cross-disciplinary, advancing with human-ecological-technical systems (Anderies, Janssen, & Ostrom, 2004); (2) cross-scale, addressing the linkages between local, regional, and global structures and dynamics (Scholes, Reyers, Biggs, Spierenburg, & Duriappah, 2013); (3) cross-system, interrogating the dynamic interactions across interconnected systems that result in the propagation of vulnerabilities and resiliencies across the interconnected systems (Berardy & Chester, 2017); and (4) cross-temporal, addressing the divergent timing cycles that characterize many sustainability challenges (Holdschlag & Ratter, 2016). In summary, sustainability scholarship requires deft capabilities both to model systems and to anticipate and strategically develop innovative interventions or policies, such as resilient infrastructure systems.

Understanding the causes and consequences of long-term interactions between human and natural forces is vital to addressing questions of sustainability. However, the complex nature of both social and ecological systems and the even more complex interactions between human and natural systems severely limit our capacity to intuit the causes of change and the consequences of human action. Reductionist analytical approaches designed to isolate linear cause and effect relationships are therefore often ineffective (Dawson, Rounsevell, Kluvánková-Oravská, Chobotová, & Stirling, 2010). These issues of non-linear causality and long time-scales have made quantitative, process-based modeling especially important for scientific study (Dearing et al., 2014). Model-based science provides tools for the exploration and analysis of the multi-dimensional, non-linear, and, often, counter-intuitive interactions between social and biophysical processes that drive modern earth systems. Modeling environments can be used as virtual laboratories to study how system dynamics can play out over long time spans (van der Leeuw, 2004).

Promising practice. The Acara Challenge at the University of Minnesota’s Institute on the Environment provides interdisciplinary and cross-sector coaching opportunities for undergraduate and graduate students that includes impact labs, courses, and study abroad experiences in which students engage in solving real-world

problems. Every spring a competition is held that awards students up to \$5000 in funding for their projects. <http://environment.umn.edu/leadership/acara/>

Emotional Intelligence & Well-Being

Beginning in the ecological literature, and more recently adopted by social-ecological science and sustainability, resilience is an important concept that recognizes the relationship between adaptation and transformation and stability of systems. Expanding the notion of resilience to also include the individual, we should encourage individuals to transform when opportunities arise as well as develop an adaptive capacity to navigate the difficult (and often novel) challenges in the sustainability space. To encourage this, we argue that we must focus our attention on the critical issues of psychosocial support within the academy and our communities of practice and recognize the opportunities for transformation and change during periods of crisis (Kremers & Hecht, 2019). Vulnerabilities must be recognized in systems, societies, groups, and individuals while not isolating them from the structural interconnections within the broader system within which we live and work (Cole, 2016). There are numerous opportunities to engage with vulnerability, such as through self-reflection, but major events and disasters provide opportunities to reassess practices and build resilience. Instead of only seeing loss with disaster, we must recognize the opportunities that are present.

There is a different mindset required to harness vulnerability (Brown, 2018). Developing this mindset requires exposure to new ways of thinking about change and resilience. Coupling theoretical training with experiential learning, especially the coproduction of knowledge with diverse communities, grounds this abstract idea in the real world. Vulnerability in one individual, place, or community does not mean universal weakness; building teams, networks, and collaborations between people, cities, and societies enables the larger collectives to leverage diversity via the uniqueness of the components. Building, designing, and responding to change in new ways will require innovation that is based on creativity and imagination that is enhanced through diversity, coproduction, and encouraging students to embrace novel insights and ways of knowing. With this focus on vulnerability, we must also provide diverse change agents with the necessary psychosocial support. We must support diverse individuals and communities at our university and beyond.

Promising practice. In the Boreas Leadership Program at the University of Minnesota, all of the students take the EQi, an emotional intelligence inventory that flags students who may need additional mental health support during graduate school and also points out the students who have the greatest leadership potential. This tool, and other assessments like it, provide students opportunities for enhanced self-awareness, other-awareness, and transformational coaching. <http://environment.umn.edu/leadership/boreas/>

Energy & Commitment

Mustering and harnessing the courage, imagination, and discipline needed to tackle the wicked sustainability challenges we face requires immense energy and commitment. Working with policy actors and communities,

dealing with loss and uncertainty, working across cultures, and negotiating conflicting priorities are time intensive, cognitively intensive, and emotionally intensive tasks. Change agents will face a multitude of challenges to which there is no one roadmap or formula to follow. Commitment and the resulting energy from that deep sense of commitment are key to navigating the issues that will naturally arise. Co-creating, sustaining change, and constantly recalibrating to the call of the future as situations shift and evolve are necessary in the dynamic world we seek to protect.

Promising practice. Arizona State University (ASU) is making the commitment and investing the energy needed to transform into a New American University (n.d.). Motivated by ASU's charter the university is, "measured not by whom we exclude, but rather by whom we include and how they succeed." Commitment to the charter is demonstrated through faculty hiring and tenure decisions, the creation of new programs, and allocating scarce university resources to individuals who are collectively advancing eight design aspirations: leverage our place, enable student success, transform society, fuse intellectual disciplines, value entrepreneurship, be socially embedded, conduct use-inspired research, and engage globally. The commitment and energy of the entire university, including faculty and students, is transforming the university and motivating it to shift toward a change agent mentality. <https://newamericanuniversity.asu.edu>

Reflexivity, Reflection, & Action

There are no panaceas for sustainability governance questions (Ostrom, Janssen, & Anderies, 2007). We must tailor our science, policy recognitions, universities, programs, and ourselves to the particular strengths and challenges we face. Building upon the idea of adaptive management, especially adaptive co-management, we must reflexively and continuously monitor change (Waghid, 2002). We must be willing to ask tough questions of ourselves and each other in order to improve (Viegas et al., 2016). As each of us determines how we might be a better change agent, we must first assess where own strengths, experiences, and opportunities lie. Instead of constantly looking over our shoulders at the neighboring students, faculty members, universities, or communities, we must instead focus on ourselves and assess who we can be given who we are. Part of this exercise in reflexivity should focus on building diverse teams and networks in order to leverage our diversity (Wilsey et al., 2019). Higher education has been recognized as a means to foster meaningful change in societies (Stephens, Hernandez, Román, Graham, & Scholz, 2008); likewise, with the emergence of sustainability as an academic discipline, a body of work has focused on how higher education can be transformed to advance the new discipline (Gosselin et al., 2016). In our view, there is a gap in the literature leading to minimal exploration of the reflexive processes whereby higher education and society are transformed by the actions of the public, students, faculty, universities, and networks and associations of scholars and universities.

Promising practice. In 2016, faculty and academic professionals from across ASU came together to critically question why diversity in the faculty was lacking; this gap was especially worrying given the university's commitment to transdisciplinary research (which necessitates diverse ways of thinking) and the increasingly diverse undergraduate body. The university's self-reflective process, which consisted of a series of

workshops held by representatives from across ASU's four campuses, led to an understanding that along the entire "pipeline," from undergraduate students, graduate students, and post-doctoral fellows to junior and senior faculty members, the mentoring structures in place were not adequate for supporting intersectional diversity that recognized gender, race, ethnicity, foreign-born status, sexual orientation, disability, rank, and discipline. A result of this reflexive process was a National Science Foundation ADVANCE grant used to develop the resources needed to support underrepresented students and faculty through their entire academic life course. These resources include *The 7 Minute Mentor* professional development videos that provide individual leaders' "stories of reflection, lessons learned, and what drives their passion for advocating for equity for all" (Arizona State University, 2018). The Arizona State University ADVANCE Program (n.d.) has led to the creation of external and internal structures and processes to continuously examine whether ASU is meeting its equity goals. <https://advance.asu.edu/>

Key Strategies

How do we develop these five critical change agent capacities? Throughout this volume, scholars have provided a rich set of individual, programmatic, university, and inter-university network approaches. Below we synthesize these into three key strategies that enable the development of change agents while also recognizing that there are numerous strategies for developing change agents.

Key Strategy I: Getting out of the Ivory Tower and into Communities Through Stakeholder-engaged Teams

Institutional change and decision-making is possible from within institutions, whether through senior leadership positions, a seat at the table, or passionate individuals at any level. But change agency should not be limited to internal change or patiently waiting for momentum toward transformation to build from the outside in, whether through government legislation, donor funding, or social pressures. The effort toward developing a capacity for effective, impactful change must transcend the academic milieu. Whether by establishing connections with and within communities through community brokers, leveraging community engagement initiatives, or other connections, as Holden et al. (2019) emphasize, universities should consider alternative models to graduate training beyond the single, scholarly dissertation. One way to achieve this would be by adjusting existing timelines and benchmarks, like time to degree, to support the often long length of time that is required to meaningfully engage communities in transdisciplinary science.

Furthermore, the complexity of sustainability problems requires extraordinary collaboration that transcends traditional disciplinary divisions. As authors Dale and Leighton (2019) illustrate, sustainable community development can be tackled not only in a theoretical way but also by literally taking the classroom to the city. In order to fully explore a robust amount of possible resolutions, being immersed in the context where problems emerge or subsist, in this case the city, creates space for sustainable community development through

immersion in the city. This also involves working closely with city staff to identify problems that need to be solved, acknowledging that relationship-building is a key to sustainable community development. By creating such a space, collaboration can be cultivated beyond the theoretical, problems can be addressed, and knowledge becomes action.

Key Strategy II: Building Trust Through Cohorts, Networks, and Genuine Collaboration

Not all academic departments encourage collaborative work in the same way. This is why cohort-building and engagement in networks is key. For example, leadership and sustainability problem-solving can come together in a pivotal way that allows public policy to shape debates and tackle issues. Hence, capacity building that connects science and policy has the chance to support action in impactful ways and help develop leaders that are able to work across both science and policy while using skills that support sustainability. This is the sustainability leadership model of development that is addressed by John et al. (2019), where some key points of educational program design include creating an environment of trust, striving for diversity among program participants, and establishing an alumni network.

Establishing trust is not easy. Trust has to be earned which takes time. For programs to successfully champion this strategy for developing change agency, they should consider following the model addressed by Wilsey et al. (2019), the Master in Development Program (MDP). The MDP curriculum has been adopted and adapted by more than 40 universities. Hallmarks of the program have been adaptations to local needs, values, and university strengths such as in-depth training in indigenous worldviews at the University of Winnipeg, curriculum extension through a joint law and MDP program at the University of Florida, and a novel pedagogical innovation of a year-long Development Lab at Columbia University. All of these MDPs have a required field practicum that provides necessary training in a consultancy model because most developing practitioners engage in it throughout their career. Therefore, graduate programs that adapt to local conditions and connect to other universities' experiences and innovations through a global network allow strategic evolution that addresses real world needs to occur.

Key Strategy III: Transforming Support & Reward Structures to Elevate Innovations in Interdisciplinary and Transdisciplinary Approaches

A critical aspect to furthering sustainability science and education is dismantling or disrupting organizational hierarchies that limit or restrict innovations that are driven by faculty, students, or other sources. As Carlson (2019) describes, graduate students come to the classroom with a more nuanced understanding of complexity and sustainability than some academics. These students often challenge disciplinary boundaries that restrict their ability to conduct thoughtful sustainability science and apply it to real-world problems. Hence, Carlson

(2019) argues that students are agents, not simply recipients of existing knowledge, and by harnessing their insights and recognizing their role in motivating individual faculty, students co-develop graduate education models, challenge existing structures, and influence faculty perspectives and attitudes overall.

Additionally, Weller, Wall, and Baron (2019) discuss how a cohort model provides, among a variety of skills development opportunities, essential training in areas, like communication, to help cultivate the capacity for scientists to share research findings beyond the establishment – a facet of sustainability leadership requiring an incentive beyond the traditional academic milieu. Although rewarded in the academic context, communicating exclusively with peer experts through publications or conference presentations fails to net the impacts that we argue are required to adequately address sustainability challenges. Similarly, written work remains more valued than oral presentation contributions. Luckily, the capacity to communicate across audiences is being increasingly recognized as essential to graduate student training and education through opportunities like the *Three Minute Thesis*, a global competition founded by the University of Queensland in 2008.

Transdisciplinary collaboration also means that different types of partnerships will need to be supported. This is why, in highlighting the center-focused approach taken by the Mitchell Center at the University of Maine, Bieluch, Hart, McGreavy, Silka, & Strong (2019) present a case for partnerships inside and outside academia that support graduate students with leadership development so they can act as change agents on complex problems in a multifaceted world. Altogether, these partnerships and collaborations leverage various factors to enhance professional success for both faculty and students but requires that the capacity to communicate across audiences becomes an integral part of the graduate education experience.

In summary, we recognize that there are numerous strategies for developing sustainability change agents. We concede that this volume is not exhaustive, so the question to our audience is: What are other strategies? We must not only look toward future possibilities of alignment with scholarship and practice but also work toward it, which is why we optimistically conclude with possible future directions.

Future Directions

This collective work identifies a path forward for developing change agents that includes a number of areas that could benefit from increased scholarship and experimentation. Specifically, there needs to be significant development in the literature on diversity and vulnerability. Diversity and inclusion are both challenges and opportunities that must be addressed at multiple levels and in multiple dimensions. Simply put, not all people, places, or universities are the same. Instead of attempting a cookie-cutter approach to graduate education for sustainability, we must instead reflect upon the diversity of strengths and weaknesses. Without embracing diversity on teams, across programs and universities, and through community-university collaborations, we are more vulnerable and less knowledgeable. Without using reflexivity to improve, adapt, and build diverse, transdisciplinary teams we will fail in our quest to tackle sustainability issues. In this section, we unpack the frontiers of diversity and vulnerability necessary to develop change agents for leadership in sustainability.

Partially an artifact of the original ANGLES Network, which originated with American and Canadian universities, and also reflective of western-dominated sustainability scholarship (Nagendra, Bai, Brondizio, & Lwasa, 2018), this volume lacks the necessary international diversity to tackle sustainability planet-wide. Because of this, we urge readers to view this volume as a starting point, a call for reflexivity, renewed energy, and commitment to transforming higher education. Even as we engage in more North-South transdisciplinary scholarship, we must be aware of the power differences and historic lack of diversity and colonialism associated with the scientific enterprise (Schmidt & Neuburger, 2017). More voices are needed to help advance this agenda and embolden change agents throughout the world.

In order to recruit, retain, mentor, and develop diverse students and scholars, we must look reflexively and closely at ourselves. Universities have always faced a diversity challenge (Patton, 2016). Typically, diversity is viewed as a long-term problem that needs, and will attain, an eventual solution. However, this “slow” approach does not match the seriousness and immediacy of the diversity crisis nor does it provide the means to attempt to deal with these challenges head-on. Women and minorities continue to face systematic, silent discrimination and harassment as well as direct and severe attacks both online and in-person. The diversity “issue” is often framed as a lack of access or inequality for particular students and populations, but this perceived failure also exacerbates inequalities (Nagendra et al., 2018) and engineers systems that distribute unequal risks and vulnerabilities across groups (Chatterjee & Turnovsky, 2012). Furthermore, recent scholarship has demonstrated that access to higher education without adequate support is insufficient when it comes to retaining and developing diverse undergraduate student bodies (Jack, 2019) and that the key to support is inclusion and embracing diverse identities (Puritty et al., 2017). As change agents, we must build the programmatic and community scaffolding within and across universities to support individuals and historically underrepresented groups, dismantle the impacts of structural racism and white privilege on our campuses, and aid in efforts to tear down these insidious structures across the globe.

How to Get Started

Every person reading this book (students, faculty, academic professionals, administrators, or otherwise) can become a change agent. Working collectively at multiple levels and scales with diverse perspectives and experiences we can transform institutions in order to solve global challenges. All too often, the process of conceptualizing problems and developing high-level strategies is disconnected from concrete steps, a path forward. We tasked our authors to focus their attention on specific elements of their training programs and experiences and then used those elements to identify the critical capacities and key strategies listed below. Depending on your role and interests, as well as programmatic and university contexts, you can pick and choose from the capacities and strategies listed below to begin to transform the academy.

Challenging the dominant pedagogical models is not easy, but there is agency with individual students (Carlson, 2019; Holden et al., 2019; Kremers & Hecht, 2019), faculty (Dale & Leighton, 2019; Demorest & Potter, 2019; John et al., 2019), programs (Bielich et al., 2019; Weller et al., 2019), and universities (Carlson,

2019). Our authors also often point out the strength that comes from cohorts (Weller et al., 2019), faculty teams (Dale & Leighton, 2019), program networks (Wilsey et al., 2019), and higher education networks (Carlson, 2019). What these various perspectives point out is that collectively we can make significant progress if we work together. Motivating groups to tackle major issues and affect change is not easy. Doing so requires sophisticated leadership skills that include the ability to understand incentives and constraints of decision-makers and targeted training to build capacity to affect change (Gordon et al., 2019). In addition to multifaceted training in communication, students, faculty, and publics need to learn how to increase efforts to help transform research projects, outreach, programs, and communities. Although rich literature on team collaboration (e.g., McGreavy et al., 2015) with diverse stakeholders (e.g., Finio, Lung-Amam, Knaap, Dawkins, & Knaap, 2019) and decision-makers (e.g., Schoon & Cox, 2018; York & Schoon, 2011) exists, much of the “art” of collaboration requires experiential learning in order to understand how to codevelop research questions with publics, work with diverse sets of stakeholders, and engage the public with science in a useful way (Brundiers & Wiek, 2017). Many sustainability challenges require society to scale solutions and governance without losing site of diversity and local context (Singh, Keitsch, & Shrestha, 2019; Sheridan, Satterwhite & McIntyre Miller, 2019). Likewise, changing higher education to meet these needs also requires establishing and building new networks. One of the first steps that change agents can take is transforming the curriculum to meet these immediate needs.

Looking Forward

As we look to the future, we must first understand where we are now. We encourage every program, department, and college to utilize a systems thinking perspective to examine the barriers to developing change agents. In what ways, during recruitment, selection, retention, and post-graduation, could you better support and challenge your students and alumni to be agents of change? How are you currently failing? We must take an honest, hard look at ourselves, our programs, and our institutions with great care. If our charge is, “How can we help challenge and support our students to flourish so that they can do seemingly impossible things?”, what do we need to do differently?

Throughout this book, we have explored various changes that can be made to the competencies and associated learning outcomes needed to address the wicked sustainability challenges we face. In addition, we explored how there is a tendency to externally look at the scale of these grand challenges we face rather than acting on the interior landscape challenges faced in our institutions, departments, labs, teams, and indeed, ourselves. To develop change agents we must radically reshape the academy to create cultures that cultivate and nurture risk taking and resiliency and that honor varied paths. Cultural change is not for the faint of heart, but radical change is necessary to create academic cultures which support, develop, retain and promote change agents. Our collective mindset needs to shift from, “How will we do this?”, which tends to provoke conversations that swirl in stagnation in academia *to* actively prototyping our way forward with a willingness to

take risks and continually learn from our mistakes and successes along the way. This is our generation's version of the moon landing. Together we can (and must) go far.

10 Key Questions to Examine the Health of Your Academic Unit and Develop Change Agents

1. What opportunities exist for your students to engage in stakeholder-engaged research and scholarship?
2. Do you highlight faculty and/or other role models (including successful alumni) who have made real-world impacts?
3. How does your program encourage students, staff, and faculty to take part in risk-taking and prototyping?
4. What are successful transdisciplinary and interdisciplinary initiatives that have been supported by your academic unit?
5. How do you support the mental health and well-being of your graduate students and faculty? How do you create a culture of resilience?
6. How do you nurture the next generation of diverse students and faculty? Are there support structures in place that help individuals deal with biases and navigate unequal access? What are the efforts being made to dismantle structures that perpetuate inequality both on campus and beyond?
7. How are you supporting champions of change and developing your change agents? Do you support and empower professional staff and academic faculty in your programs to affect change?
8. How reflexive and committed are your university, programs, faculty, and students to continuous transformation?
9. What are the unique ways in which your unit can train graduate students to be sustainability leaders today and tomorrow? Are there supports in place to build capacity for both academic and non-academic non-traditional roles?
10. If the traditional post-secondary academic context is undergoing a radical transformation, how can students, staff, and administrators remain ahead of the curve and proactive in solving wicked problems?

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