

13 Evaluation of an interdisciplinary graduate program

Lessons learned from the Tufts Water Diplomacy program

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Context and rationale

Nearly every grant-funded project will come with requirements regarding reporting and evaluation. For large organizations such as the National Science Foundation (NSF), the routineness of evaluation and the desire to compare performance across programs contributes to formulaic assessment strategies and a heavy reliance on output-oriented metrics. For an interdisciplinary research program, especially one in its early stages, these traditional approaches are unlikely to capture the developmental progress of the program, its impact on students and faculty, or its consequences outside of the academy. This mismatch can lead to frustration and lost opportunities.

While we seldom question the importance of regular reflection and self-evaluation in our personal and professional lives, our reaction to external evaluation can be much more averse. Rote reporting to a funding agency can become a task with little value if it is perceived as an unnecessary exercise that simply satisfies the funder. Such exercises can move from simply time consuming to adversarial when external evaluators render judgment that are not in alignment with views and perceptions of program leaders regarding performance and effectiveness.

Even *The 2010 User-Friendly Handbook for Project Evaluation*, produced under contract from the NSF, acknowledges those responsible for reporting often perceive evaluation as “threatening, disruptive, and not very helpful to project staff” (Westat et al. 2010). This frustration with evaluation often masks its capacity as a transformative practice that can help ensure innovative research programs adapt and thrive. In order to realize this potential, program evaluation must move beyond its number-centric conceptualization as a tool for cross-comparison. Program administrators need more flexibility to measure success on terms they feel reflect the program’s goals, and participants must be allowed to have their narratives weighed alongside their numbers.

When program evaluation is thus aligned with program context, regular reporting need not to be seen as a Sisyphean task, but as a genuine opportunity for growth. Since every program is different, the challenge is to match the evaluation with appropriate methods and attention to process. In sharing our stories

and experiences with alternative program evaluation, we hope to demonstrate what is possible and help readers avoid potential pitfalls.

How has our thinking, planning, and implementation of the program assessment evolved?

Our Water Diplomacy Integrative Graduate Education and Research Traineeship (IGERT) experience has significantly shaped our views and perspectives about assessment and evaluation: we have evolved from being assessment-agnostics to assessment-believers. In fact, our first interaction with SustainaMetrix (our external evaluator) in 2009 was quite revealing. Initially we saw assessment as a bookkeeping tool to track classes, publications, and conference participation rather than a practice that could improve the experience for participants and promote mission-aligned outcomes. Yet at the end of our IGERT, we were impressed by the transformative experience for students, faculty and administrators that was shepherded along via high quality external assessment. This jointly authored contribution by our external evaluator (Page) and principal investigator (Islam) is evidence of our adaptive learning.

We now have a better appreciation about how our formative assessment activities led to changes in our program and our intellectual culture; and how our external advisory committee helped shape the growth and on-the-go adjustment of initial program elements through adaptive feedback and careful guidance from our external evaluation team. The external assessment of the Water Diplomacy IGERT was innovative and served as a springboard for longer term institutional change as the SustainaMetrix Team was asked to work with Tufts Institute for the Environment to conduct transformative organizational scenario planning. This exploratory process generated new research directions and helped launch the new Sustainable Water Management M.S. program in 2018.

What is needed to make evaluation of interdisciplinary training effective?

Evaluation of an interdisciplinary training program is a challenging endeavor. Measuring genuine success involves not only evaluating whether the principal investigators and collaborating faculty have created a training program in which the student participants (trainees) have developed the expected core competencies but also the capacity to compose program elements in ways that generate new knowledge and insight for both theory and practice. From an evaluation perspective, it is not enough to put together a set of scholarly training experiences that fuse different disciplines, methods, and tools into academic activities, even if there are perceived needs for this fusion. The program needs to demonstrate these elements have been combined in a way that enables program graduates to apply their acquired competencies to creatively address novel problems. Trainees from any graduate program need to be sufficiently competent with their disciplinary knowledge and expertise. For participants in interdisciplinary programs, it is also essential for them to

know what their disciplinary expertise can't provide and why they need complementary expertise to excel in their interdisciplinary niche – Water Diplomacy in our case.

Evaluation and assessment of interdisciplinary scholarship encounters difficulties when approaches based in single disciplines or traditional methods of program evaluation are applied without fully appreciating the nuances of interdisciplinarity. Too often, bibliometrics such as number of peer-reviewed publications in high-impact journals and subsequent citations are used as the “gold standard” to evaluate effective research and by extension graduate research trainee programs. We think assessment of interdisciplinary scholarship requires criteria and metrics that are specifically chosen to be aligned with the goals and objectives of the program. In an interdisciplinary context, this often means negotiating a balance between the recognizable aspects of traditional program evaluation (which are important to funding agencies as well as individual departments) with novel approaches that provide sufficient flexibility for the program to grow and adapt in alignment with its specific goals.

What was done at Tufts University and how?

An interdisciplinary Water Diplomacy Program was conceived and designed to educate a new generation of water professionals called Water Diplomats. A Water Diplomat is an interdisciplinary professional who contributes to the resolution of complex water problems that include: (i) multiple stakeholders with conflicting or divergent interests and (ii) sources of uncertainty in either the scientific or sociopolitical domain (or both). Water diplomats are trained to become competent in multiple water-related disciplines and applied fields. A key challenge was how to measure the development of these competencies as an interdisciplinary skill set. While there has been significant progress in the design and use of assessment protocols for undergraduate learning, there are few established models for assessment of student progress in interdisciplinary doctoral-level graduate education. This chapter explores the results of a novel approach to identify, track, and measure the development of key interdisciplinary competencies by each student to become a Water Diplomat. Problem-focused principled pragmatism drove the process – both the development of the Water Diplomacy Framework and the evaluation of the program. In this chapter, using recent findings from the developmental evaluation literature and our decade-long experience at Tufts, we will show by examples of lessons learned about what to do, what not to do, when to adapt, and how. These lessons and related insights are expected to have wider applications in designing and implementing other interdisciplinary graduate education programs.

Moving beyond traditional evaluation frameworks

Under conditions of interdisciplinary exploration and innovation, traditional evaluation methods and frameworks are not useful (Patton 2016). These approaches are often categorized as “formative” or “summative.” Formative

evaluations examine the design or ongoing progress of a program and suggest improvements to its model. Summative evaluations, on the other hand, are used to assess a program retrospectively and assess whether the program produced the desired outcomes and to what degree those outcomes can be attributed to the program model versus exogenous factors. Both types of assessment have their place and merits, but as Patton (2011) notes, “evaluation practitioners have become sloppy about what actually constitutes a formative or summative evaluation and the connection between the two.” Designed to clarify the practice of evaluation and make it more effective, the developmental evaluation framework proposed by Patton (2012) has proven itself a useful evaluation approach in recent years.

Based on reviews of literature (Patton 2011; Preskill and Beer 2012; Dickson and Saunders 2014; Lam and Shulha 2015), we determined that a synthesis of traditional formative and summative assessment could be fused with recent findings from developmental evaluation approaches to create an appropriate evaluation framework to assess the evolution of our interdisciplinary Water Diplomacy Program. We recognized that there were aspects where formative evaluation approaches were appropriate, and suggestions garnered through formative evaluation led to the improvement of a team-taught course in the Water Diplomacy curriculum. We also identified key summative moments where rendering judgment on the merits and worth of the overall funded model was justified and created a summative report as a capstone for the end of the five-year funding cycle. We also felt that to assess the evolution of the Water Diplomacy graduate program and the progress of institutionalizing the Water Diplomacy Framework into the Tufts University academic model, a different set of criteria and metrics was needed. As such, traditional evaluation that advocates for clear, specific, and measurable outcomes that are to be achieved through logical and linear processes was not appropriate. Implementing an integrative training program requires ongoing innovation and adaptation. Traditional methods required a level of up-front specificity that we felt did not work under conditions of high innovation, exploration, uncertainty, and emergence that were signatures of this traineeship. On the other hand, one does not want to overeagerly dispense with certain early commitments, such as the goals and mission of the program. From this perspective, we found that our take on the developmental evaluation framework provided the necessary ingredients: evaluative rigor and timely feedback to inform adaptive development while maintaining fidelity to the initial ideas conceived by the program. This evaluation process allows one to: (i) ask evaluative questions; (ii) apply evaluation logic; and (iii) gather and report evaluative data to support and refine the goals and objectives of the program in an adaptive way.

How did we align evaluation with our program’s pedagogical structure?

The Water Diplomacy Framework (WDF), serving as the overarching pedagogical structure, is based on a simple inquiry: who decides, who gets water,

and how? The WDF defined a set of core competencies of the trainees so that they can understand how to better define, govern, and manage water problems with conflicting needs and priorities. The trainee is expected to recognize the interconnectedness of values, interests, and tools as they relate to framing of problems and formulation of policy within a politically contentious world. Competencies include recognizing competing values and interests of the political community and interdisciplinary perspectives of the knowledge community to develop scientific and technological solutions that are contextually relevant and actionable. Given the contingent nature of problem diagnosis and policy implementation, the WDF requires a principled and pragmatic approach to negotiation for more effective resolution of complex water problems. Developmental evaluation is based on a set of attributes that can be tracked as trainees build their competencies; for example, what specifically they were doing to develop interdisciplinary competencies, why they are choosing the specific activities such as internships and research directions, and how they are demonstrating their competencies. This exploration was identified as an alternative to the more traditional methods for evaluation of interdisciplinary programs that is largely reduced to bibliometrics that quantify the number and type of intellectual outputs that are collaborative. A new approach was needed and was developed by our partners at SustainaMetrix, who applied a mixed methods approach with numbers and narratives that are interpreted through a systems lens that examines scale, gives attention to inevitable and often arbitrary boundaries, accounts for a variety of perspectives, and examines the dynamic interrelationships that occur in an interdisciplinary graduate degree program. The hope is to move away from attribution analysis and the “tyranny of metrics” toward a more holistic contribution analysis. This provided a new way to assess interdisciplinary graduate education.

What are the key attributes of our proposed evaluation and assessment model?

The external evaluation was led by SustainaMetrix, a global consulting firm based in Portland, Maine, with previous experience in evaluation of interdisciplinary graduate research. The External Evaluation Team and Tufts Water Diplomacy group discussed the challenges of evaluating interdisciplinary education programs, the limitations of available methods, and the desire for the evaluation to contribute to the ongoing development of the Water Diplomacy graduate program. The SustainaMetrix team recognized that doctoral programs already have an established suite of assessment instruments to evaluate individual student development, and these are typically administered by the advisor, examining committees of graduate faculty, or academic departments and programs. Key assessment events include qualifying exams, development of dissertation proposal, and defense of dissertation research. Furthermore, doctoral programs have relied on a traditional suite of systemwide metrics to evaluate program efficacy (Golde and Dore 2001). Far too often, quantitative

measures focus on retention/attrition rates and time to graduation. However, these traditional metrics do not speak to the heart of outcomes assessment of doctoral programs, that is, the ongoing development of a trainee and their evolution from “senior learner” to “junior colleague” to “disciplinary steward” (Walker et al. 2008). Based upon their experience with other IGERT programs, the SustainaMetrix team placed an emphasis on the core competencies of the student and the faculty in working in interdisciplinary settings with multiple perspectives. They recognized the common lenses of disciplinary bias, which complicates assessment and adaptation of curricula toward something that is useful for students and faculty from many disciplinary homes. A set of attributes on how developmental evaluation would be applied for the Tufts Water Diplomacy IGERT was developed and implemented as follows:

- **Developmental purpose:** a key goal of the evaluation was to illuminate, inform, and support the development of the Water Diplomacy Framework and training program by identifying the aspects of the training that are most effective.
- **Evaluation rigor:** by applying evaluation logic and appropriate methods, the evaluation was designed to gather, collaboratively interpret, and report data.
- **Utilization focus:** the intended use of the evaluation was to help the principle investigators (PIs) further develop an integrative framework for training graduate research in Water Diplomacy and for the external evaluation to be useful for participants.
- **Innovation niche:** Water Diplomacy was conceived as an innovative approach to define, govern, and manage intractable water problems, to influence systems change, and to provide rapid response under crisis conditions – the evaluation was envisioned to support the innovation and adaptation that was needed to shape the training program.
- **Complexity perspective:** the evaluation applied a set of complexity science concepts to make sense of the dynamic and emergent challenges of implementing the training program as part of a PhD experience.
- **Systems thinking:** both the evaluators and the PIs were deeply invested in systems thinking by considering interrelationships, multiple boundaries, and other dimensions of the interdisciplinary training program.
- **Co-creation:** the evaluators and PIs formed an interdependent and iterative process so that the results of the assessment were truly co-created.
- **Timely feedback:** the evaluators provided timely feedback during the external process to inform ongoing adaptation as needs, findings, and insights emerged rather than only at the end of the assessment period.

The remainder of this chapter will examine how this synthesis of evaluation methods was applied, how the team gathered data regarding what was unfolding and emerging, and how numbers and narratives of the program’s evolution provided insights and rationale to the students and faculty. It will also show how to better adapt and learn to make a better program during the evolution of the

program as well as what key lessons were learned that may be transferrable to other interdisciplinary settings.

Developmental purpose

An overarching objective of the traineeship was to co-develop a Water Diplomacy Framework (WDF) with the faculty and students. This was accomplished through an iterative process that began with a model initially proposed in Islam and Susskind (2013) and allowed for ongoing critique and feedback as to the effectiveness, appropriateness, and usefulness of the framework by student participants from this program and water professionals through the annual Water Diplomacy Workshop.

For example, one of the students remarked on the notion of principled pragmatism as a way to operationalize the WDF:

“I really like the definition of principled pragmatism that we have used, and really feel that this described my goals for my work well. I would refine ‘WDF explicitly recognizes interconnectedness of values, interests, and tools as they relate to framing of problems and formulation of policy within a politically contentious world’ to include a more explicit acknowledgement of societal systems, as I think we are subjects to not just our interests and tools as we approach problems but also to our embeddedness in social norms and values.”

Another student described the developmental nature of the WDF:

“Who decides who gets water, how and what for? The WDF is a way to understand and manage water problems in regions with conflicting needs and priorities around this natural resource. WDF recognizes the competing values and interests of the political community and the interdisciplinary perspectives of the knowledge community to develop scientific and technological solutions that are contextually relevant . . . Given the contingent nature of problem diagnosis and policy implementation, WDF requires a principled pragmatic approach to negotiation – for effective resolution of complex water problems – that is based on equity and sustainability as the guiding principles.”

Evaluation rigor

The program featured several examples of applying evaluation logic and appropriate methods in order to gather, collaboratively interpret, and report data. In fact, a novel method was further developed and refined that allowed the trainees to define their interdisciplinary pathway. As the program unfolded, the key evaluation question that emerged was to what degree did the Tufts Water Diplomacy IGERT contribute to equipping student participants with the training and academic experience needed to build breadth in applying the Water Diplomacy Framework and depth in their chosen discipline to become interdisciplinary scholars and leaders in this emerging field? With this question in

mind, the evaluation team proposed methods for tracking our students' development in terms of both breadth and depth. A conceptual framework was developed to define the explicit learning goals of students and track how they were related with disciplinary and interdisciplinary educational and research activities. The framework featured methods for the graduate students to define their developmental pathways to interdisciplinarity based on their aspirational goals for breadth and depth. Some of these methods are captured in the description of the "T" metaphor and exercise in the following section. The results have yielded a quantitative and qualitative measurement of a student's self-perception of his/her knowledge, interest, and development in interdisciplinary research across multiple disciplines over the duration of their graduate studies.

The "T" metaphor and exercise

A simplifying metaphor (Newell 2012) of a "T" was used as part of the external evaluation of the IGERT, which itself was used as a foundational concept to help develop different educational and research components of the Water Diplomacy Program. The T model provides a framework to articulate learning goals, define perceived current and aspirational future balance between disciplinary and interdisciplinary endeavors. The T model is also used as a quantitative and qualitative means to evaluate current and future learning goals and overall graduate program effectiveness. The T tool has considerable utility in measuring knowledge and interest in interdisciplinary research across a range of disciplines and graduate programs. Students report maturing of their learning by doing interdisciplinary scholarship and completing the program with a greater sense of their own breadth and depth dimensions of interdisciplinarity that also helped them to define their own educational path to create and navigate.

This exercise was developed by the SustainaMetrix Team in partnership with the Coastal Institute IGERT at the University of Rhode Island (August et al. 2010). The exercise involves asking the trainees to allocate 20 imaginary "blocks" on the vertical and horizontal axes of the T that represent their perception of the shape of their current T. They are also asked to reflect on their aspirations for the development of this T at the end of the IGERT experience and 5 to 10 years after attaining their doctorate. Each of the 20 blocks represents a unit of perceived interest, knowledge, and capability in disciplinary or interdisciplinary research. A T with 10 blocks vertically and 10 blocks horizontally represents an ideal balance of disciplinary and interdisciplinary interests and expertise. Tall and narrow Ts represent highly disciplinary emphasis, while short and broad Ts represent highly interdisciplinary emphasis.

This process yields a suite of simple, quantitative metrics that allow us to capture current and aspirational allocation of time and emphasis in disciplinary and multidisciplinary focus among our students. In addition, the T tool provides rich qualitative data as trainees engage in self-reflection and articulate the rationale

behind their T construct. Aspect ratio (i.e., breadth divided by depth) simplifies the metaphor of the T into a single metric (Figure 13.1). When students build a T that increases in aspect ratio (broadens) when compared with previous Ts, this demonstrates their perception of an increased ability to perform interdisciplinary research. Conversely, students whose T aspect ratios decrease demonstrate their perception that they are focusing on enhancing depth in their chosen discipline. The results are not viewed as a value judgment; rather, they serve to provide students and faculty with a clear sense of individual goals and an ability to measure progress in meeting those goals. The T metaphor provides students with a vocabulary and nomenclature to identify current learning profiles and develop career goals as well as the opportunity for regular self-reflection. It also provides a shared vocabulary to communicate with peers coming from varied academic disciplines with different sets of academic and research challenges.

Within the first few weeks of starting the program each year, every incoming graduate student is asked to describe their perceived T expertise and interest with 20 blocks to allocate among three categories: vertical (disciplinary), horizontal (interdisciplinary), and “currently unallocated.” This exercise is understood as a trade-off, as the trainees need to design and navigate between developing disciplinary depth and building interdisciplinary competencies with a focus on Water Diplomacy. An example from one trainee is presented

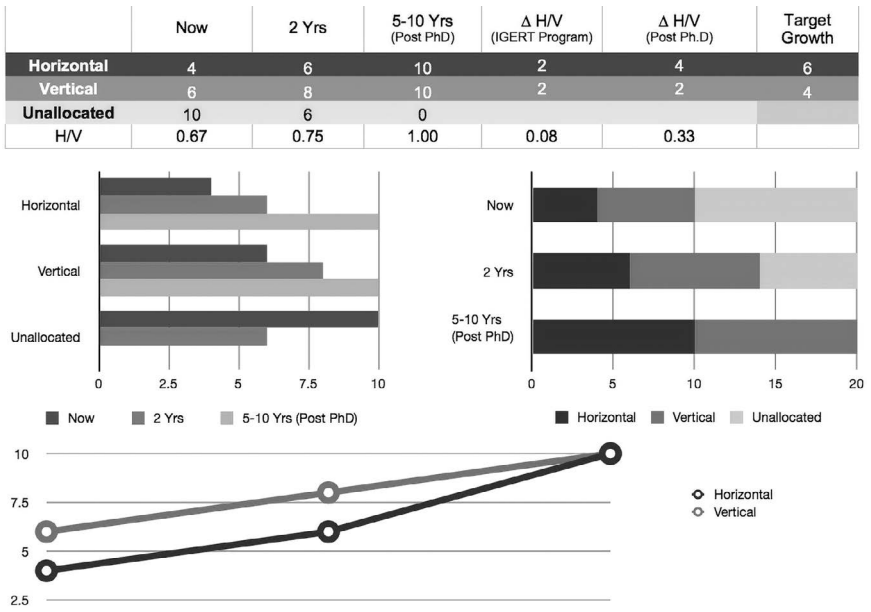


Figure 13.1 Example of a T-Competency Summary that captures a student’s progress benchmarked against their original conceptualization of their interdisciplinary journey.

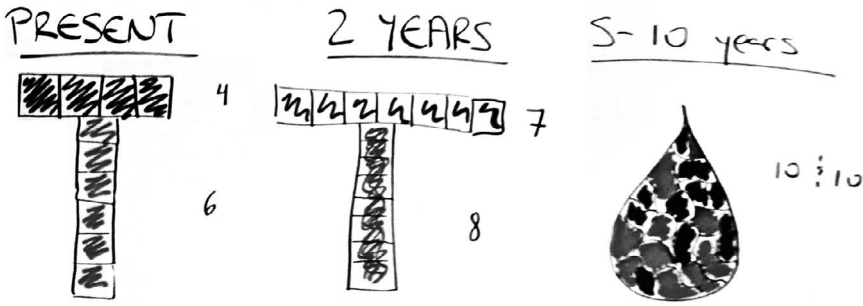


Figure 13.2 Example of a student's illustration of their interdisciplinary trajectory as conceptualized during the T exercise. An initial T with disciplinary emphasis morphs into a more balanced interdisciplinary T over time with an aspiration to become an "interdisciplinary water droplet" that brings both the breadth and depth dimension of an effective Water Diplomat.

below that illustrates trainee aspiration to become balanced between depth and breadth over time: the student started with (4, 6, 10) and had evolved into (7, 8, 5) in two years with an aspiration to become (10, 10, 0) in the future. An initial T with disciplinary emphasis has morphed into a more balanced interdisciplinary T over time with an aspiration to become an "interdisciplinary water droplet" that brings both the breadth and depth dimension of an effective Water Diplomat (Figure 13.2).

The following are comments, reflections, and insights from students regarding the T assessment exercises. These short commentaries, which include specific examples from our Water Diplomacy Program, highlight the utility of T expertise when conducting interdisciplinary scholarship:

- "I think that it was helpful to sit down and think about which fields we are really digging into in depth."
- "The answers to the questions in the T assessment were not obvious and really required me to think deeply about what strengths I have developed and what areas I want to really dig deeply into."
- "I liked the goal-setting exercise at the beginning of my time in the program. I had some goals in mind, but I think the T-assessment helped me to clarify and make them more specific and measurable . . . On one hand, it pushed me to think bigger than I otherwise would have and to be explicit about some larger dreams. At the same time, this framework took some of the pressure off by allowing me to be realistic and avoid seeing 100% of my goals as outcomes that I am absolutely expected to achieve."
- "The T-assessment process was a challenging, out-of-the-box 'exercise' that pushed me to define my professional life in a way I had not foreseen before. The vision of myself, my time, my career, in other words, my life, as a collection of 20 blocks was quite frightening at first. However, after a thinking period needed to overcome the unknown and the new, I saw the exercise as an opportunity for a reinvention."

- *“The self-reflective aspects were by far the most valuable.”*
- *“The most valuable aspect was thinking about my present knowledge (both in and outside my discipline) and how I wanted that knowledge to develop over the course of my PhD. The T-assessment provided a road map for me to identify and explore topics outside of engineering that will help me become a successful engineer that can communicate and collaborate with experts from a variety of disciplines.”*
- *“The most valuable aspect of the T-Assessment was to think through, at the beginning of my PhD, what balance of disciplinary depth and breadth I was aiming to achieve. I think this helped me be more purposeful in my selection of classes, projects and other learning opportunities.”*
- *“Once I started thinking about my depth in terms of the type of analysis and research methods I want to have expertise in, rather than specific content knowledge, it became easier to think about my T and identify the steps I would take to gain expertise in my skill-based depth. Having honed in on this depth early on was really helpful in developing my dissertation research proposal because I knew which skills I wanted to focus on in my project and that helped me narrow down my ideas.”*
- *“I have a tendency to go broad, such that I am more ‘inter’ than ‘disciplinary.’ Foremost, the T exercise was useful in stressing the importance of building in depth. Laying out specific blocks helped me be more realistic about what could be done in the span of a few years, and through a life-long career. Lastly, having a visual check-in has been helpful to revert back to and to see how well I am meeting my initial goals, and if not, more intentionally examine why and if that’s ok.”*
- *“The T assessment laid out a really realistic ‘block’ allotment, which helped discipline my big appetite. . . . The T Assessment helped create a structure within which I could imagine what areas I want to develop further.”*

Utilization focus

Adopting a utilization focus means the program is concerned with maximizing its utility to its participants. By adopting a concern for both breadth and depth, students engaged in interdisciplinary research must take care in investing their most limited resource: time. The limit of 20 blocks in the T exercise was one way we attempted to help students maximize the benefits they received in exchange for their investment of time into the program. In order to support students in coping with the competing demands of breadth and depth, we also asked them to routinely report on the core integration challenges they faced. In addition, we created other measures to help them plan, reflect, and adjust how they were investing their time. These included a set of “graduate progress markers” based on the Outcome Mapping exercise developed by the International Development Research Centre in Ottawa, Canada (Earl et al. 2001). We used these progress markers along with the following questions to guide students in this process:

- What do you EXPECT TO SEE as an outcome of your interdisciplinary Water Diplomacy training? Consider 2–3 outcomes that you see as the low-hanging fruit which would be relatively easy to accomplish.

- What would you LIKE TO SEE as an outcome of your interdisciplinary Water Diplomacy training? Consider 3–4 outcomes that may require more active learning or engagement, as well as the involvement of others but you would nevertheless like to accomplish.
- What would you LOVE TO SEE as an outcome of your interdisciplinary Water Diplomacy training? Consider 2–3 outcomes that would be truly transformative. These may be even be outcomes that are difficult to imagine but if they did happen would be evidence of profound change.

Students would track these developments in a journal and share the results with the external evaluator to discuss progress toward their interdisciplinary goals.

Finally, students were asked to identify and interview another member from the IGERT student cohort, someone with at least a year of experience in the program. Aside from a few priming questions, this conversation was left open-ended. Students found value in these focused conversations, which often clarified questions of what to expect and what has or has not worked with the program. All students were asked about how they valued these reflective exercises, and the results below show that students found use of the T metaphor and 20-block T exercise to be valuable for their interdisciplinary development (Figure 13.3). Defining the outcome challenge was also considered valuable by most, while the other exercises were considered valuable or extremely valuable.

Innovation niche

The Water Diplomacy Framework (WDF) was conceived as an innovative approach to define, govern and manage intractable water problems, to

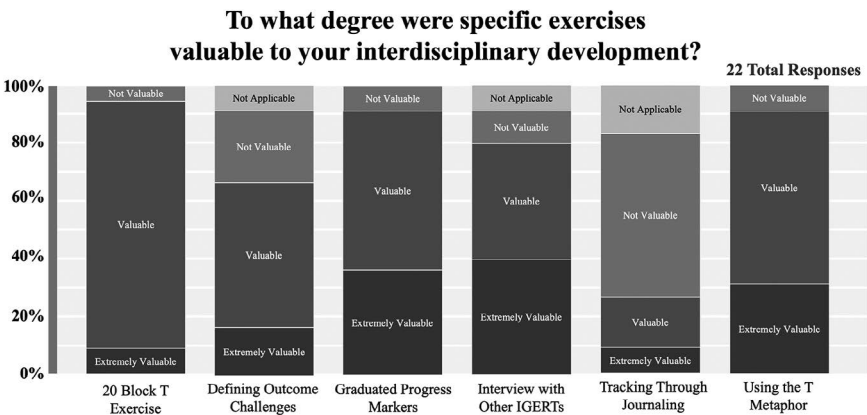


Figure 13.3 Example feedback demonstrating how students valued evaluation exercises in terms of positive impact on their interdisciplinary development.

influence systems change, and to provide rapid response under crisis conditions. It was critical that our evaluation framework would support rather than hinder the innovation and adaptation needed to shape the training program. The WDF aims to help resolve water-related conflicts. It acknowledges that traditional problem-solving frames are adequate to address simple and complicated problems where reasonable scientific certainty and consensus about intervention exists. The WDF hypothesizes the counter-productivity of these traditional frames when water challenges stem from complex – interconnected, uncertain, unpredictable, and boundary-crossing – system dynamics with feedback. A recurrent factor for such limitations is that traditional problem-solving frames often separate the observation-based technical (what is) from the value-based sociopolitical (what ought to be) dimensions of the problem. The WDF further hypothesizes that when dealing with complex problems, these dimensions cannot be de-coupled. The WDF acknowledges both the limits to knowledge – objectivity of observations and subjectivity of interpretation – and the contingent nature of our action.

The WDF proposes a principled pragmatic approach to negotiation that is based on credible scientific knowledge mediated through equity and sustainability as guiding principles for policy action. The WDF approach emphasizes that when addressing complex water problems, all parties have a legitimate right to have a voice about the evidence used and its interpretation, evaluate the future implications of an intervention, define measures of equity and sustainability, and be critical of the proposed package of actionable solutions. These parties include users and producers of water knowledge, managers, technical experts, policy makers, decision makers, and politicians. Furthermore, the WDF asserts that parties need to seek consensus and mutual benefits when negotiating a resolution. From an evaluation perspective, there is abundant evidence that this framework was innovative and has undergone adaptive enhancement over the duration of this program. At the end of the program, all program students were asked to define their degree of agreement with the WDF at the time of the survey and showed strong agreement but also some elements of disagreement, which led to further refinement of the WDF (Figure 13.4). The results are evidence of data being collected to measure consensus on the innovation.

Complexity perspective

The evaluation applied a set of ideas from complexity science to make sense of the dynamics present within a university context. These included incentives and reward structures that enabled or hindered collaboration across the disciplines as well as consideration of the unique challenges inherent in implementing the training program as part of a more disciplinary-focused PhD experience. This is illustrated in the methods used to encourage reflexivity as the trainees navigate their interdisciplinary path as well as methods that were used to identify patterns, explore and understand how the training program

Degree of Support for DRAFT Water Diplomacy Framework

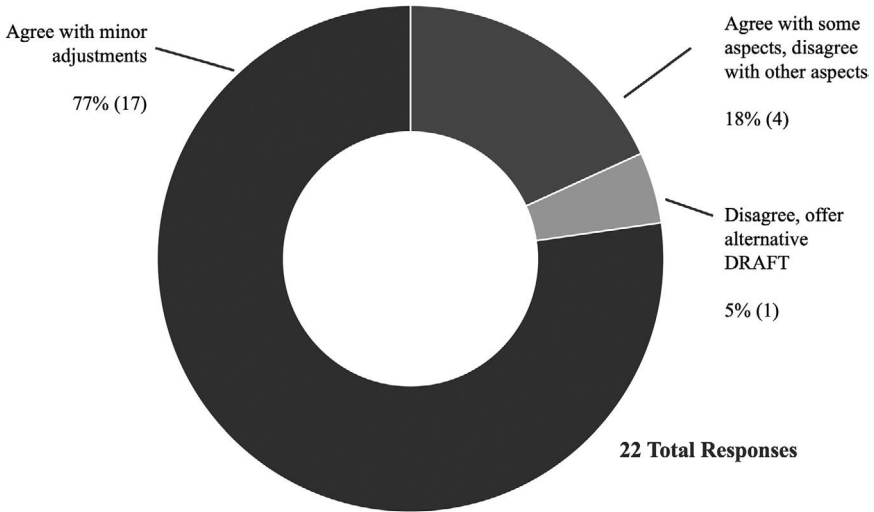


Figure 13.4 Feedback on the Water Diplomacy Framework, which co-evolved with student and faculty input since its formal introduction by Islam and Susskind (2013).

evolves, and observe how learning by doing is integrated into day-to-day activities. When evaluating our program and thinking about adaptations, we have viewed our program as a complex adaptive system. Our complexity lens colored the way we thought about adaptation and innovation within the structure of our program. It gave us a consistent framework for interpreting student feedback, contextualizing apparent shifts in collective thinking, testing changes in program structure, and accounting for exogenous and endogenous risks to program implementation.

For example, a major evaluation challenge was to explain and reaffirm the developmental purpose and appropriateness of the evaluation approach to new faculty, students, and other key stakeholders such as the provost and other senior administrative personnel. We were especially alert to changes in personnel that would require immediate relationship building to confirm the focus on a developmental perspective with a complexity mindset.

Systems thinking

Both the evaluators and the PIs were deeply invested in systems-thinking by considering interrelationships, multiple boundaries, and other dimensions of the interdisciplinary training program. This is best illustrated with the systems thinking contained within the concept of principled pragmatism that was developed through the course of the traineeship:

“Water Diplomacy is a principled pragmatic approach to negotiation that is based on credible scientific knowledge mediated through equity and sustainability as guiding principles for policy action. When addressing complex water problems, students are trained to appreciate that all parties have a legitimate right to have a voice about the evidence used and its interpretation, the past evidence and future implications of an intervention, metrics of equity and sustainability, and the package of actionable solutions. These parties include users and producers of water knowledge, managers, technical experts, policy makers, decision makers, and politicians. The training was designed to develop competencies to better engage with users and producers of water knowledge, managers, technical experts, policy makers, decision makers, and politicians. To seek consensus and mutual benefits when negotiating a resolution.”

Co-creation

Both the evaluators and PIs formed an interdependent and iterative process so that the results of the assessment were truly co-created. The following illustrates what the students valued most about the collaborative creation process:

- *“I value the quality of scholarship and collaboration across the cohort it has engendered at Tufts.”*
- *“The funding provided through this program has been incredibly valuable because it validates and provides space for the importance of developing your own interdisciplinary water approach . . . I really love the program’s focus on our work as that of ‘principled pragmatists’”*
- *“The retreats and other activities alike were very helpful to get to know fellows, professors and program managers in depth.”*
- *“The variety of students that it attracted and the collaborations that were possible because of the program.”*
- *“Involvement in the IGERT shaped the way I think about water challenges. I think three things led to that: (1) Shared office space with students from a range of departments, (2) Core IGERT courses and (3) Colloquium discussions on student presentations.*
- *“I value the introduction to ‘diplomacy’ from a non-technical perspective. I wish that we had more technical courses that had a water negotiation aspect.”*
- *“I value the exposure to interdisciplinary work, including its value and the challenges and complexities involved.”*
- *“The recognition that we are working on complex problems that exceed the capacity of traditional disciplines and techniques and that this work is messy and sometimes does not have a clear solution. The IGERT provides space for people working on these problems to share knowledge and burdens. It also lends a shield of legitimacy against people sceptical of the importance of the issues we study or our approach and stated problematics.”*

Timely feedback

Feedback was provided to the PI and to the senior faculty team on a close-to-real-time basis as the external evaluator would brief the committee while on

site to share immediate feedback that was gained in the evaluation process. While there were reports, the vast majority of information was either delivered verbally while on site or via email within 3 to 5 days of the field visit to inform ongoing adaptation as needs, findings, and insights emerged rather than only at the end of the assessment period.

The Water Diplomacy program has actively promoted adaptive learning to continuously improve how we teach, communicate, and collaborate in this interdisciplinary program. It has challenged existing thinking and practice by focusing on defining, refining, and implementing key features of the Water Diplomacy Framework in their dissertation research. We expected students from our Water Diplomacy Program to develop a broader understanding of key ideas, assumptions, and principles of the Water Diplomacy Framework through individualized curricula, the weekly colloquium, a PhD dissertation that fulfilled the discipline-specific requirement but contained a Water Diplomacy issue, joint advising on the dissertation by both a natural and societal domain faculty, and an internship experience with relevance to Water Diplomacy. Here, we highlight a few examples of learning by doing through continuous feedback from different stakeholders – students, faculty, administrators, and external advisory board of the program.

Following the 2013 External Advisory Board meeting, a set of curriculum suggestions emerged from a thoughtful and spirited interchange with Water Diplomacy (WD) students and subsequent discussion amongst the board. Several students suggested that the third course in the Water Diplomacy series of core courses (WD III: a synthesis course) could usefully be scheduled first, before WD I (natural science of water) and WDII (societal aspects of water). The students argued that WD III could provide an early synthesis of the key and distinctive ideas of the Program, motivating engagement by seeing the big picture at an earlier stage of their engagement. The board also suggested that the two domain courses, WD I (natural science) and WD II (social science), should no longer be optional for those students with skills in that domain. Engagement with both classes could facilitate greater collaborative learning and group cohesion for the cohort of Water Diplomacy students. If WD I and WD II are taught after WD III, it is likely that these classes can also move from a semiremedial status, gaining intellectual challenge and subject specificity from the prior learning of key Water Diplomacy ideas in WD III. These changes in the sequencing of WD courses were implemented from fall 2014.

The external board suggested that students be encouraged by the program to make full use of their second advisor. In addition, the board suggested that the core program faculty regularly review student contact with advisors, to ensure that faculty are actively engaged in student learning. This aspect of dual advising and follow-up was actively pursued and implemented throughout the program.

Similar to many interdisciplinary initiatives, the Water Diplomacy Program was challenged during the first few years by a lack of a shared language across

disciplines. Based on feedback from students, faculty and external advisory board, we have agreed that a shared framework is needed to identify and understand a problem and discuss methods to meet one's research goals. As a way to achieve this goal, the format of the weekly colloquium was restructured. The initial plan for the colloquium was to discuss one case study per semester in detail. In the revised structure, weekly colloquium supported both topical explorations with invited guest speakers with relevant interdisciplinary expertise and presentation opportunities for students' own evolving research. Students were invited to bring rough presentations and half-baked ideas to clarify, refine, and improve with their peers and professors at the colloquium. Many students found the colloquium experiences to be uniquely beneficial in sharpening their research agenda. It also helped develop group projects and provided a community setting for collaboration and development of a shared language over time. The revised format allowed participants to learn from each other and to actively employ and engage with concepts and methodologies from disparate disciplines. It also allowed students to apply these interdisciplinary understandings to their own problem context and effectively communicate their research questions, analysis, and findings to a broader audience.

Concluding remarks: key lessons learned

Interdisciplinary research and practice is not easy. It must be supported by a wider range of stakeholders – students, faculty, university administrators, and employers – and funding mechanisms to address real-world challenges. Despite wide-scale acceptance of interdisciplinarity as an effective mode of addressing complex problems, we need to recognize the challenges and opportunities provided by the context. The following lessons summarize some of the key learnings from our decade-long journey within the context of the Tufts Water Diplomacy Program that we suggest are transferrable to other interdisciplinary settings.

Combine tools for navigation with flexibility in milestones

The program must provide students with navigational tools (such as the 20 block T-Assessment process) to define their interdisciplinary goals and track their evolution over time. This will help them manage the expectations and requirements of an interdisciplinary program and their disciplinary home department. Paying attention to the expected level of engagement in various interdisciplinary activities by students from different disciplines is important. Specifically, program structure and procedures should be flexible to assist students who are pulled in different directions because of meeting their disciplinary requirements, expectations, and milestones. Program flexibility in terms of meeting requirements and the timing of doing so at different points in their PhD process is essential.

Create an open intellectual forum for candid interdisciplinary conversation

Attracting and recruiting students with a wide range of research interests but with an overarching programmatic framework is critical. In this case, the focus and the framework is Water Diplomacy, while the research topics covered by the students included a wide range of disciplines. Such a diversity is interesting and enlightening to students; yet we need to recognize that it also makes interdisciplinary activities difficult to coordinate and implement within and across cohorts. We have created an open intellectual forum through our weekly Water Diplomacy Colloquium. Every week, students present their research ideas and seek feedback from a diverse group of faculty and students from multiple schools and disciplines. Weekly colloquium is an effective way to operationalize this pairing of intellectual diversity and research topics with a shared framework.

Provide a shared physical space for “accidental interdisciplinary” encounters

Students unanimously agreed that the common Water Diplomacy office space created for them a unique environment for highly productive and often accidental interdisciplinary encounters that led to many new ideas, publications, and research proposals. Shared office space and informal conversations created room for the free exchange of ideas after an exciting seminar or invited talks. The formal activities (such as shared classes and the annual retreat) also helped to build a sense of belonging to an interdisciplinary Water Diplomacy community.

Make the courses relevant to the chosen framework

Ensure that required interdisciplinary classes are strong on practical applications of the chosen framework. Use the classes to emphasize the need to develop a shared vocabulary that is transferrable across disciplines and contexts. For example, the first required Water Diplomacy course draws on a number of ideas from complexity science and negotiation theory. It begins with the Water Diplomacy Framework; then it uses three key ideas from complexity science (interdependence and interconnectedness; uncertainty and feedback; emergence and adaptation) and three from negotiation theory (stakeholder identification and engagement; joint fact-finding; and value creation through option generation) to show how application of these ideas can help enhance the effectiveness of water management.

Forge strong program ties with university administrators

Since interdisciplinary conversations in academic settings often exist between departments, interdisciplinary programs need institutional support to encourage and incentivize cross-departmental collaboration from the university at the

highest level. Support in the form of teaching opportunities, post-NSF funding, and reward structures that incentivize tenure-track faculty engagement are critical in allowing the program to thrive. This dimension can ebb and flow depending on the individuals who serve as department chairs, deans, and provosts. It is essential to develop and maintain a communications strategy to keep them informed of benefits and the added value that interdisciplinary programs offer as well as national trends regarding student demand as well as job opportunities for students with cross disciplinary training.

Think early about building institutional memory

Too often, students move on after their funding ends. It is crucial to empower students who have graduated to maintain and strengthen their presence on campus and host events to familiarize other students and faculty about the opportunities and importance of interdisciplinary work. Our attempt to publish this book is an example of operationalizing the notion of building institutional memory.

Recruit and support a strong program coordinator

The role of an effective program coordinator is essential and often underrecognized. Selecting the right candidate and providing the necessary support through training and administrative power will allow the program coordinator to excel and support the complex tasks that are needed for a fully functional interdisciplinary program.

Take time for an annual retreat to bond, share stories, and adapt

At the start of each academic year, we welcomed the new cohort by hosting a weekend retreat off site for all members of the Water Diplomacy Program. This allowed the new cohort to bond as a group as well as develop relationships with faculty and existing students in an informal setting. While there was time for group recreation at the retreats, we also used the time to openly discuss what was going well and what could be improved and to set expectations for the upcoming year. Coordinating this event was a challenge, but it was well worth the investment.

Don't underestimate the importance of small gestures

If you can't afford to take your team off site for a retreat, consider ways you can utilize limited funds to improve the experience for students in small ways. While we don't have any official data on the matter, we suspect that the fact that we had food and coffee at our weekly colloquium went a long way in making the experience enjoyable, relaxed, and inviting. Other than food,

we also invested in small gifts – water bottles, T-shirts, etc. – that helped keep a sense of unity and team spirit as the program adapted and evolved.

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