

PRACTICE BRIDGE

A cross-campus professional development program strengthens graduate student leadership in environmental problem-solving

Joshua G. Smith¹ and Meredith L. McPherson²

The growing urgency of environmental concerns around the world highlights the need to equip rising scientists with high-impact leadership and communication skills in order to effectively engage in interdisciplinary problem-solving. However, opportunities for authentic interdisciplinary professional development training for student scientists are not extensively available within single-institution programs. This study evaluates the impact of the Monterey Area Research Institutions' Network for Education (MARINE), a regional cross-campus professional development program aimed at preparing graduate students for interdisciplinary leadership positions in environmental problem-solving. An online survey was conducted to evaluate students' perceptions of whether MARINE effectively enhanced leadership, improved collaborative relationships, and prepared students for interdisciplinary environmental problem-solving. Overall, MARINE participants emphasized practical skill development, exposure to careers outside of academia, and interinstitutional networking as the most valued outcomes of the cross-campus professional development program. Based on survey results and the demonstrated practices of MARINE, we recommend a set of 4 key design principles for institutions to consider when creating future cross-campus professional development programs: (1) a student-led governance framework to ensure that the program's focus is centered on topics and issues that participants find most relevant, (2) event planning committees that engage the larger pool of graduate students from across the network in authentic leadership, (3) professional development opportunities focused on interactive forms of activity, and (4) an annual colloquium for students to apply their training in leadership and interdisciplinary communication. Greater application of these practices and principles in cross-campus programs may present new opportunities for preparing rising leaders to take an active role in interdisciplinary problem-solving.

Keywords: Leadership, Capacity building, Communication, Graduate students**Introduction**

The growing urgency of environmental concerns (e.g., climate change, overfishing, pollution) around the world highlights the need for empowering rising scientists to take an active role in effective science communication, leadership, and in developing integrated approaches to creating solutions (Parrot and Meyer, 2012). As such, there is a critical need to provide scientists, especially student scientists, with high-impact tools and skills needed to enable lifelong decision making and professional and leadership development. There are now active calls for student scientist training programs to focus on communication, education, networking, multidisciplinary decision

making, and diverse student perspectives (Scheve et al., 2006; Cvitanovic et al., 2016; Dickson-Hoyle et al., 2018). These skills not only enable students to become leaders within their respective disciplines, but they also increase the breadth and scope of student preparedness for entering multiple career paths (e.g., as resource managers, science policymakers, teachers). While many academic universities and research institutions offer internal training programs for student skill development (Ingvarson et al., 2005; Baughman, 2012), opportunities for students to enhance and apply their acquired skills may be improved by leveraging the exchange of knowledge and ideas through cross-campus and interinstitutional programs (Rempel et al., 2011; Rosario et al., 2013).

In recognition of the need for preparing student scientists to bridge science and action, an emergent body of literature has focused on experiential and collaborative learning processes for students to apply acquired knowledge and leadership toward meaningful participation (Justice et al., 2007; Riemer et al., 2014; Dickson-Hoyle et al., 2018). Active, participatory, and engaged learning

¹Department of Ecology and Evolutionary Biology, University of California, Santa Cruz, CA, USA

²Department of Ocean Sciences, University of California, Santa Cruz, CA, USA

* Corresponding author:
Email: jogsmith@ucsc.edu

encourages students to think critically, reflect and discuss, consider complex issues from diverse perspectives, and transform any unsustainable values or beliefs (Burns, 2015). Models that support these processes of transformative learning are essential to both empowering and preparing students for leadership beyond the classroom (Burns, 2015; Buchanan, 2017). However, the traditional classroom environment alone often does not fully promote active participation and deep engagement in authentic, real-world leadership development (Riemer et al., 2014).

Spaces for students to share knowledge, network, and engage in experiential learning outside of the classroom include conferences, forums, and workshops (Pancer et al., 2002; El Zoghbi, 2015). These spaces provide opportunities for students to gain exposure to issues relevant across fields (e.g., scientific research, science policy, resource management, science communication, outreach) and to interact with peers and professionals. Many discussions in conference-style forums are intergenerational, which help to exchange knowledge in a way that is reflective of real-world decision-making processes (Pancer et al., 2002). However, research suggests that many students lack confidence, networking and communication skills, and the ability to effectively communicate and share ideas (Dickson-Hoyle et al., 2018). Therefore, creative and innovative models are required to address these elements of effective student skill development.

The Council for the Advancement of Standards (CAS, 2015) in Higher Education calls for student training programs that “enhance opportunities for student learning and development from higher education programs and services” by focusing on leadership, personal development, interpersonal and practical competence, and civic engagement. Growing awareness of the importance of these domains has led to innovative and creative strategies in higher education, such as the development of functional area standards, flexible credit leadership courses, self-assessment guidelines, and cross-functional frameworks (Falchikov and Boud, 1989; Patterson et al., 2013; Zafar et al., 2014). However, recent studies suggest that efforts to enhance student multi- and interdisciplinary perspectives can be improved through cross-campus collaborative learning experiences (Kinzie and Kuh, 2004; Janssen and Bacq, 2010; Rosario et al., 2013).

In this study, we build on the CAS’ call to action by designing, implementing, and evaluating the effectiveness of a cross-campus professional development program for enhancing graduate students’ lifelong interdisciplinary leadership skills and preparation for entering multiple career paths. Our study is motivated by the following overarching questions: (1) Which cross-campus program outcomes (e.g., application of leadership training, enhanced personal responsibility, improved collaborative relationships, ignited motivation) are most effective in building program participants’ knowledge and skills and supporting peer-to-peer and intergenerational networking and discussions? (2) What are the major barriers that prevent graduate students from efficient and effective knowledge exchange (e.g., among scientists, policy makers), and

how effective is a cross-campus professional development program in reducing these barriers? (3) To what extent do students feel their participation in a cross-campus training program translated into active and meaningful engagement beyond the classroom? and (4) What core capacities are required of a cross-campus training program to enhance lifelong leadership and preparation for entering multiple career paths? Further, we describe how cross-campus networking opportunities improves student self-identity, self-confidence, and leadership skill development. After evaluating and discussing these skill-building dimensions, we describe the format and outcomes of a cross-campus graduate student training program as a model system that can be widely adopted by other academic and research institutions.

Program design

The Monterey Area Research Institutions’ Network for Education (MARINE) is a cross-campus networked community of graduate students and faculty who focus on ocean-related interdisciplinary fields in science and policy. The overarching goal of MARINE is to equip graduate students with effective leadership and communication skills for interdisciplinary environmental problem-solving. This is achieved by providing students leadership and communication resources early in their careers and encouraging students to contribute to environmental decision making via quarterly short courses, workshops, focused networking events and colloquia, and high-impact speaker panels.

MARINE is a cross-campus program comprised of seven adjacent (greater Monterey Bay area, California, USA) academic higher education campuses: California State University Monterey Bay, Hopkins Marine Station (an extension of Stanford University), Middlebury Institute of International Studies, Moss Landing Marine Laboratories (an extension of San Jose State University), the U.S. Naval Postgraduate School, Stanford University, and the University of California Santa Cruz (UCSC). MARINE began in 2009 and was initially piloted by Stanford University’s Center for Ocean Solutions. In 2018, the program ownership and stewardship were transferred to the Coastal Science and Policy Program at UCSC.

The interdisciplinary structure of MARINE builds on the seven partner institutions’ unique missions, programs, and student interests. Of the 7 campus partners, 2 represent institutions with master’s-level degree programs focused on both research- and nonresearch-oriented careers (California State University Monterey Bay and San Jose State University); 4 of the 7 campus partners represent institutions with doctoral-level programs heavily focused on research spanning ecology, evolution, marine and ocean sciences, and environmental policy and law (Stanford University, Stanford University Hopkins Marine Station, University of California Santa Cruz, and Naval Postgraduate School); and one campus partner represents an institution focused on language, culture, and international social–environmental justice (Middlebury Institute of International Studies). The cross-campus framework of MARINE leverages the seven unique programs and strengths of these institutions to equip early career and

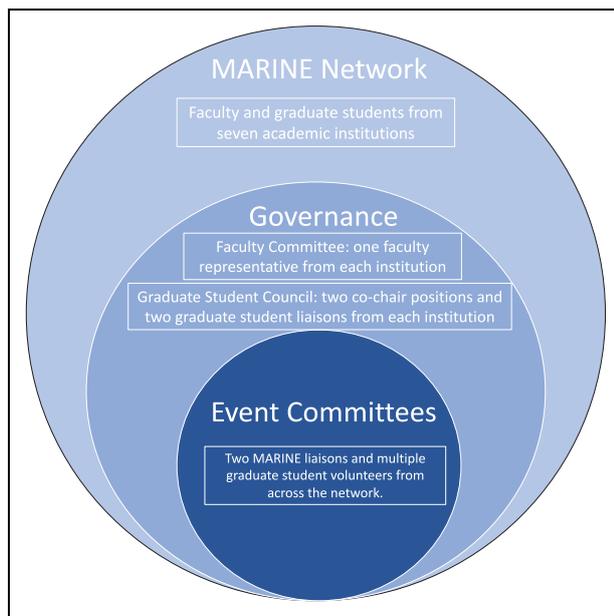


Figure 1. Nested structure of MARINE. The MARINE network (outer circle) is comprised of faculty and graduate students from across seven academic institutions. MARINE is governed by a graduate student council comprised of liaisons from each institution and a committee of faculty members oversees operations (middle circle). Liaisons assemble single-event planning committees that draw graduate student volunteers from the cross-campus network (inner circle). DOI: <https://doi.org/10.1525/elementa.085.f1>

upcoming professionals with interdisciplinary skills to be leaders, effective communicators and collaborators, and to enhance student preparedness for entering multiple career paths.

The MARINE program and all associated events are planned and facilitated entirely by graduate students from across the campus network. A graduate student council (GSC) comprised of two cochair positions and two liaisons from each of the 7 partner campuses serves as the overarching steering committee and is advised by a faculty representative from each institution (**Figure 1**). Liaisons are volunteer 2-year leadership positions. Liaisons are responsible for disseminating important MARINE information throughout their respective campus communities, recruiting graduate student volunteers for event planning committees, attending all GSC meetings, and leading at least one event planning committee per academic year. Quarterly MARINE events are planned and organized by event planning committees. These committees are comprised of two MARINE liaisons who lead the committee and multiple graduate student volunteers recruited from across the 7 partner campuses.

MARINE's professional development activities are centered on five themes for enhancing student preparation for engaging in science policy processes: (1) provide multicampus graduate professional learning opportunities related to ocean leadership; (2) reflect current interdisciplinary thinking and practice in science and policy,

highlighting concepts or processes that are transferable to other environmental problem-solving contexts; (3) contribute to building and reinforcing interinstitutional collaboration; (4) extend the existing expertise within the institutions by incorporating multiple perspectives and creating interdisciplinary opportunities; and (5) integrate professional development activities that enhance students' leadership skills, focusing on communication, such as listening, negotiation, or tailoring messages; innovation, such as thinking creatively about solutions; and collaboration, such as teamwork, conflict resolution, or forging partnerships.

Evaluation and assessment

An online survey was conducted to evaluate graduate students' perceptions of MARINE as a cross-campus professional development program for enhancing leadership skills in environmental problem-solving and preparation for entering multiple career paths. The survey was designed to assess student perceptions across 10 key domains: intercampus networking, facilitation, critical thinking, diverse perspectives, self-identity, preparedness for engagement, community, science and policy training, environmental problem-solving, and participation translated into action. The survey was distributed through the MARINE network to a total of 45 active graduate students and alumni (at the time of the survey, based on annual attendance data during the 2018–2019 study period). A total of 26 graduate students and 8 alumni responded to the online survey ($N = 34$). All of the survey respondents reported that they had participated in at least one MARINE event. A majority of participants ($n = 18$, 54%) reported that they had led small group discussions and designed, organized, or planned events. Most of the survey participants ($n = 21$, 70%) had never served as a MARINE liaison, but nearly half ($n = 14$, 42%) reported that they had participated in an event planning committee (**Figure 2**).

Thematic analyses of open-ended questions were conducted to evaluate students' perceptions of program outcomes surrounding interdisciplinary knowledge exchange, skill building, and networking. To ensure themes were relevant and valid, data were coded a priori, and emergent themes continually checked against the data from which they were derived. Data on both theme frequency and the number of individual respondents to raise a theme were collected (to distinguish artifacts of speech vs. the number of respondents who raised a theme). The survey coding produced 13 themes that mapped to 2 thematic objectives (**Table 1**). A total of 23 respondents identified cross-campus networking with both students and leaders across relevant fields as a highly valued program outcome (**Table 1-e**). One respondent stated, "I have met students from other institutions and have built a network outside my home institution through MARINE" (ID6). Others identified how the cross-campus framework provided exposure to career paths outside of academia (**Table 1-f**; $N = 11$), facilitated interdisciplinary discussions (**Table 1-i**; $N = 9$), engaged students in science policy training (**Table 1-h**; $N = 7$), and diversified student perspectives (**Table 1-j**;

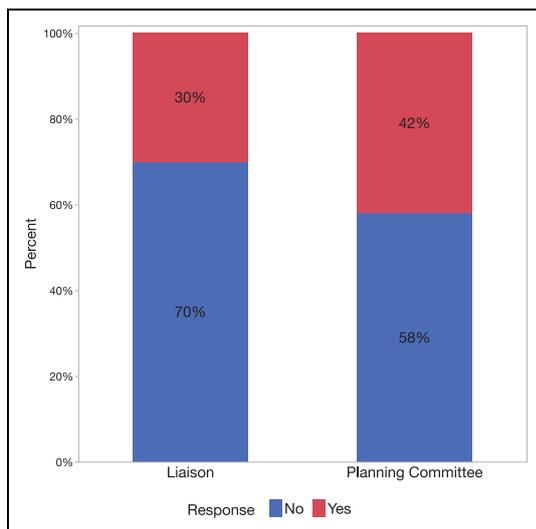


Figure 2. Proportion of MARINE members who filled a leadership-level position. Each bar represents a leadership role (liaison, planning committee), and each color identifies a “no” (blue) or “yes” (red) response. Percentages indicate the proportion of respondents within each category. DOI: <https://doi.org/10.1525/elementa.085.f2>

$N = 4$): “MARINE events exposed me to a lot of local professionals and enabled me to network with people outside of my field” (ID16).

Several respondents raised four themes related to within-institution barriers that inhibit graduate students from effective knowledge exchange and interdisciplinary engagement (Table 1: j–m). Of these, survey participants spoke most frequently about institutional barriers and the extent of support provided by faculty advisors (Table 1-a): “... institutional programs typically focus on science or policy, not both. Without a cross-campus program, students must find their own way to bridge this gap” (ID17). In particular, students identified support from faculty advisors as a major source of successful interdisciplinary engagement: “a lot of faculty are against [activities] that take students away from their immediate research” (ID5). This was affirmed by another respondent who said, “... academic instructors teach what they know (i.e., how to be a research scientist) and often do not support the independent interests of their students” (ID30). Respondents also spoke about economic barriers as graduate students, financial hardships, mental health, and time.

In order to evaluate the extent to which student participation in a cross-campus professional development program translated into active and meaningful participation, students were asked to respond to a series of questions on a 5-point agree–disagree Likert-type scale (Figure 3). Results indicated that respondents felt strongly that MARINE increased their ability to develop practical solutions ($M = 3.96$, $SE = 0.13$), and to disseminate results from their own research across fields to broad audiences ($M = 3.8$, $SE = 0.18$). Knowledge and skill domains surrounding communication, problem-solving, and

critical thinking were also received well by participants. In general, participants felt that MARINE had increased their confidence in communicating original research ($M = 3.8$, $SE = 0.14$). In the problem-solving and critical thinking domains, participants reported increased skill development in active listening ($M = 3.8$, $SE = 0.14$) and analyzing evidence ($M = 3.4$, $SE = 0.16$).

A core focus of MARINE is to design events that immerse students in activities that mirror real-world decision-making processes such as the application of research to solving problems, development of solutions, and the dissemination of knowledge to broad audiences. Respondents indicated the most valued events were those that focused on science communication ($M = 4.78$, $SE = 0.07$) and careers outside of academia ($M = 4.78$, $SE = 0.08$). Other highly valued events included workshops ($M = 4.37$, $SE = 0.14$), short courses ($M = 4.12$, $SE = 0.17$), and seminars ($M = 4.28$, $SE = 0.13$). MARINE also hosts an annual colloquium at the end of each academic year where students and professionals share ideas, learn new skills, and network across the science, policy, and management spaces. The colloquium typically features a keynote speaker, student talks, and interactive sessions that focus on science communication, training, and leadership. Respondents highly rated this annual event ($M = 4.28$, $SE = 0.17$) as a space to apply their leadership and communication training, and to interact with professionals.

Overall, MARINE participants emphasized practical skill development, exposure to careers outside academia, and interinstitutional networking as the most valued outcomes of a cross-campus professional development program. Participants stated that MARINE workshops increased their skill development and preparedness to be interdisciplinary leaders. “MARINE workshops provided me a better understanding of how policy works and the relationship between scientific research and policy” (ID14). Other students said that MARINE “... brings together a diverse group of people” (ID31), “I gained perspectives from people with different backgrounds about the importance of science policy” (ID14). Many students joined MARINE because they wanted to explore opportunities beyond academic careers: “MARINE opened many opportunities for me beyond academia” (ID6), “I originally joined MARINE to gain exposure to active research at other campuses, but I’ve come to appreciate the ability to network with people outside of traditional academic careers” (ID28).

Discussion

This study is among the first to design, implement, evaluate, and demonstrate the effectiveness of a cross-campus professional development program for enhancing graduate students’ interdisciplinary leadership in environmental problem-solving. Student perceptions of the program indicate that MARINE enhances opportunities for interdisciplinary graduate student professional development through (1) a student-driven governance framework designed to target student needs and interests; (2) event planning committees that engage graduate students from across the network in interdisciplinary leadership; (3)

Table 1. Analysis hierarchy of emergent themes derived from survey results with MARINE program participants mapped to two central research objectives. DOI: <https://doi.org/10.1525/elementa.085.t1>

Research Objective	Theme	Frequency	No. of
			Participants
Outcomes of MARINE as a cross-campus professional development program	a. Interinstitution networking	34	23
	b. Exposure to career paths outside of academia	17	11
	c. Interdisciplinary discussions and events	9	9
	d. Interacting with policy makers and professionals	13	8
	e. Training on how research informs policy	10	7
	f. Multiple perspectives	5	4
	g. Staying connected to relevant and emerging science and policy	4	3
	h. Short courses	3	3
	i. Engaging local communities	2	2
Perceived barriers to graduate student success	j. Lack of support from faculty advisor and institutional barriers to engage beyond immediate research	9	8
	k. Time constraints	6	5
	l. Financial constraints	4	4
	m. Societal views of science	4	3

Frequency is the number of times a theme was coded across all survey responses, while the number of participants represents the number of respondents who indicated the theme (total respondents = 34).

panels, discussions, and interactive-style events that foster communication and expand professional networks; and (4) an annual cross-campus colloquium where students apply their leadership training and engage in knowledge exchange through formal and informal activities.

Creating solutions to the world's greatest environmental issues requires training students for interdisciplinary leadership and problem-solving, but such training is not extensively available within single-institution programs (Baldwin and Baldwin, 2007; Morse et al., 2007; Beddoes and Borrego, 2014). MARINE imparts broader societal benefits by training students for communicating scientific information beyond the traditional academic setting to foster greater public access and trust in the environmental sciences (Kuehne et al., 2014); direct engagement with international, national, and local governments to meet common goals (e.g., the United Nations Sustainable Development Goals for "Climate Action" and "Life Below Water"; Dickson-Hoyle et al., 2018); and preparing the next generation of scientists, policy makers, and resource managers to create innovative and adaptive solutions to growing environmental concerns (Manolis et al., 2008). While most academic institutions focus on training graduate students in disciplinary expertise, students typically do not receive the skills required to meaningfully engage, navigate, and lead in multifaceted interdisciplinary problem-solving (Kainer et al., 2006; Manolis et al., 2008; Beddoes and Borrego, 2014). Our findings add to a growing body of literature surrounding the need to train graduate students to bridge science and action by revealing that a cross-campus graduate student professional development program enhances skills essential for

multiple career paths in interdisciplinary environmental problem-solving.

Participants in MARINE found the cross-campus program to be a positive learning experience that provided essential professional development training that they otherwise would have not received at their home institution alone. Because within-institution graduate programs generally focus on disciplinary training, it is often difficult for students to engage in professional development outside of their immediate research activities (Baldwin and Baldwin, 2007; Morse et al., 2007). The quarterly event structure of MARINE provided a space for students to build professional development without distracting from their disciplinary training. Additionally, cross-campus activities enhanced students' professional networks and increased access to a broad scope of careers outside of academia while supporting students' academic development and study interests.

Over the course of MARINE's 10-year history, the program's administrative structure evolved from a top-down, nonstudent-led organization to what is now a fully student-driven, bottom-up design. Several studies have demonstrated that leadership and hierarchical organizational structures are directly linked to the effectiveness of knowledge exchange (Dietz et al., 2004; Manolis et al., 2009; Cvitanovic et al., 2016). Therefore, MARINE's shift toward a bottom-up, student-driven facilitation presents several advantages over a faculty-led, top-down design. For example, MARINE liaisons must communicate and represent the interests of the larger graduate student populace from their respective home institutions. Strong professional and collaborative relationships are also developed across a range of disciplines. Furthermore, reciprocal



Figure 3. Results from survey participants in MARINE ($n = 34$) across 10 knowledge and skill domains. Data are presented as the mean response for each question with standard error bars on a Likert-type scale of 1–5 (1 = dissatisfaction, 5 = complete satisfaction) and listed in descending order within each domain. DOI: <https://doi.org/10.1525/elementa.085.f3>

exchange of knowledge and ideas between MARINE members (i.e., graduate students) and liaisons facilitates transformational leadership (Buchanan, 2017).

MARINE’s framework emphasizes the core elements of adaptive leadership, which include combining strengths of multiple leaders, extending influence through networks of relationships, nurturing productive conflict, and cultivating diversity (Heifetz, 1994). Through the active involvement in event development, planning, and hosting, MARINE

liaisons and committee planning volunteers actively build relevant leadership skills necessary to serve as leaders both within and beyond their immediate disciplines. Importantly, event planning committees engage the broader pool of graduate students from each partner campus, without the extended 2-year leadership commitment required of a liaison. This multifaceted governing approach infuses multiple levels of leadership opportunities for graduate students across the entire network.

Table 2. Recommended design principles for successful cross-campus professional development training. DOI: <https://doi.org/10.1525/elementa.085.t2>

Principle	Outcomes	Facilitation
Student-driven governance framework	<ol style="list-style-type: none"> 1. Application of leadership training 2. Development of strong collaborative relationships 3. Infrastructure focused on student experiences 	<ol style="list-style-type: none"> 1. Student-driven steering committee that manages organization, approves changes to internal policy, and votes on elected positions 2. Student representatives from each campus or partner institution
Event planning committees	<ol style="list-style-type: none"> 1. Distributed leadership opportunities for students across the network 2. Strategic event focus and design 3. Enhanced personal responsibility 4. Dedicated skills and confidence-building opportunities 	<ol style="list-style-type: none"> 1. Student committees responsible for event facilitation and design. 2. Planning committees comprised of interinstitutional teams that plan and organize each event 3. Student volunteers lead discussions, introduce speakers, and moderate panels
Panels, discussions, and interactive events	<ol style="list-style-type: none"> 1. Enhanced networking 2. Knowledge exchange 3. Diverse views that promote shared learning and decision making 4. Practical communication. 5. Increased problem-solving 	<ol style="list-style-type: none"> 1. Nontraditional events that focus on developing skills in a way that mirrors real-world science and action 2. Integration of high-impact speakers and participants (e.g., policy makers, scientists, NGO leaders)
Annual colloquium	<ol style="list-style-type: none"> 1. Disseminated knowledge between students, scientists, policy makers, and NGOs 2. Practiced communication, knowledge exchange, and student engagement 3. Ignited motivation, increased learning, and shared ideas 	<ol style="list-style-type: none"> 1. Student members share formal and informal presentations, participate in discussions, and learn about current research and environmental action 2. Guest speakers, breakout sessions, group engagements, and social interactions

MARINE accomplishes practical skill development and interdisciplinary environmental problem-solving by hosting a wide range of events that enhance communication and engagement, facilitate networking, disseminate information, and emphasize leadership development. Graduate students highly valued these MARINE events because of the exposure to careers outside of academia and the ability to hone science communication skills. Although quarterly events often target a single skill development over a 2-h event, MARINE's annual themed colloquium is a day-long event where graduate students specifically practice communication skills through formal and informal presentations (geared to science, policy, management, and interdisciplinary themes), participate in workshops, and engage in intergenerational networking with panelists and keynote speakers who are often key figures in the regional and state science policy sphere. The colloquium is a MARINE tradition, beginning in 2009, and serves as

a platform for students to apply skills gained from smaller quarterly MARINE events.

A synergistic grant can be useful to further build capacity for cross-campus interdisciplinary collaboration that results in action. In 2018, MARINE faculty representatives from the Coastal Science and Policy Program at the University of California, Santa Cruz, launched an annual synergistic grant for MARINE members. The grant requires student groups to propose novel projects that foster interdisciplinary and institutional collaboration across campuses with broader policy, community, or societal outcomes in ocean- and/or coastal related issues. The MARINE synergistic grant directly cultivates cross-campus relationships by requiring each project to include students from 3 different programs across the MARINE network and to obtain matching funds from outside of MARINE (from any source, including campus, departmental, governmental, or private). In doing so, students

conduct innovative projects that embody the goals of MARINE by bridging science and action.

Based on survey results and the existing structure of MARINE, we recommend institutions building a cross-campus graduate student professional development program adopt a set of 4 key design principles (**Table 2**). First, a student-led governance framework ensures that the program's focus is centered on topics and issues that participants find most relevant. This principle creates an infrastructure focused on student experiences and provides a space for graduate students to apply their interdisciplinary leadership training toward program facilitation (Baran and Correia, 2009). Second, cross-campus professional development programs should organize event planning committees that draw from the larger pool of graduate students from across the network. Rotating event planning committees engage students who are not directly part of the program's graduate student steering team in authentic leadership (Pedersen et al., 2012). Third, professional development opportunities should avoid traditional seminar-style lectures and instead focus on interactive forms of activity. Examples of interactive activities include high-impact panels, small group discussions, and workshops with policy makers, scientists from NGOs and other private organizations, artists, researchers, conservation scientists, communication experts, and others. Interactive events expand professional networks, promote knowledge exchange, and engage students in interdisciplinary communication (Morse et al., 2007; Newing, 2010). Finally, cross-campus programs should host an annual colloquium for students to apply their training in leadership, interdisciplinary communication, and problem-solving. Colloquium sessions structured around breakout groups, discussions, and formal and informal presentations can ignite student motivation, demystify the process of knowledge exchange (e.g., between scientists, resource managers, policy makers), and facilitate shared ideas toward problem-solving (Dickson-Hoyle et al., 2018).

This study highlights that a cross-campus graduate student professional development program prepares rising leaders for interdisciplinary, real-world problem-solving by leveraging the unique missions and program types of multiple institutions. The structure, practices, and principles presented here provide a framework for other institutions to consider when designing future cross-campus professional development programs. Greater application of cross-campus programs across disciplines may therefore present new opportunities for preparing rising leaders to take an active role in interdisciplinary problem-solving.

Acknowledgments

We thank the two anonymous reviewers who provided detailed comments on a previous version of this article. We thank all participants who took part in the survey presented in this study. The survey was undertaken with approval from the University of California, Santa Cruz, Internal Review Board (HS3397). JGS was supported by a National Science Foundation Graduate Research Fellowship. We extend special thanks to L. Good, A. Heidt, and Stanford's Center for Ocean Solutions for piloting

MARINE. We are grateful to all of the MARINE faculty representatives, members of the student governance council, and the Coastal Science and Policy Program at UCSC for their ongoing support. Thank you to S. Eminhizer and A. Kapuscinski (UCSC Coastal Science and Policy Program) for guidance, leadership, and insightful discussions that improved the manuscript.

Competing interests

The authors do not have any conflicts of interest.

Author contributions

Both authors contributed extensively to the work presented in this article. JGS and MLM designed the study and survey, and prepared the manuscript; JGS conceived the study, conducted the qualitative analyses and thematic coding, and prepared the figures; MLM distributed the survey, collected data, provided conceptual advice, and prepared the tables. Both authors have agreed to be listed and approved the submitted version of the manuscript.

References

- Baldwin, Jr, DC, Baldwin, MA.** 2007. Interdisciplinary education and health team training: A model for learning and service. *J Interprof Care* **21**(Suppl. 1): 52–69.
- Baran, E, Correia, AP.** 2009. Student-led facilitation strategies in online discussions. *Distance Educ* **30**(3): 339–361.
- Baughman, J.** 2012. Student professional development: Competency-based learning and assessment in an undergraduate industrial technology course [Graduate theses and dissertations]. 12592. DOI: <https://doi.org/10.31274/etd-180810-2498>.
- Beddoes, K, Borrego, M.** 2014. Facilitating formation of shared mental models in interdisciplinary graduate student teams. *Int J Collab Eng* **1**(3–4): 236–255.
- Buchanan, JL.** 2017. Leadership development and experimental methodology: The impact on learning leadership. *Int J Arts Sci* **10**(2): 601–608.
- Burns, HL.** 2015. Transformative sustainability pedagogy: Learning from ecological systems and indigenous wisdom. *J Transform Educ* **13**(3): 259–276.
- Council for the Advancement of Standards in Higher Education.** 2015. CAS learning and development outcomes, in Wells, JB ed., *CAS professional standards for higher education*. 9th ed. Washington, DC.
- Cvitanovic, C, McDonald, J, Hobday, AJ.** 2016. From science to action: Principles for undertaking environmental research that enables knowledge exchange and evidence-based decision-making. *J Environ Manage* **183**: 864–874.
- Dickson-Hoyle, S, Kovacevic, M, Cherbonnier, M, Nicholas, K.** 2018. Towards meaningful youth participation in science-policy processes: A case study of the youth in landscapes initiative. *Elem Sci Anth* **6**(1): 67.
- Dietz, JM, Aviram, R, Bickford, S, Douthwaite, K, Goodstine, A, Izursa, JL, Kavanaugh, S, MacCarthy, K, O'Herron, M, Parker, K.** 2004. Defining

- leadership in conservation: A view from the top. *Conserv Biol* **18**(1): 274–278.
- El Zoghbi, M.** 2015. Conferences as learning spaces on climate change and sustainability: Insights from university students' experiences, in Wilson, S, Stevenson, C eds., *Promoting climate change awareness through environmental education*. Hershey, PA: IGI Global: 37–59.
- Falchikov, N, Boud, D.** 1989. Student self-assessment in higher education: A meta-analysis. *Rev Educ Res* **59**(4): 395–430.
- Heifetz, RA.** 1994. *Leadership without easy answers*. Cambridge, MA: Belknap Press.
- Ingvarson, L, Meiers, M, Beavis, A.** 2005. Factors affecting the impact of professional development programs on teachers' knowledge, practice, student outcomes & efficacy. *Educ Policy Anal Arch* **13**. DOI: <http://doi.org/10.14507/epaa.v13n10.2005>.
- Janssen, F, Bacq, S.** 2010. Cultural and outcomes-related issues in implementing an interdisciplinary cross-campus entrepreneurship education program. *J Small Bus Entrep* **23**(Suppl. 1): 733–746.
- Justice, C, Rice, J, Warry, W, Inglis, S, Miller, S, Sammon, S.** 2007. Inquiry in higher education: Reflections and directions on course design and teaching methods. *Innov High Educ* **32**: 201–214. DOI: <http://doi.org/10.1007/s10755-006-9021-9>.
- Kainer, KA, Schmink, M, Covert, H, Stepp, JR, Bruna, EM, Dain, JL, Espinosa, S, Humphries, S.** 2006. A graduate education framework for tropical conservation and development. *Conserv Biol* **20**(1): 3–13.
- Kinzie, J, Kuh, GD.** 2004. Going DEEP: Learning from campuses that share responsibility for student success. *About Campus* **9**(5): 2–8.
- Kuehne, LM, Twardochleb, LA, Fritschie, KJ, Mims, MC, Lawrence, DJ, Gibson, PP, Stewart-koster, BEN, Olden, JD.** 2014. Practical science communication strategies for graduate students. *Conserv Biol* **28**(5): 1225–1235.
- Manolis, JC, Chan, KM, Finkelstein, ME, Stephens, S, Nelson, CR, Grant, JB, Dombeck, MP.** 2009. Leadership: A new frontier in conservation science. *Conserv Biol* **23**(4): 879–886.
- Manolis, JIMC, Chan, KAIM, Finkelstein, ME, Stephens, S, Nelson, CR, Grant, JB, Dombeck, MP.** 2008. Leadership: A new frontier in conservation science. *Conserv Biol* **23**(4): 879–886.
- Morse, WC, Nielsen-Pincus, M, Force, JE, Wulfhorst, JD.** 2007. Bridges and barriers to developing and conducting interdisciplinary graduate-student team research. *Ecol Soc* **12**(2): 8.
- Newing, H.** 2010. Interdisciplinary training in environmental conservation: Definitions, progress and future directions. *Environ Conserv* **37**(4): 410–418.
- Pancer, SM, Rose-Krasnor, L, Loiselle, LD.** 2002. Youth conferences as a context for engagement. *New Dir Youth Dev* **2002**(96): 47–64.
- Parrott, L, Meyer, WS.** 2012. Future landscapes: Managing within complexity. *Front Ecol Environ* **10**(7): 382–389.
- Patterson, BJ, Garza, OW, Witry, MJ, Chang, EH, Letendre, DE, Trewet, CB.** 2013. A leadership elective course developed and taught by graduate students. *Am J Pharm Educ* **77**(10). DOI: <https://doi.org/10.5688/ajpe7710223>.
- Pedersen, J, Yager, S, Yager, R.** 2012. Student leadership distribution: Effects of a student-led leadership program on school climate and community. *Int J Educ Lead Prep* **7**(2).
- Rempel, HG, Hussong-Christian, U, Mellinger, M.** 2011. Graduate student space and service needs: A recommendation for a cross-campus solution. *J Acad Librariansh* **37**(6): 480–487.
- Riemer, M, Lynes, J, Hickman, G.** 2014. A model for developing and assessing youth-based environmental engagement programmes. *Environ Educ Res* **20**(4): 552–574.
- Rosario, L, Flemister, E, Gampert, R, Grindley, CJ.** 2013. Cross-campus collaboration and experiential learning at Hostos Community College. *Peer Rev* **15**(1): 25.
- Scheve, JA, Perkins, DF, Mincemoyer, C.** 2006. Collaborative teams for youth engagement. *J Community Pract* **14**(1/2): 219–234. DOI: https://doi.org/10.1300/J125v14n01_13.
- Zafar, S, Manjurekar, B, Kumar, NP, Khan, ZA.** 2014. Effects of FFCS (fully flexible credit system) on learning experience and academic performance. *Procedia Soc Behav Sci* **143**: 4–7.

How to cite this article: Smith, JG, McPherson, ML. 2020. A cross-campus professional development program strengthens graduate student leadership in environmental problem-solving. *Elem Sci Anth*. 8: xx. DOI: <https://doi.org/10.1525/elementa.085>.

Domain Editor-in-Chief: Alastair Iles, University of California Berkeley, CA, USA

Knowledge Domain: Sustainability Transitions

Published: 00, 0000 **Accepted:** September 22, 2020 **Submitted:** December 18, 2019

Copyright: © 2020 The Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC-BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited. See <http://creativecommons.org/licenses/by/4.0/>.



Elem Sci Anth is a peer-reviewed open access journal published by University of California Press.

OPEN ACCESS The Open Access icon, which is a stylized padlock with a circular arrow around it, indicating that the content is freely available.