UCSD Undergraduate Climate Education

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Executive Summary

Climate change, climate disruption, global warming -- the beast known under many guises. Whichever terminology you use, the reality is clear. It is scientific consensus that our climate is undergoing shifts that are induced by anthropogenic greenhouse gases (Allain 2017). According to the 2018 Intergovernmental Panel on Climate Change (IPCC) Report, "global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate." This scenario sets us on the path for up to 2°C above pre industrial global temperature by 2050 (IPCC 2018). To return to 1.5°C or under by the end of the century, two things must happen: Global CO_2 emissions must reach net zero by 2040 or sooner while warming from other sources of radiative forcing (aerosols, methane, nitrous oxide, and other anthropogenic forces) must be reduced by 2030 (IPCC 2018). This newest report emphasizes the significant difference in impact between 1.5°C and 2°C in terms of sea level rise, heat extremes, heavy and intense precipitation in some areas and extreme drought in others. The same is projected for threats to biodiversity related to species extinction; ocean acidification; threats to human health, water supply, and food security; and adaptation needs and ability (IPCC 2018).

It is evident that contributions to climate disruption are multi-faceted and thus solutions require a range of approaches. Climate solutions exist in various fields and most often rely on interdisciplinary cooperation and coordination to most effectively tackle this global problem. As set forth by the "Bending the Curve" report, a comprehensive plan of 10 scalable solutions for carbon neutrality and climate stability developed by over 50 scholars and researchers across the University of California (UC) system, solutions fall into the following six clusters: 1) science solutions; 2) societal transformations; 3) governance solutions; 4) market- and regulation-based solutions; 5) technology-based solutions; and 6) natural and managed ecosystem solutions (Ramanathan et. al 2015). Undergraduate education holds the potential for pivotal action on climate disruption and influence, directly or indirectly, all six clusters.

Existing Efforts on Climate Education at UCSD

There are already some efforts to address the responsibilities and opportunities of UCSD (University of San Diego) and the wider UC system in the realm of climate education. In 2015,

the UC Office of the President (UCOP) provided funding for all ten universities to conduct pilot programs aimed at incorporating climate change education throughout their respective curricula. UCSD directed this effort toward a workshop program in 2016 in which two dozen faculty integrated climate change education into existing courses. UCSD independently conducted another even smaller scale but more comprehensive faculty workshop program in 2018, and recently added a climate change studies minor under the Scripps Institute of Oceanography (SIO). This provides an opportunity for undergraduate students to receive credit and recognition for learning more extensively about climate change throughout their undergraduate education. The diverse course selections under the minor also illustrate the increasing number of climate and sustainability related courses offered at UCSD. "Bending the Curve" is an excellent example of an interdisciplinary course offering that sets the UC system apart from other universities in the realm of climate education.

In the 2016 UC Annual Report on Sustainable Practices, UC President Janet Napolitano remarked that "[at] UC we combine education, research, operational sustainability, cutting-edge entrepreneurship, and public service in a way that uniquely positions us to help take on both the local and global challenges of climate change" (UCOP Sustainability Report 2016). The efforts already underway demonstrate that, on the front of education, this is not just rhetoric. It is important to highlight, however, that the UC has been far more aggressive on some of the other fronts Napolitano mentions. For example, in late 2013, Napolitano introduced the Carbon Neutrality Initiative, which aims for net zero greenhouse gas emissions from UC buildings and its vehicle fleet by 2025. To achieve this goal, UCSD has taken a multifaceted approach that includes building a microgrid, nearly doubling the campus' thermal energy storage capacity, and converting the campus fleet to majority alternative fuel vehicles. UCSD puts forth a detailed, updated climate action plan annually. The boldness of these goals and the potency of the associated actions reflect the urgency and seriousness of climate disruption. The same degree of purpose, ambition, and energy has not been channeled toward utilizing UCSD's position as a large *educational* institution to combat climate. Consequently, the current UC and UCSD specific endeavors to further climate change education must be built upon and reimagined.

Research Strategy

A SWOT analysis was performed to discover areas for improvement and solutions not yet utilized. Each of the six clusters were considered in our analysis. UCSD already possesses many strengths that we can build off of to more thoroughly integrate climate education within the undergraduate curriculum. As noted above, UCSD already offers a climate change studies minor with course options from a number of disciplines. The diversity of these offerings are a definitive strength of the existing UCSD undergraduate curriculum, and they reflect the strategic importance of teaching students the connection each cluster has to the overall problem of climate change. The many talented and devoted faculty teaching these courses and engaging in their own research are another strength that UCSD has to offer.

However, there are also many areas in need of improvement. Among the weaknesses we identified, the main concern is that these climate education courses do not reach the majority of the student body. Additionally, the classes often do not fulfill major or general education (GE) requirements, which can disincentivize students taking them. Many faculty members involved in climate research are disengaged from one another -- a common problem at a large institution where departments may be siloed off. Other opportunities that UCSD could potentially take advantage of include the body of knowledge available from attempts other schools have made in integrating climate education within their own curricula. We can learn from the successes of the other UC campuses, California State Universities (CSUs), California community colleges, and state and private colleges across the nation. We can also learn from the potential threats that UCSD faces in its efforts, including lack of funding and staffing, lack of wide-spread faculty buy-in, potential lack of interest from the student body, and a lack of a centralized mechanism to oversee the process of integration. These challenges are considerable and require innovative and practical solutions to overcome cultural and institutional barriers.

The University of California is leading the way on many issues of global import and it serves as a living laboratory on how to bend the curve of climate disruption. Integrating climate change education within each campus's undergraduate curriculum is a critical part of such efforts. UCSD can serve as a model for other campuses within UC and elsewhere of how to meaningfully and pragmatically engage students on solutions to this global crisis. The proposed

strategies include 1) large scale, mandatory climate change curriculum, 2) faculty workshops on how to integrate climate change education into existing curricula, 3) extra credit workshops offered through the Sustainable Resource Center, and 4) Freshman, Senior, and Global Seminars focused on climate-related topics. The strategies are briefly outlined below and more thoroughly explored within the body of the report.

Strategies for Integration of Climate Change into UCSD Undergraduate Education

The first of our proposed strategies is mandatory college or university-wide curriculum enacted as a 4-unit university-wide sustainability-related course graduation requirement and/or implementation of "Bending the Curve" or a slight alteration thereof, as the upper-division course requirement for projected students of Seventh College at UCSD. As a proposal for a new graduation requirement on sustainability has never been proposed to Academic Senate, the details and logistics of such a proposal have been explored -- and modeled off the Diversity, Equity, and Inclusion (DEI) requirement. Additionally, the curriculum of Seventh College is under development by an appointed committee -- with the "Bending the Curve" course being considered as one of the options for the upper-division synthesis course requirement for Seventh College students. A detailed structure for the scaling of this class to an approximated 1,300 students per year has been explored, as well as the value of "A Changing Planet" as a college theme and the status of the development of college plans.

Our second strategy seeks to integrate climate change into the existing UCSD curriculum. This approach addresses and even capitalizes on the complex, interdisciplinary nature of climate change as an opportunity to draw relevant climate change links in a wide range of existing courses related to all six clusters. To implement this solution, we propose a faculty workshop model that builds upon UCSD's past successes. This program entails a full day of workshops, funding for curriculum modification/redesign, publication of newly created materials to climate education web resources, and a networking event 6 months later in which workshop participants present on their new curricula. To build upon and extend the reach of the program, we suggest the addition of departmental events. These two hour mini-workshops would be presented by a member of the department who attended the full workshop program, and provide a platform for

them to share department-specific and more general knowledge and insights they gained from it. This addition exploits resources already invested in the existing model to dramatically increase its impact.

Third, we propose to create a program through which faculty can offer extra credit for student participation in a workshop focused on climate education. This is to incentivize climate education and to counter potential faculty resistance to altering established course material. We propose that this program would be run through the Sustainability Resource Center (SRC). These workshops would be peer-to-peer education on any number of climate-focused topics that would incorporate and can relate back to all six clusters of necessary transformations and solutions. The workshops will meet weekly and include a capstone project involving a small commitment to a community service project in order to give the program substance and allow the students to experience a tangible result for their efforts. This type of solution will engage students from a diverse range of majors and programs and will foster an environment of climate action, collaboration, and communication across disciplines, and it will involve content and include solutions from all six clusters.

Lastly, the introduction of freshmen and senior seminars will distribute climate change knowledge into bite-sized chunks in order for the student body to absorb, transform, and utilize going forward. The goal is to introduce students to interdisciplinary fields and solutions in the form of climate change introductory courses. These 1-2 unit freshman and senior seminars expose incoming freshman to climate disruption and equip outgoing seniors with the necessary climate knowledge to ensure they graduate with an understanding of climate disruption. Ways of distributing these seminars must also be taken into account as smart strategies are needed for communication. The UCSD Global Seminars are an additional platform to experience knowledge without walls while developing students into international agents of change. Additionally, these global seminars highlight global development, justice, morality, immersion, and engagement. Education and knowledge do not bind themselves to books and classrooms but are transcribed as a result of real life experiences and research.

Introduction

Roles of Universities and Members in Undergraduate Climate Change Education

Education is most evidently associated with the cluster of societal transformation. However, education -- and especially undergraduate education -- builds on this foundation of societal change to reach into the other five clusters. Based on data from the National Center for Education Statistics, universities across the U.S., in the 2018–19 school year, are projected to award 1.9 million bachelor's degrees (NCES 2019). In the typical four years of an undergraduate program, students already act as voters, activists, researchers, and influencers. Upon graduation, this population not only feeds into existing jobs opportunities, but they form startup companies, push for more employment opportunities in the sectors they find relevant, and continue to pursue the passions they developed while in university by applying their various degrees and skills to the problems they find pertinent.

But is it really a lack of education that is slowing progress and action on climate disruption? After all, a 2018 survey found that 91% of incoming freshmen at UCSD were either "very worried" or "somewhat worried" about climate change (Chaiken 9). The key here is that concern does not equate to knowledge or urgency around the topic. This is evident in that only 73% of the students stated they thought "global warming [was] caused mostly by human activities" and 51% of the students surveyed, never or rarely talked about the issues with their friends or families (Chaiken 10). Furthermore, most students held some misconceptions that toxic waste and the hole in the ozone layer contributed "some" or "a lot" to global warming (Chaiken 11).

Such uncertainties in knowledge may dissuade students from publicly speaking about climate disruption, leave them remiss in working towards solutions, and impede informed choices regarding policy support and voting priorities. With policies regulating primary and secondary education and limiting the language that teachers are allowed to use regarding climate change (NCES 2019), it is up to universities to take action based on the excellent scientific and social research findings centered around climate change and action.

Common sentiments following surface-level exposure to climate disruption include a sense of hopelessness, lack of optimism and, worst of all, mental and emotional paralysis. Climate change paralysis reflects an incapacity to process the projected consequences of climate disruption against humanity's deepest fears, a lack of confidence in our ability to cooperate as a result of rampant political polarization and, more importantly, the lack of an established plan of adaptation. Action legitimizes climate change, and also leaves local and global communities with more time to efficiently prepare against the inevitable.

While the issue of polarization can be mitigated through time, education, science, and the rise of a majority consensus, the latter problem requires institutional involvement to augment adaptational efforts and propel the movement towards a near-zero-carbon society. Universities as a whole are especially well equipped to contribute to solutions in the science, technology, and managed and natural ecosystems based solutions to establish a unifying climate culture on campus. Shared climate culture promotes sustainable societal changes and mindsets while maintaining a sense of legitimacy regarding the threat of climate disruption. Furthermore, it contributes to the development of adaptational pathways to divert the sense of paralysis by involving university students in the technological and societal innovations that hold great potential to bend the CO_2 curve towards a sustainable future. Over time, climate cultures, combined across many institutions, can influence greater political change as localized climate adaptation becomes more efficient and abundant worldwide.

In the context of action on climate change, the roles of universities and their members are to:

1. Uphold a mission of fostering sustainable development through knowledge distribution and proliferation.
2. Legitimize the urgency of climate adaptation and mitigation through the integration of climate solutions throughout university curriculum.
3. Strive to be global leader in climate action by supporting UC innovation and implementing clean, renewable energy sector-wide while promoting campus-wide green behavioral practices.

4. Prepare and equip students with the knowledge and skills needed to thrive in a greening economy.
5. Develop interdisciplinary approaches to climate solutions by providing opportunities to address climate disruption from both STEM and non-STEM fields.
6. Provide platforms with that further enable students to discover, absorb, and dispense climate change knowledge through fusion courses; college writing programs; TedX showcase events; and freshmen, senior, and global seminars.

The normalization of climate change into modern society and institutions will also see the normalization of individual student entrepreneurship and self-creation, diverging from the traditional path of career development as society effectively adapts to climate disruption. Institutionally integrating climate change studies into undergraduate education is an immediate way to legitimize the reality and threat of climate change while also providing opportunities for students to become local and global leaders against climate disruption. Through institutional acknowledgment of climate change, the university dispels negative social stigma surrounding the topic and replaces it with objective science-backed course, reestablishing and reaffirming the fundamental principle of knowledge. Deep within the societal transformation cluster, education pulses through society feeding generation after generation as society without education and culture cannot thrive.

However, the path to a sustainable future rests not only on universities as an institution, but also on faculty and students who comprise the institution. To maximize efficiency in climate change combat and reach sustainable green society, universities, faculty and students must cooperate and harness collective knowledge by combining diverse academic fields, perspectives, and resources through active and passive engagement to reach creative solutions and adapt. In doing so, new dynamics between the roles of teacher and learner come to fruition allowing for a non-centralized bottom-up grassroots campus climate culture. Climate culture promotes sustainable technological and behavioral habits while at the same time establishing ways of adaptation to move past the paralysis stage. Over time, climate cultures combined can influence

greater and global political change as localized climate adaptation becomes more efficient and valuable worldwide.

Strategy #1: Mandated College- or University-Wide Climate Change Education

The first of our proposed strategies is mandatory college or university-wide curriculum enacted as a 4-unit university-wide sustainability-related course graduation requirement and/or the implementation of "Bending the Curve" or a slight alteration thereof, as the upper-division course requirement for projected students of Seventh College at UCSD. Either of these approaches supports several aspects of UC San Diego's Strategic Plan (UCSD 2019a). Most directly, they would support three of the plan's four grand research themes: Understanding and Protecting the Planet; Enriching Human Life and Society; and Understanding Cultures and Addressing Disparities in Society. Regarding the five transformational goals outlined in the plan, the topic of climate disruption implemented under these approaches holds the potential to support and promote the following goals: Student Experiences, Interdisciplinary Research, and Community Enrichment.

Most importantly, the administrative choice to announce these curriculum requirements holds great value in setting precedent for other academic institutions and in sending a clear public message of the earnestness and dedication with which the university approaches the threat of climate disruption. As a university grown from the founding of Scripps Institution of Oceanography, with Roger Revelle and Charles Keeling as major influencers in the University and in the field of anthropogenic climate change, it is of utmost importance that UC San Diego builds upon this legacy to prepare its students for the challenges of the present and future (UCSD 2019b).

A major benefit of climate change education being mandated, even if only in the form of a single course, is that it greatly augments the potential for interdisciplinarity at the university. Rarely does a topic arise that is relevant to most, if not all, departments at such a large academic institution. With only optional electives as a pathway for a large portion of students to be exposed to climate change, the possibility for interdisciplinary progress diminishes across the university.

Importantly, an aspect of climate change education that makes it so interdisciplinary and beneficial to the overall student experience (Goal 1 of UCSD's Strategic Plan [2019]) is that it

creates opportunities for problem-based learning. This type of learning forces connections between co-curricular experience and academic knowledge application, while promoting problem analysis and critical thinking skills, as well as cooperation and collaboration amongst students and faculty of different social, academic, and cultural backgrounds (McCright 714). Furthermore, this work can help in "retaining talented young people in STEM fields and enhancing multiple literacies of all students" to make graduates of the university more diverse in terms of career prospects and post-graduation opportunities (McCright 713).

I. University Sustainability Graduation Requirement

The idea for a themed university-wide graduation requirement is rooted in UCSD's Diversity, Equity, and Inclusion (DEI) requirement. This requirement was introduced in 2011 following the infamous "Compton Cookout" hosted by a fraternity at UCSD (Schneider 2017). The group set the occasion during Black History Month and asked guests to dress according to racial stereotypes, even after fellow students urged them not to put on this offensive and culturally ignorant event. In this case, it took a campus-wide outcry and a publicly visible crisis for the university to add a further graduation requirement. As a result, the campus has improved student and faculty awareness and understanding of issues pertaining to minorities in the U.S. and social inequalities that still exist in this country.

Building off this precedent, we propose a 4-unit university-wide sustainability-related course graduation requirement. Paralleling the DEI framework is not meant to equate climate issues to issues of race and discrimination. However, both, in their own right, make evident the need for greater societal change. Now, in a context where the issue of anthropogenic climate change is frequently discussed in global conferences, news outlets, and political statements -- our actions and reactions must parallel the language we use around the topic. As stated by Nilza Sena, Chair of the General Committee on Economic Affairs, Science, Technology and Environment (OSCE 2017):

> Considering the dire situation we face in terms of rising sea levels, intensified heat waves, droughts, forest fires, and stronger storms, it is clear that we need an

all-hands-on-deck approach that utilizes innovation and creative thinking to move towards a more sustainable, low-carbon economy.

As a university, though we have announced goals to move towards clean electricity and zero waste by certain years, there has been no clear expectation of students to participate in or enable this vision.

Proposal Details and Logistics:

University-wide graduation requirements must be considered and approved by the San Diego Division of the University of California Academic Senate at UCSD. The Academic Senate is one of three governing bodies in the University of California system, along with the Board of Regents and the Administration. In charge of directing the education function of the University, members of the UCSD Academic Senate meet regularly to address campus concerns and proposals. Though a new graduation requirement is unlikely to be approved -- it has also never been proposed. The goal for this portion of the Undergraduate Education project is to submit a proposal to the UCSD Academic Senate to be considered at the Undergraduate Council meeting. As proposals require a brief cover memo from the relevant Department Chair/Program Director(s), a further aim would be to get statements of support for this requirement from several Department Chairs or Provosts, to add further legitimacy to the request.

Request:

The request is that the university implements a sustainability graduation requirement, applying from the class of incoming freshmen the following year, and onwards. This would not disrupt the graduation requirements of current students and would allow for notification of new students in a reasonable time to incorporate an appropriate course into their 4-year academic plan. Just as with the DEI-requirement, the course would be a four-unit course that could be taken for a letter grade or Pass/ Not Pass.

Rationale and Justification:

The graduation requirement, while flexible enough to avoid extending time to graduation for students, would uphold and propagate Goal 3 of UCSD's Strategic Plan [2019] -- nurturing interdisciplinary research. Primarily, Strategy 6 under this goal accentuates the need for UCSD to "identify emerging and future trends and strategic thrusts to increase [its] impact and enrich society." Importantly, three of the four grand research themes (Understanding and Protecting the Planet; Enriching Human Life and Society; Understanding Cultures and Addressing Disparities in Society) that this strategy is meant to support, all directly or indirectly relate to climate disruption.

It is clear that in the U.S. even highly educated individuals lack sufficient understanding of climate change to appropriately assess short and long term global impacts (Aksit 551). Among undergraduates, it has been shown that improved education around the topic augmented risk perception (Aksit 551) and those students were more likely to support policies that promote renewable energy and regulate carbon emissions (Chaiken 8). In seeking to support an academic culture that reflects one of the key core guiding principles for university activities -- sustainability -- it would be of great value to announce and implement this new requirement. The university's goals would grow to more closely align with student interest and, as a bold action, press coverage could further boost UC San Diego's role and public image in the setting of global climate action.

Accepted Courses and Curricular Logistics:

As is the case with the upper-division writing requirement and the DEI course, the sustainability requirement would be allowed to overlap with any other graduation requirements, including major, minor, or other general education requirements. Applicable courses would be any of the following or any further petitioned classes.

Climate Change: Solutions

SIO 109/POLI 117. Bending the Curve: Solutions to Climate Change (recommended)

ESYS 103/MAE 124. Environmental Challenges: Science and Solutions

BIBC 140. Our Energy Future—Sustainable Energy Solutions

Climate Change: Understanding the Science

SIO 25. Climate Change and Society

SIO 117. The Physical Basis of Global Warming (recommended for students in science, math or engineering majors)

ESYS 10. Introduction to Environmental Systems

ESYS 101. Environmental Biology (4)

ESYS 102. The Solid and Fluid Earth (4)

SIO 10. The Earth

SIO 20. The Atmosphere

SIO 35. Water

SIO 40. Life and Climate on Earth

SIO 50. Introduction to Earth and Environmental Sciences

BILD 18. Human Impact on the Environment

ESYS 10. Introduction to Environmental Systems

ENVR 30. Environmental Issues: Natural Sciences

BIEB 174. Ecosystems and Global Change

BIEB 182. Biology of Global Change

CHEM 171. Environmental Chemistry I

CHEM 172. Environmental Chemistry II

CHEM 173. Atmospheric Chemistry

ESYS 102. The Solid and Fluid Earth

MAE 118. Introduction to Energy Systems

MAE 119. Introduction to Renewable Energy: Solar and Wind

MAE 120. Introduction to Nuclear Energy

MAE 122. Flow and Transport in the Environment

SIO 108. Introduction to Paleoclimatology

SIO 115. Ice and the Climate System

SIO 116. Climate Change & Global Health: Understanding the Mechanisms

SIO 143. Ocean Acidification

SIO164/ANAR 164. Maritime Archeology

SIO 173. Dynamics of the Atmosphere and Climate

SIO 174. Chemistry of the Atmosphere and Oceans

Climate Change: Social and Human Dimensions

SOCI 30. Science, Technology, and Society

COMM 171. Environmental Communication

ECON 131. Environmental Economics

ECON 132. Energy Economics

ETHN 102. Science and Technology in Society: Race/Gender/Class

ETHN 103. Environmental Racism

HISC 180. Science and Public Policy

MGT 166. Business Ethics and Corporate Responsibility

PHIL 148. Philosophy and the Environment

POLI 104E. Environmental Law and Policy

POLI 104P. Science, Technology, and the Law

POLI 162. Environmental Policy

SIO 114. The Science and Analysis of Environmental Justice

SOCI 149. Sociology of the Environment

SOCI 171. Technology and Science

USP 124. Land Use Planning

USP 170. Sustainable Planning

USP 171. Sustainable Development

Global Seminars

SIO 116GS. Climate Change and Global Health: Understanding the Mechanisms

SIO 118GS. Responding to Climate Change: Possible Solutions

ENVR 142GS: Wilderness & Human Values Abroad

SIO 10GS: The Earth

SIO 170GS: Intro to Volcanology

II. Climate Change Education in Seventh College: A Changing Planet

UCSD operates under a system where students are divided into various colleges, each with a different theme. This is meant to provide the proximity and community of a small college while giving students the resources and diversity of a large university. Currently, UCSD has six colleges, with plans for two additional colleges underway. Seventh College will be the next college built, and it has been decided that its theme will be titled "A Changing Planet." Every UC San Diego general education program must address five general academic realms: Art; Humanities; Social Science; Natural Sciences; and Quantitative Reasoning. Students will be expected to take two courses from each area, which they will choose courses from a curated list. Furthermore, students will take a "high impact" course (study abroad, internship, mentored research, etc.) and one upper-division and two lower-division "synthesis" courses.

In current discussions of the academic plan for Seventh College, a strong case can be made for an existing course to be modified to fit the upper-division synthesis requirement for the college's general education. The proposed course, "Bending the Curve", already incorporates most of the visions outlined in the "7th College Full Proposal" and would merely need some adjustment in structure to effectively scale to serve an expected 1,333 students per year.

<u>"Bending the Curve" as a College-Wide Upper Division Synthesis Course: Synthesis 100</u>

In the existing structure of SIO 109/POLI 117, individuals rank preferred project choices from a list of topics and are organized into groups, with an attempt to maintain some diversity in majors and backgrounds to promote collaborative, creative work. Projects have in the past have focused on local and international areas, with themes ranging between Climate Action Plan analyses, reduction of campus food waste, studies on the future of Tesla, student movements on climate action, and many more. These projects include a formal report written partially as

individuals and partially as a group. Students are incentivized by the formal publishing of especially successful, well-executed reports or projects.

Importantly, the factor that should be maintained in application to Synthesis 100, is the exploration of climate disruption through the six cluster model. Doing so maintains value on interdisciplinarity in the synthesis course and greatly augments the scope of student projects. The six cluster model should be taught to the class as a whole and, though it may not be fully applicable to each student project, it would be useful for each group to highlight where their project falls within the clusters.

The structure for the project sections is still being actively discussed. Either, each course would address the topic and "mode" that the entire course follows for that quarter. Or, the topic would apply to the entire course, but each discussion section would have a "mode" where TAs could help develop student knowledge regarding that practice. Modes might include some of the following: design projects, community projects, research projects, or video/film projects. As explained in the academic committee's most recent academic plan (Teranes 2019a):

> In lieu of discussion sections, the larger lecture course would be broken into several small, co-requisite courses led by teaching assistants or associate-ins from a variety of disciplines (and aligned with the topic and mode). These represent the workspace for students to choose their project ideas and engage with their other group members. The instructors help students identify and refine group projects over the quarter and determine personal contribution by assigning roles to each member.

Regarding project assignment, students could propose unique ideas in the first two weeks of the course. After week 2, students could either rank top 3 project choices from a list or be assigned a project topic. Individual contribution is assessed, as each project, with the help of TAs, would be subdivided with roles for each member of the group. This would be where students could take personal responsibility and bring in their own backgrounds, passions, and ideas, and receive an individual grade for their work on that section.

"Bending the Curve" has associated with the course topic "Climate Change Solutions" with a mode of written project reports. While the written portion is important for detailed

exploration and organization of the project content, a deliverable would also contribute to the implementation potential of the students' work. The current academic plan for Seventh College stresses the focus of Synthesis 100 as a design course with "design-oriented investigation and writing, where students produce textual and multimodal artifacts, including investigative journalism, scientific reports, and presentations." The deliverable may also come in the form of a video, art installation, infographic, website, or urban planning model.

The final product could vary based on the group but would culminate in a symposium setting where projects would be shared with the other students and open to a wider audience of faculty, political representatives, industry members, etc. UC San Diego's Design Lab could aid many students in creating deliverables or content for their project, improving usage of campus resources, and amplifying the reach and legitimacy of student projects -- exposing them to research techniques, promoting community involvement (local interviews, outreach to industry members related to projects, discussions with elected officials, community-based projects), and aiding students' collaboration amongst students and between students and faculty.

Some beneficial organizations/industries in San Diego that could act as partners to the projects and relate most prominently to the six clusters include:

- Sierra Club San Diego (Society, Ecosystems, Policy)
- Birch Aquarium (Ecosystems, Society, Science)
- American Institute of Architects San Diego (Governance, Policy)
- California Solar Energy Industries Association San Diego (Technology, Market/Regulation)
- Center for Regional Sustainability, San Diego State University (Society, Technology)
- Center on Policy Initiatives (Governance, Policy)
- Circulate San Diego (Transportation, Government, Policy)
- City of San Diego- Environmental Services Department (Governance, Market/Regulation, Policy, Society)
- Climate Education Partners-San Diego Region (Society,
- ECOLIFE Foundation (Ecosystems, Science, Society)

- Equinox Center (Technology, Ecosystems, Policy, Society, Science)
- San Diego Renewable Energy Society (Technology, Science)
- San Diego Roots Sustainable Foods Project (Society, Ecosystems, Regulation)
- UCSD Sustainable Solutions Institute (Society, Ecosystems, Science, Technology)
- Urban Design Committee San Diego (Technology, Society, Governance, Policy)
- US Green Chamber of Commerce (Policy, Governance, Society, Market/Regulation)
- Water Conservation Program (Policy, Governance, Society, Market/Regulation, Ecosystems, Science)

Ultimately, the primary benefit of a mandated climate change curriculum is the strong message it sends regarding university priorities. Furthermore, the scaling of the curriculum to reach thousands of students greatly benefits the interdisciplinary approach to climate solutions, reflecting the goals of the six cluster format in incorporating multiple frameworks into any given solution. Mandatory undergraduate education is most directly oriented around the societal transformation cluster, with science; technology; and natural and managed ecosystem solutions being developed in classrooms and labs, and governance and market- and regulation-based solutions becoming evident in student and alumni contributions through career choices, business conduct, and decisions regarding policy support and voting trends.

Strategy #2: Integrating Climate Change into Existing Courses via Faculty Workshops

One of the most significant barriers to understanding and addressing climate change is the interdisciplinary nature of the issue. While climate science forms the basis of our understanding of the problem, it does not paint a complete picture of its roots and impacts, and cannot unilaterally chart the solution. The format of the "Bending the Curve" report is based on the reality that climate disruption must be addressed from multiple angles through independent work and collaboration between experts in numerous fields. While the complexity of climate change presents an educational challenge, it also presents a powerful *opportunity* to draw the connection to climate change in a wide range of existing courses.

Even in most university level science materials, however, climate change is rarely emphasized. In their recent research, science professors Rachel Yoho and Bruce Rittman found that in 16 of the leading undergraduate physics, biology, and chemistry textbooks, less than four percent of all pages mention global warming, climate change, renewable energy, or related issues (731). If natural science textbooks make so little reference to climate change, its presence in textbooks for fields such as social sciences, humanities, medicine, and engineering is undoubtedly even more lacking. Yet climate disruption interacts with all of these fields in a meaningful way. Clearly, mainstream course materials and teaching methods are lagging behind on perhaps the most pressing issue of our time. It is therefore up to professors to take the lead on analyzing the links between their subjects and climate change and developing seamless and effective ways to present them to their students. UCSD has the opportunity to lead both the UC and the entire higher education community in this endeavor.

Infusing climate change into existing courses has several unique advantages and contributions. First, it does not encounter many of the administrative and planning hurdles associated with introducing entirely new courses. It also does not put any additional demands on students' time or degree plans. This makes it the simplest solution to improve climate literacy in a large number of students, especially those who would otherwise have minimal exposure. These include students pursuing degrees not typically associated with climate change, and those who would not actively select courses geared toward the topic. Incorporating climate change across

the curriculum also optimizes the chance that each student encounters it in a context that resonates and promotes understanding due the repeated, varied, and major-specific nature of the exposure. Climate change would be discussed numerous times during a single course and across multiple courses throughout students' undergraduate education. This repetition alone helps them solidify and retain key climate disruption concepts. Exposure in a variety of disciplines gives students a more comprehensive picture of the problem. It also provides greater opportunity for climate change to be brought up in the context of an issue or group they care about, and therefore strike a chord with them. Widespread integration into the curriculum also leads students to learn about climate change through the lens of their own major, where they are best positioned to find it comprehensible and salient. It is uniquely positioned to do so with depth and nuance because climate disruption can be discussed in relation to a range of advanced concepts within the discipline.

Increasing students' knowledge about the relationship between climate change and their own majors has other key benefits. It improves their own abilities as advocates by giving them the tools to approach others about climate disruption from a perspective with which they already possess the knowledge and credibility to speak confidently and authoritatively. In this way, educating students can have a snowball effect as they find their own voices to propel societal transformation.

Finally, upper division courses address the skills and knowledge most directly relevant to students' future careers, making them the best setting to equip students to address the unique climate change challenges in their field. This is an opportunity for UCSD to set itself apart by providing superior preparation to students in their careers and the emerging and evolving challenges within them. It is also an effective way for UCSD to target all six climate solution clusters. Well-trained emerging professionals in engineering have enormous potential to contribute to the innovation and adoption of technology based-solutions. Those in fields such as law, public policy, economics, and international relations must work toward governance and market and regulations-based climate solutions. Individuals in fields including earth sciences, marine biology, and environmental systems are essential to implement natural and managed ecosystem solutions. Emerging physical and atmospheric scientists must measure and predict the

effects of climate change, inform the basis of the other clusters' solutions, and instruct the implementation of science-based solutions. Finally, young professionals in sociology, education, communication, psychology, and even fields such as the visual and dramatic arts, literature, third world studies, ethnic studies, and religion are particularly well poised to inspire societal transformation. Elevating climate disruption in all of these majors is therefore a powerful opportunity to further climate solutions on multiple fronts.

Some of the advantages associated with incorporating climate change in courses across the undergraduate curriculum have already been recognized and acted upon by UCSD and wider UC administration and faculty members. Our proposal builds upon the past successes of these small-scale efforts. UCSD's first attempt to integrate climate change into the curriculum was part of an all ten campuses, UCOP funded initiative. UCSD directed its resources from the initiative toward a faculty climate curriculum workshop program consisting of one full day of workshops and a follow-up networking event six months later.

During the main workshop day, participating faculty received lectures from colleagues leading in climate change education and created plans to incorporate climate change into their courses through collaborative activities and discussion. Two dozen faculty members in over twenty different departments attended the program, most of whom did not specialize in climate or sustainability issues in their research or teaching. The subsequent networking event featured presentations by the participating faculty about the changes they had made to their curricula as a result of the program. The titles of the presentations demonstrate the wide range of topics and strategies professors used to integrate climate change. These included, among others:

- "Connecting genetics to climate change"
- "Exercise for an undergraduate biology class"
- "Incorporating climate change topics in introductory geology classes"
- "Reversing the cost of a carbon tax in China, India, and the United States"
- "Politics of development and climate change"
- "Three climate change poetry prompts"
- "Teaching climate change in a large general education class"
- "Mathematical models for the impact on sea level from Greenland ice melt"
- "Physics 10: a survey of physics through a climate change lens"

- "Including climate warming datasets in some upper level undergraduate statistics classes"
- "Theatre as a social force for climate change action"

These presentations also highlight two basic approaches: some professors choose to add a module, assignment, or lecture about climate change, while others integrate examples or themes of climate change throughout the course. Either way, the alterations improve students' climate change literacy and connect the issue to an area in which its relevance is rarely highlighted.

Jane Teranes built upon the successes of this original program (in which she also had a leadership role) in the 2018 climate change curriculum workshops funded by Understanding and Protecting the Planet at Scripps Institute of Oceanography. The revised program added an emphasis on developing student learning objectives and evaluating student outcomes and offered significantly more funding for participants so that they could devote more resources to curriculum redesign. Essentially, it was designed to go into greater depth with fewer faculty. Teranes also sought to extend the reach of the program by requiring participating faculty to publish the materials they created to one or several of Carleton College's popular, reputable web resources for climate education and UCSD's own Understanding and Protecting the Planet website. This aids not only other UCSD professors, but also those at other universities who wish to incorporate climate change into their courses.

The first step in our proposal is to run this faculty workshop program on an annual basis and double the number of participating faculty from ten (in 2018) to twenty. In our meeting with Jane Teranes, she emphasized that virtually all participants were open, enthusiastic, and serious about integrating climate disruption into their courses. While this may not be universally true of UCSD faculty, it is likely reflective of a significant portion of them. Teranes emphasized that an impediment is not lack of faculty interest, but rather the many existing strains on their time. This is especially relevant because in this faculty curriculum model, the bulk of work comes after the full day of workshops as each participant creates, refines, and implements their own individual plan to integrate climate change into one of their courses. For this reason, funding faculty, just as they would be funded to conduct research, is a key component of this proposal. We estimate that $6,000 in funding is necessary for each participating faculty member. This is a slight increase from the $5,000 provided in the 2018 faculty curriculum program, due to the additional portion

we propose to build upon the program, which is detailed below. It would be provided in the same manner as it was in 2018: "as a stipend, transferred into a departmental account that could be used for salary, materials, graduate student support etc. as needed to support development of curriculum materials relevant to their discipline and course" (Teranes 2019b).

For the remaining areas of necessary funding, I defer to Jane Teranes' 2018 proposal, which called for $2,000 to hold the workshops and $10,000 for a graduate student to "assist with planning and implementation of the workshop, follow-up events, and the dissemination of materials on various websites" (2019b).

What seems to be lacking in past programs is a significant effort to reach and influence UCSD faculty who aren't directly involved in them. Due to funding constraints and faculty obligation, the number of faculty who can partake in this more comprehensive curriculum integration program is clearly limited. Sharing resources online could help professors who are already seeking to integrate climate issues into their teaching. It does not, however, highlight the issue to the many other professors who may be open to it, encourage them to utilize these online resources, or stimulate widespread conversation between colleagues. This could be achieved through additional two-hour events held after participants have taught their revised course for at least one quarter, perhaps shortly after the networking event already included in the original programs. These would be held separately in as many of the departments of the participating faculty as possible, for other faculty members within that department. If necessary, some related departments (e.g. political science and economics, biology and chemistry, several types of engineering) could coordinate to hold a combined event. A rough format for the event is as follows:

The graduate student arranging the event gives an introduction (30 minutes). They summarize the campus wide initiative to integrate climate change into existing courses and explain its value while simultaneously providing an overview of some key concepts in climate science. They also introduce the main presenter(s), who speaks for one hour. (If there is more than one presenter at a single event, they split this time). Presenters at each event are the faculty members within the department who participated in the curriculum workshop program. They use the knowledge they acquired through the program to elucidate the connection between this

specific field and climate disruption, including how it will be affected, its contributions to the problem, and its current and potential role in the solution. They then provide a more in-depth version of the presentation they gave at the networking event, about how they infused climate change into a course they teach. Presenters are encouraged to also suggest simpler or less extensive course alterations that professors in their discipline could make to draw the connection to climate change. Additionally, they point their audience toward of the web resources they and others have shared for additional guidance and inspiration. The final portion (30 minutes) of the event is designed to spark engagement, conversation, and collaboration on climate change integration within the department. Attendees are broken into groups of three to four individuals to discuss a series of questions such as the following:

- How do you see the role and responsibility of [insert discipline] in climate disruption and climate action?
- Do you currently bring up climate change in and of your courses? If so, how? What has been the reception/engagement from students?
- What is one additional opportunity you see to make a climate change connection in one of your courses?

To conclude, each group is asked to share a portion of what they discussed with the entire group.

Approximately an additional $500 in funding would be required to hold each departmental workshop. If we assume that 10 are held annually, this adds $5000 to the total cost. Also, note that we requested $6,000 per faculty member for the main workshop program, rather than the $5,000 that Jane requested in her 2017 proposal. This $1,000 per participant extra funding covers the additional time and resources to prepare and execute the hour-long presentation to his/her colleagues. An estimated $8,000 is also necessary to hire graduate students (preferably more than one to ensure that one will be available for each event) to organize, introduce, and facilitate the departmental events.

The cost, however, is minimal compared to the added value this expansion to past faculty workshop models provides. It capitalizes on the resources already invested in the main workshop program; participating faculty have already gained knowledge and insight on climate change curriculum integration and invested in curriculum modification/redesign. Passing this forward

has the potential to magnify the benefits with relatively little additional investment. It is also a pragmatic model because it recognizes the institutional constraints in calling for widespread curriculum redesign, and that different faculty members will have the desire and ability to modify their curricula to varying degrees. The full workshop program is an invaluable opportunity for faculty with more interest in climate change and openness to changing their teaching. The departmental events, on the other hand, give tools to those less inclined to make sweeping changes by providing simpler modification ideas and resources that lower the individual cost of implementing them. Simultaneously, they elevate climate disruption as a salient issue within the field, and gradually increase openness to adjusting curricula to reflect this.

The total estimated cost of running the program annually comes out at $145,000/year. We hope we have been persuasive in demonstrating that this required funding is minimal when weighed against its potential to further climate change solutions, and that it will benefit students and set UCSD apart as an institution. Annual implementation is essential because an urgent, ongoing, and evolving issue like climate change requires continual attention and commitment. It will expand and advance the climate disruption conversation amongst educators and ensure that the information conveyed to students on the issue is relevant and updated. It also ensures that, each year, climate change will be more widely integrated into UCSD courses throughout the curriculum.

Strategy #3: Extra Credit Workshop Offered through the Sustainable Resource Center

Our third strategy is to offer extra credit workshops on climate change solutions through the Sustainable Resource Center (SRC). This would incentivize students to take advantage of an opportunity to both learn about climate change and to receive extra credit for their classes. It also would counter potential faculty resistance to altering pre-established curriculum. We envision the workshops as peer-to-peer education and centered around the six clusters. We propose a capstone experience involving community service for the students to receive extra credit for participating. This design is to give the program substance and allow the student to experience a tangible result for their efforts. We also hope this requirement will legitimize these workshops for faculty who are considering allowing their students to participate for extra credit for their classes. The capstone is a critical aspect of our proposal because of the high need to actively engage in projects that will have a real impact on our campus and community. We also hope that these projects will foster a lifelong sense of responsibility and a habit of service in student participants. We have drawn on an existing workshop template at Santa Monica Community College, which recently has made integrating sustainability into its curriculum an institutional objective and offers extra credit "greening" workshops as part of that ongoing effort. With this as our inspiration and blueprint, we offer our own version of this strategy designed to be as cost-effective and easy to implement as possible.

As we discussed earlier, faculty time constraints and/or lack of buy-in is a considerable cultural and institutional barrier to proposing any changes to the undergraduate curriculum. This strategy would also serve any faculty who are interested in encouraging students to engage with climate change solutions but teach courses or disciplines that are unsuitable to alteration or incorporation, including those who teach completely unrelated subjects. Furthermore, this would be an ideal method to allow faculty to contribute to a meaningful education project even if they lack sufficient familiarity to incorporate climate change solutions into their own class material. Notably, among U.S. science teachers, approximately "30% of teachers emphasize that recent global warming 'is likely due to natural causes,' and 12% do not emphasize human causes (half of whom do not emphasize any explanation and thereby avoid the topic altogether)" (Pluzter et al. 664). The low-cost of this proposal allows it to be implemented first or, in a worst case

scenario, alternatively to our second proposal of faculty workshops dedicated to climate education that can alleviate concerns about possible knowledge gaps among UCSD faculty. As a temporary measure, however, it allows willing faculty to contribute to the overall goal of educating UCSD undergraduate students about climate change solutions regardless of their personal expertise, discipline, department, or desire to participate in any faculty workshop. As an ongoing project, this strategy would also address the need to engage faculty across departments and disciplines who are currently siloed off from one another. This format could engage those faculty and offer them access to a large body of knowledge on the solutions contained within all six clusters, as well as other faculty who are working on those solutions.

Another major advantage of this method is that it could potentially incentivize students to take an interest in climate change solutions and climate education in general. If the program is sufficiently advertised, allowing faculty from a diverse range of disciplines to participate, then it could draw in students who are otherwise uninterested in climate change education by granting them extra credit for their classes. Even a small amount of extra credit is a powerful incentive for students to participate. Furthermore, studies suggest that service-learning projects incentivized by extra credit actually improve student outcomes within a course (Strage 5). Service learning, which is "distinct from 'volunteerism' in that it is explicitly linked to curricular objectives" has a number of other advantages including "fostering students' civic responsibility, their acceptance of diversity, and their leadership skills as they move on to assuming roles in their communities as committed and engaged citizens" (Strage 5). Studies suggest that even students who are not generally interested in service projects do receive benefits from participating in them including "maximiz[ing] the possibility of rewarding experiences that produce intrinsic motivation for community engagement" (Moely & Ilustre 14). These workshops, with a service-oriented capstone project, can potentially introduce new students to climate-related issues, improve their student learning outcomes within their classes, and strengthen their connection to the community. With the great need to engage students on projects involving solutions related to all six clusters, this method is an easily-implemented strategy to quickly achieve tangible results.

Our proposal is modeled on extra credit workshops offered by Santa Monica Community College. In 2007, SMC made sustainability an institutional objective and priority as part of their

5-year strategic planning process. As part of its efforts, one of the college's first steps was to hire a sustainability coordinator to oversee the process (SMC 2008). As of 2019, a part-time coordinator operates a program called "greening workshops." Faculty from any department can offer extra credit (with the amount offered independently determined by each faculty member) to students participating in a peer-to-peer educational workshop where they learn about key topics related to sustainability. The coordinator is paid $30,000/year and oversees approximately 30 volunteer students who lead the workshops in pairs. Each workshop can accommodate 15-25 students and are offered at different times over the course of the week and semester. The program requires students to complete eight one-hour workshops over the course of a single semester with a three-hour community service capstone project. Since the program's creation in 2012, it enrolls on average 365 students per semester with a completion rate of 88% (Kawar). Each semester of workshops results in almost 1,000 hours of community service performed, and over half of the participants stating they are interested in obtaining "green" jobs in the future. It is remarkable that such results are obtainable with only the cost of the salary of the part-time coordinator (who also has other duties within SMC's sustainability department), but the utilization of student volunteers is what allows the program to reach so many students for such little cost.

Another significant feature of the SMC program is its widespread implementation across departments. On average, faculty from fourteen different departments offer these workshops as extra credit opportunities. Participating departments have included Business; Communications & Media Studies; Computer Science; Counseling; Design Technology; Earth Science; Recycling & Resource Management; English; History; Kinesiology; Life Science; Mathematics; Philosophy & Social Science; Physical Science; Psychology; and Theater Arts. According to SMC's project manager for sustainability, the diversity of faculty involvement is necessary for students to understand the interdisciplinary nature of the issues and to hear about it from multiple sources (Kawar). It also allows professors who may be "having a harder time incorporating sustainability into their curriculum...to do it without having to change their coursework" (Kawar). On average, over 50 faculty members offer extra credit for participation in the workshops. However, one potential area that UCSD could improve upon is advertising its extra credit workshop program to

faculty. At SMC, faculty are recruited primarily through word-of-mouth from other faculty. UCSD could use this opportunity to address the need to engage faculty across departments and disciplines by performing more substantial outreach to a diverse range of faculty.

SMC's greening workshop curriculum was developed by Sustainable Works, a non-profit environmental education organization funded by the City of Santa Monica. It is oriented around solutions to six focus areas: water, energy, waste, chemicals, transportation, and shopping/food. Each workshop curriculum includes an overview of the issues relating to each focus area as well as an overview of previous and ongoing solutions already implemented by national and sub-national organizations. The curriculum also includes information on personal and community-based actions that individual students can take to fight climate change and environmental harm. To incentivize student participation, practical strategies to save money by reducing their impact are utilized. Additionally, it includes an overview of green jobs and careers relating to each focus area. The curriculum is thorough, exploring ten personal strategies for each focus area as well as including other helpful information such as sustainability related apps and community based organizations to join. The curriculum workbook is available to the public online and consists of 170 pages of useful information and solutions that can be readily implemented on a personal or a community basis (SMCa). The SMC workbook can serve as a model or even be directly adapted for use at UCSD. The Sustainable Works program offers a service where they will work with an educational institution to design a presentation to fit that organization's individualized needs and budget, including designing personalized presentations/demonstrations "on a range of environmental topics and sustainable solutions that will benefit and enlighten [a] campus population" (Sustainable Works). Thus far, this program has already been adapted for nine other community colleges in the greater Los Angeles area.

We envision the UCSD extra credit workshops operating in a similar format; however, we recommend that the curriculum be oriented around the six clusters from the "Bending the Curve" report and class. Much of the same information on general background, individual solutions, and potential careers can be re-organized into new categories based on the clusters. For instance, the information on strategies to reduce air pollution from vehicles and toxic chemicals can be shared in a science solutions framework; information on car-sharing and plant-based diets

in a societal transformation solutions framework; boycotting and environmental activism in a governance solutions framework; energy efficient appliances and water-saving devices in a technology-based solutions framework; socially conscious investing and green power credits in a market- and regulation-based solution framework; and composting and plant-based air-filtering in a natural and managed ecosystems solutions framework. We believe the six clusters framework is a more efficient way to convey the information to the students, and it is reflective of the interdisciplinary nature of the problem and the need for interdisciplinary solutions. The flipped course format used by the "Bending the Curve" class is also an efficient method for delivering the information to participants. In a flipped classroom, the student views online video lectures prior to the class meeting with classroom time being devoted to discussion and activity. Recent findings suggest a flipped classroom could be more effective for millenials as they respond better to active learning strategies because those who use "rapidly evolving technologies demonstrate decreased tolerance for lecture-style dissemination of course information" (Roehl 44).

We also propose to alter the overall workshop format and program to suit UCSD's unique needs and budget. Our strategy is to minimize both cost and effort. We envision the workshops will be led by student volunteers. These volunteers can be drawn from the pool of students who have taken the "Bending the Curve" class or other climate-related courses, student members of the Inter-Sustainability Council and the Student Sustainability Collective, or the student body at large. The workshop leader position will be advertised through the SRC, the dozens of current student groups and organizations related to climate and sustainability, and the college-specific and university-wide Associated Students leaders who have positions relating to the environment. The volunteers will undergo substantial training prior to leading any workshops. The Sustainable Works program consists of a training program composed of two eight-hour leadership training sessions, which UCSD can adapt to its own specific workshop curriculum. The workshop leaders will facilitate discussion, track attendance, and provide feedback and suggestions on community service capstone projects. Workshop meeting space can be easily and independently reserved at no cost in the SRC (SSC). The only expected cost is the salary of a program coordinator. The position at SMC pays $30,000/year; the salary for such a position at UCSD can be adjusted as

needed, or the duties can be split between multiple existing positions if possible. As designed by Sustainable Works, a Student Program Coordinator (SPC) conducts outreach to faculty and student groups, gives in-class presentations in interested faculty members' classes to recruit students, leads the workshop meetings during the first term, trains and supervises peer leaders for subsequent workshops, awards participants with certificates of completion, and generates a list of students who completed the program for faculty ease of awarding extra credit.

The SPC will also ideally record and analyze program trends, completion rates, and other data of interest for the University to monitor and evaluate the program as needed. Additionally, they will maintain a list of organizations and projects that workshop students volunteered at and participated in as part of their capstone. If this list is published on a program website (created and maintained by the SPC), it would serve as a valuable resource to the entire UCSD community. Such a database will ensure future workshop students can easily connect to local opportunities for their own capstone projects. In the SMC program, the capstone project involved a three-hour community service commitment. We propose a capstone time commitment of at least three hours to an on-campus project, non-profit organization, or K-12 school outreach. In order to receive credit, students would be required to produce a short personal reflection that explains how their service project is connected to at least one of the six clusters covered by the workshop. Additionally, surveys on knowledge and interest should be conducted at the start and completion of the program to provide an additional success metric for analysis. Approximately 50% of SMC students stated that they utilized 6-12 solutions total during the term -- resulting in an implementation of approximately 3,500 solutions utilized during the term (Kawar). This type of data will provide a method of evaluating how effective the program is at meeting its goals of real impact within the community on climate change. Furthermore, a detailed analysis of the clusters that students most often draw their solutions from will give a general overview of how students are engaging with material from each cluster.

Another significant finding of the SMC program was the high diversity of its participants. Most notably, approximately 10% identify as a member of an indigenous community -- although such students only comprise 0.2% of the general SMC student body (SMCb). These are exactly the students that such a program should ideal reach. Indigenous and other marginalized

communities are often the least aware of and engaged with climate education and solutions, yet they are also often the most impacted by the consequences of climate change. Additionally, women are comparatively at high-risk of suffering from climate disruption effects, and remain less engaged in solutions than men (Habtezion 1). We propose the workshop program target its recruitment efforts at women and marginalized groups, and include a focus on the impacts of climate change on these communities. Furthermore, we suggest that workshop leaders and the SPC encourage participants to choose a capstone project that will be of service to a marginalized community if possible. In particular, we recommend that the SPC encourage capstone projects that involve outreach to K-12 schools. Children are the most at-risk demographic, yet they are consistently the least engaged on this topic (Corner et al. 4). There is a critical need to engage young people in the fight against climate change; therefore, education on climate change must begin early while a child's worldview is still forming. Compared to adults, ideological identity "may not dictate climate change risk perception among adolescents in the same way" (Stevenson et. al 295) so there is a limited window for children to form a worldview oriented around climate change solutions. Anxiety about climate change is typically high among young people, making it essential to provide them with viable solutions to relieve their anxiety. Outreach at a K-12 school could have a substantial impact in creating a new generation of climate educators and warriors, especially when women and marginalized groups become engaged in the solution process.

With the high need for the engagement of students and young people on climate change solutions, these workshops provide an easy and low cost alternative to more complex methods of integrating climate change education with the undergraduate curriculum. It can be implemented as an early step in the integration process and will hopefully serve to bring awareness to faculty and students about the need for more education on climate change solutions on topics relating to all six clusters. The workshop program itself can be considered a societal transformation solution localized at UCSD that fosters "a global culture of climate action through coordinated public communication and education at local to global scales" (Ramanathan et. al 10). The capstone project component provides a unique opportunity for students to create lifelong habits of service and sustainability, and it will create a real world impact by contributing thousands of hours of work on necessary solutions to a very dangerous problem.

Strategy #4: Seminar Courses on Climate Education and Application

Due to the wealth of environmental knowledge that currently exists and is growing, a variety of methods of dispensing information to large audiences are necessary to promote a culture of climate action through awareness, exposure, and education. However, the lack of widespread faculty buy-in impedes progress as some professors are not able or willing to dedicate time and energy to invest in implementing or developing climate change related curriculum. Budget constraints also impede progress and prevent implementation of faculty workshops, university-wide courses, and other large scale interventions. Therefore, we also offer suggestions that are smaller in scale and perhaps more easily implemented, and largely focused on incentivizing climate change studies in existing research programs.

One way to truly integrate climate change education into undergraduate education is to feature climate change studies as the theme for campus college writing programs. The function of the writing course is to teach students the basics of writing research papers and promote exploration of academic fields through critical thinking. Blending climate change studies with the college writing programs will ensure exposure to and engagement with climate change research, and solutions for every student at UCSD. The flexibility of these courses allows the students to choose what aspect of climate change they wish to investigate, developing them into independent researchers. This would require coordination with each college's writing program department to include climate change studies in one of the writing required courses. However, as the topic of writing courses may change quarterly and there is no set theme between colleges, options for more easily implementable solutions than the creation of brand new courses or the alteration of existing ones could be of use to universities aiming to implement climate curriculum.

One option is to focus on the progress, innovation, and technological advances produced by students related to climate solutions, that can be showcased mobilize the community around climate action and promote ingenuity. UCSD has hosted TEDx events before, so establishing a similar event focused on climate would be highly manageable. The challenge would be having enough TEDx-standard material to launch a series of talks by rising UC scholars as part of a

climate awareness initiative. By focusing on student research, the school would thus support both undergraduate research and the exploration of climate change solutions. The final presentation on stage would be the culmination of students' research projects. Beyond the college research writing courses, a potentially fruitful area in which students are already undertaking original research are the freshman, senior, and global 1-2 unit seminars.

Existing seminars related to climate change solutions are taught by UCSD faculty and are hosted by the UC Deep Decarbonization Initiative which has annually offered six research seminars on campus, once a month starting from September to April since Fall Quarter 2017. The UCSD Deep Decarbonization Initiative is a large scale ongoing research project that focuses on interdisciplinary solutions to climate change and the challenges of switching to a net-zero carbon emissions society. "Bending the Curve" is one of many climate change-focused interdisciplinary courses sponsored by the Deep Decarbonization Initiative. The Initiative links together faculty from diverse disciplines on various relevant courses, research projects, and seminars.

The seminars are open to faculty, independent researchers, and qualified students with research experience. Recognizing that climate change requires innovative solutions beyond any single discipline, the seminars are explicitly intended to foster interdisciplinary work relating to climate change and sustainability challenges. The stated goal of the seminar program is to "reveal how the sum of energy-related research on campus can be much larger than the individual parts…[and] to be a catalyst for new cross-campus, interdisciplinary projects focused on the major challenges of deep decarbonization of the world's energy system" (UCSD 2019c). These seminars are taught by researchers who have experience in their respective fields and wish to inspire students to keep learning and understand the importance of interdisciplinary research.

However, as the UCSD student population on campus is growing, six seminars annually is simply not enough to supply the demand if this information is to be delivered to a significant portion of the student body. Therefore, we recommend that freshmen, senior and global seminars also be provided on specifically climate change studies to allow this information be distributed to the student body in a cost effective manner while also promoting independent undergraduate student research. The goal is to get minds engaged about solutions in their respective fields by

providing them with an introductory course to climate change research. We recommend that 1) individual departments/ faculty within discipline create their own seminars either focused on climate change solutions or incorporating climate change knowledge into pre-existing seminar courses, and 2) teams of faculty from different disciplines create collaborative seminars focused on interdisciplinary perspectives of climate change (potentially offered through individual colleges).

Freshman seminars are open to all freshmen, as well as sophomores once the freshman enrollment period has ended. Seminars are typically 1-unit courses, which may be repeated up to four times (provided the topics are different). Enrollment is capped at 20 students, providing a more intimate and collaborative experience than most other courses. Senior seminars are also 1-unit courses with similar class sizes and workloads but focused primarily on establishing faculty connections and networking opportunities for post-graduate research. Like freshman seminars, seniors may take up to four seminars (if the topics are different) This is a highly under-utilized area of study that can be easily expanded. As of Winter Quarter 2020, there are approximately 29 freshman seminars and only 3 senior seminars offered. We propose greatly expanding both these programs to incentivize students undertaking individual research, particularly related to climate change, with low commitment, low stress options such as a seminar.

The reasons for hosting freshman seminars are varied but they generally provide a sense of community and collaboration for first year students. Freshmen being introduced to college education may feel overwhelmed their first year and unsure on how to choose a major or career path. These freshman seminars provide an introduction to the structure of UCSD course load and classrooms, and they remove the stress of grades since they are graded on a pass/no pass basis. They also allow for peer bonding due to the 20 student roster limit and only require 8-10 hours total throughout the quarter through weekly meetings. Senior seminars offer similar benefits and are an easy way for students to maintain their units during senior year while potentially taking many high-level, high-stress classes. They have a similar structure to the freshman seminars but the dynamic is different. Senior students can use this opportunity to strengthen their relationship with faculty and create a network that could benefit them even post graduation. These seminars

provide seniors with the opportunity to expand their horizons before they graduate in a low-stress course load.

Climate change focused 1-unit seminars will expose incoming freshmen to topics relating to climate disruption and adaptation to empower them in the face of climate change despair or apathy. They will provide an outlook for pathways towards positive change while educating them about the reality of climate change. They will also equip outgoing seniors with necessary climate change knowledge to make sure they are graduating with an understanding of how and why climate disruption operates and what solutions are required, including solutions within their own disciplines. These seminars are an easy way to reach a much wider range of students than traditional courses. Many existing seminars have topics that already closely align with climate change related topics, such as "Earth's Fragile Biosphere" from Biological Sciences and "Atmosphere and Perspectives in Marine Biodiversity and Conservation" from Scripps Institution of Oceanography. As seminar topics change yearly, it is far easier to alter course materials or create new courses than to change pre-existing courses or to implement university- or college-wide required courses.

To incentivize students to take these seminars, they must first be aware that these 1-unit courses exist and how to enroll in them through WebReg. We recommend that their existence be advertised as part of freshman orientation, as well as by participating departments. Education of undergraduate counselors/advisors would also be helpful so they can spread the word about these course options. As seminars require a minimum of 10 students to receive funding, we think it is highly advisable for faculty and departments to email students with a specific list of seminars that are available at the start of each term. This is intended to be similar to the mass emails about DEI courses and other relevant new course advertisements. We also recommend that the climate change seminars be interdisciplinary so as not to exclude any disciplines and encourage a diverse set of students to be climate educated, which would also greatly increase the pool of students that register for these courses.

In terms of seminar creation, senior seminars can be offered by a department if it offers at least two freshman seminars during a quarter. At least ten students must enroll to receive the research payment for teaching a seminar but a seminar with less than ten may be taught without a

research payment. All eligible faculty teaching a 10+ student seminar receive a $1,000 stipend transferred to a departmental research account of their choice. These funds can cover expenses for travel, research supplies, seminar instruction enhancement, or any other purpose allowed by that account (UCSD 2019d). Faculty may teach up to 2 seminars per quarter; they may also teach the seminars in teams, although the research stipend would be split between the two faculty members. As the time commitment is only 8-10 hours per quarter, we believe that the stipend is a sufficient motivator for faculty participation. However, to reflect the need to expand the program and tailor it more specifically to climate change solutions, we suggest increasing the stipend to at least $2000/seminar taught.

In a different realm, the UC San Diego Global Seminars are five-week long summer study abroad experiences led by a UCSD professor. Students enroll in a package of two courses for a total of eight UCSD quarter units with class sizes between 15–28 students. These seminars are a great way to experience knowledge without walls and in an international setting to provide a true sense of internationalism through first hand immersion and engagement. Simply being in a culture different from one's own can awaken a natural curiosity. However, these global seminars are limited in variability and satisfy the interests of a small population of the student body. We strongly recommend expanding this program to focus on subjects and countries that are related to and impacted by climate change. There is likely no greater motivator to pursue climate change solutions than seeing firsthand the effects and impacts on communities around the world. There are less than 20 global seminars offered per academic year generally, but there is much potential to grow this program into a powerful tool of climate change study and collaborative research. To that end we recommend increasing the stipend for participating faculty as well as advertising this increase specifically to those engaging in climate change related research and teaching.

Evaluating different means of effective communication is also necessary. Students born into the 21st century know how to navigate the digital realm and are digital natives. Modern quotidian life requires daily interaction with technology and digital social platforms are tools that evolves with us to serve society’s needs. As a result, social media and the digital realm ought to be effectively utilized in dispensing climate knowledge online and even extending the climate campaign online. Therefore, as part of establishing freshmen, senior, and global seminars, it may

be beneficial to include an online seminar feature where students can follow the course load online with interactive modules, links to current events covered in global news, and relevant documentaries. The goal is to provide additional resources online so the student can explore at their own pace and interest, developing more tools and skills for individual research. The only costs in an online format are in the form of creative energy and technical capability.

Conclusion

"We are the University of California, and there is no reason that UC can't lead the world in this quest, as it has in so many others."

UC President Janet Napolitano spoke these words in 2013 at during the announcement of the Carbon Neutrality Initiative of the University of California. There is no quest more important to the world and our species than bending the curve of climate change. There is no project better to lead the way on, no project that will affect so many people in so many areas and over so many generations. With just a 1°C rise in global temperature, we are already experiencing "increased frequency and intensity of storms, hurricanes, floods, heat waves, droughts and forest fires… as well as the spread of certain infectious diseases, worsened air pollution, drinking water contamination and food shortages… [and a rise in sea levels] causing major damage in the world's most populous cities" (Ramanathan et. al 3). We are expecting a rise of at least 2°C by 2050 and between 2.5°C and 7.8°C by 2100. The results from such a large increase will have catastrophic economic, political, social, and public health implications. Integrating climate change education into the undergraduate curriculum may seem like it will yield only a small impact on preventing such consequences, but our situation is severe enough that we must utilize every tool available to fight climate change. And there is no tool more powerful than education.

"Bending the Curve" provides a ready guide for how to meaningfully engage on solutions that have incredible real world impact and alleviate the hopelessness many feel as we face such an enormous problem. With solutions oriented around six clusters covering societal changes; national and sub-national governance; science; technology; ecological management; and market incentives and regulations, the university classroom is the perfect opportunity to engage young people who could go onto careers and community service in any of those categories. UCSD has the benefit of belonging to a system of world-class research institutions with extremely talented professors and students. It is essential that UCSD play its part in the quest to lead the way on the most important issue of our time. It can serve as a living laboratory for UC and other campuses on how to meaningfully and ethically utilize the power of education in the service of both current and future generations.

UCSD has its own unique needs and constraints, and the solutions proposed within this report are designed to maximize UCSD's potential while minimizing cost and burden. Each of our four proposed solutions have their own strengths and weaknesses, and it may be necessary to continually revise them as our situation changes. Yet they provide a starting point for setting the institutional response to a serious global problem. Our first strategy, mandated climate education requirements, reflects the severity of the climate crisis and the need to engage in practical solutions relating to six diverse clusters. Our second strategy, faculty workshops on incorporating climate change education into their pre-existing curriculum, takes advantage of UCSD's greatest strength -- its diverse and talented faculty. Our third strategy, extra credit workshops offered through SRC, provides an intermediate solutions that can compensate for institutional barriers. Our fourth strategy, freshman, senior, and global seminars, utilize innovative class formats that engage students in practical solutions from all six clusters.

By determining how UCSD can incorporate such strategies into our efforts, we create a commitment to ongoing analysis of its responsibility and role to act on critical issues within both a localized and a larger global context. This process contributes to a core aspect of the societal transformation solution of creating a "global culture of climate action through coordinated public communication and education" (Ramanathan et. al 10). The lasting benefits of such efforts will be the generations of climate educators and advocates that can help bend the curve of climate disruption; the risks of failing to do so are too great to contemplate. UCSD's mission is to "transform California and a diverse global society by educating, generating and disseminating knowledge and creative works, and engaging in public service" (UCSD 2019a). This mission calls for public service of the highest need, and integrating climate change within the undergraduate curriculum is part of meeting that need and fulfilling UCSD's core mission values.

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