Impact of Student Motivations on Emerging and Recurrent Content of the UC Berkeley Environmental Science Senior Seminar

Nathalie A. Munoz

ABSTRACT

Since 1972, the UC Berkeley Environmental Sciences Senior Seminar has allowed fourth-year environmental science students to design and conduct individual, year-long research projects. These research experiences give students opportunities to enrich their undergraduate academic experience, network with faculty, build their resumes for future employment and graduate school, and gain specialized knowledge and skills (Rodriguez-Amaya et al. 2018). Since students are given the agency to select their own topic, I sought to understand their motivations and experiences throughout this process as well as observe the evolving content of UC Berkeley Environmental Sciences senior theses. Using discourse analysis on senior theses written since 1990, I observed trending and recurrent topics, methods, and stakeholders. Discourse analysis allowed me to identify prominent applied frameworks, and proposed solutions and recommendations to environmental challenges. I also conducted surveys of past and current seniors to identify their motivations and experiences behind selecting a research topic. I followed this up with interviews of current and previous instructors from the senior seminar to illuminate the seminar's changing pedagogical structure. I found the theses to collectively grow in complexity from their efforts to confront more interdisciplinary topics while using more involved research methods and concluding with more dynamic implications and recommendations. This parallels the growing demand, but slower implementation, of interdisciplinary research into the greater field of environmental sciences (Sivakumar 2012; Rodela and Alasevic 2017; Rosa 1999; Allyon et al. 2018). Additionally, survey results suggested there was a relationship between lack of proper training and preparation and conducting robust social science linked interdisciplinary research projects. I recommend that the ES major continue to provide accessible mentors and provide more educational opportunities prior to the seminar, especially for students with social science oriented theses. I conclude with recommendations to further update the pedagogical structure of the senior seminar to provide students with more successful, interdisciplinary, collaborative *and* independent research experiences.

KEY WORDS: Discourse Analysis, Pedagogy, Epistemology, Independent Student Research

INTRODUCTION

The process of independent research and writing for university students can be a rewarding, challenging, and insightful experience. It is also presents an opportunity for practicing self-discipline, time management, networking, and critical thinking abilities. As with many other STEM fields, the opportunity to conduct undergraduate research renders student comprehension and communication of vast and multifaceted fields like environmental sciences more fluent and effective (Colthorpe 2017; Novak 2017; Balgopal 2017). Today's college students will make up the next generation of environmental professionals and researchers to tackle environmental problems. Therefore, student motivations and experiences in performing undergraduate research, particularly in environmental sciences, is a fruitful and relatively new area of research (Bezzi 1999; Smith et al. 2013).

What seems to lie ahead in the next chapter of student environmental research is the influence of an expanding web of knowledge produced by intersecting fields within environmental sciences (Rodela 2017). This becomes important when tracing preliminary student motivations and research endeavors because students can then be re-envisioned as the next generation of ES researchers with their own interests, priorities, and approaches to future environmental challenges (Smith et al. 2013). Additionally, this could illuminate how academic institutions facilitate student accumulation, reproduction, and communication of environmental knowledge. Moreover, identifying challenges students face in conducting research can help academic institutions improve their pedagogical structure to research mentorship and curriculum (Bezzi 1999).

In the case of the UC Berkeley Environmental Sciences Senior Seminar (ESSS), students conduct year-long individual research projects; expanding the greater landscape of environmental sciences (ES) at UC Berkeley to include student incite and contemplation on the most pressing environmental challenges (Mendez and Spreyer 2014). Preliminary research suggests trends in emergent and recurrent topics of research students pursue, what kind of frameworks they use to approach such topics, and conclusions they eventually assert. The objective of my own thesis is to reveal what the content of UC Berkeley ES senior theses encompasses and how it has changed over time, coupled with student motivations to select and conduct their research. I approach this by focusing what applied frameworks students use to approach their topic, as well as who students identify as key players, and finally, outlined greater implications in their discussions and

conclusions. I anticipate finding topics to evolve in their adoption and integration of different research fields and language because this is the natural direction discursive language in research takes (Sivakumar 2012).

BACKGROUND

The ES major, established in 1972, was originally housed in the Interdisciplinary Studies Department between the College of Letters & Science and the College of Natural Resources (CNR). By 2010, CNR housed it exclusively in the Department of Environmental Sciences, Policy, & Management (ESPM). The ES senior seminar was also established in 1972 as a capstone course offering ES majors the opportunity to conduct individual research with a faculty mentor and to perfect student's writing skills. In an interview with Doris Sloan, an instructor of the seminar for 20 years, she stated that in students conducted research for the latest and most pressing bay area and on-campus environmental issues like energy use, seismic safety, and urban development. This in turn made students all the more competitive when they entered the workforce or applied to graduate school. Furthermore, she stated that theses like Allison Turner's from 1982 entitled "Historical Shoreline Changes: Natural and Artificial," had conducted such innovative groundbreaking work on local shoreline development that local planning agencies from around the bay area kept asking Doris for copies of the thesis years after it was published. To choose such ambitious thesis topics, for the first 20 years of the seminar, students would gather ideas to be voted on by their class in order to have one umbrella subject area for the whole class. Then, students using this general umbrella topic as a guide, would choose their own individual and more specific topic. Due to the growing class size and over-broadening umbrella topics, students were gradually given more liberty to select their own topic without a broader theme. Then from 2000 onward, students chose their own topics independent from any general theme or topic.

The ES senior theses, analogous to the broader "field" of environmental science, has come to encompass a variety of disciplines, frameworks, and research methods. While this can be interpreted as the overall unification of collective environmental knowledge within research, it can also result in a variety of different, albeit equally legitimate, scientific lenses for studying and interpreting our environment (Sarewitz 2004). Moreover, ES majors have historically had a broad range of course work, personal experiences, mentors, organization affiliations, and varying degrees

of preliminary knowledge in their topic. This implies that along with students' personal and academic experiences, students' political, cultural, ethical perspectives also frame their research findings (Balgopal 2016; Sarewitz 2004). In addition to their own personal backgrounds, ES students must also select one of three concentrations (biological sciences, social sciences, or physical sciences) within the major and their upper-division coursework allows them to expand their knowledge within one of those concentrations. Ultimately, this leads to an even more diverse selection of thesis topics since the number of students in the seminar is growing along with their varying interests and expertise within the ES major.

Academics and professional researchers also have this dimension of personal and academic backgrounds playing into their research (Sarewitz 2004). Therefore, a multidisciplinary research approach, in which researchers from different disciplines work together, drawing on their own knowledge, but still working on resolving their own problem within their own discipline, has been the most effective means of examining the many dimensions of environmental problems that cannot be adequately addressed with one discipline or mode of inquiry (Janssen 1996; Carlin et al. 2017). However, recently there has been a growing demand for interdisciplinary research, which integrates different knowledges and methods from varying disciplines into one problem which also generally determines what kind of researchers should be involved (Janssen 1996; Rodela 2017; Rosa 1999), has been called to be integrated into the environmental sciences research landscape due to the constant stream of new data and findings from multiple disciplines (Rodela 2017; Sivakumar 2012; Allyon et al. 2018). Students, in this case, will then continue this trend of using more interdisciplinary approaches to examine more intersections that underpin scientific fields in order to more comprehensively and holistically address social and environmental issues (Hilde and Kampen 2018).

Even though limitations to what one discipline can provide for addressing environmental systems and mechanisms, interdisciplinary research methods can more holistically address and even identify further gaps in knowledge (Allyon et al. 2018). Some scholars, however, have criticized it for going 'too far' beyond the bounds of tangible resolutions and for being too abstract in its conclusions since so many moving parts of the problem must be considered (Rodela 2017). At the same time, engaging with different parts of the moving problem, such as power dynamics and stakeholders, especially in identifying all relevant forms of knowledge, becomes critical in assessing environmental challenges (Hall et al. 2017; Hilde and Kampen 2018; Kaijser and

Kronsell 2013; Ravera et al. 2016). So, interdisciplinary research methods may better address environmental sciences research issues, but just like new fields of research, they will take longer to integrate into the landscape of institutional methods of environmental research.

Revisiting the process of academic institutions facilitating student accumulation, reproduction, and communication of environmental knowledge, it is important to also highlight the epistemic underpinnings driving independent student research. What beliefs students have about the nature of knowledge production and 'knowing' frames how they understand their research experiences as well as their greater educational experiences (O'Donovan 2017). Research has found that university students can face conflicts with their own concepts of environmental knowledge, gained through their own experiences and further accessed by the professor, the 'holder' of knowledge, and their professor's concept of environmental knowledge generated via evidence of their own research (O'Donovan 2017; Crooks 2017; Lekhi and Nashon 2016). Therefore, in order to best facilitate students in asserting their claims with their own reproduction and communication of environmental knowledge in a research setting, they must have collaborative support from their peers, mentors, and instructors throughout their college education (Condrasky et al. 2018; Kniffin and Hanks 2017; Griffeth et al. 2016).

While there are also multiple ways students can begin reproducing environmental knowledge, I will be focusing on six types of frameworks: managerial, reformist, economic, political, theoretical, and philosophical. Managerial frameworks are thought to be more technical and largely supportive of established knowledge. Reformist frameworks are considered to challenge institutional narratives and knowledge, take initiative to implement new systems or even overhaul existing systems. Economic frameworks are identified as cost-benefit oriented with incentives for industry and outlined optimized financial objectives for varying entities. Political frameworks can have two different approaches, one being government-related and the other aimed at exposing power dynamics amongst different players. Lastly, theoretical frameworks introduce and define a theory that explains why a research problem exists while a philosophical framework outlines basic sets of beliefs that guide action, implied principles or systems, respectively.

To further expose the implications behind these dimensions of student research and knowledge reproduction, discourse analysis may serve to clarify how students' environmental discussions take place and make an impact in ES research on a broader scale (Hyland 2005). Discourse is thought of as the ensemble of written and spoken communication that people, in this

case the students, use to create the 'meaning' behind these practices of communicating knowledges and ideas (Brown and Sovacool 2017; Hajer and Versteeg 2005). Additionally, discourse analysis is very critical of these meanings and 'truths' which puts an emphasis on the mechanisms constructed by social and scientific norms used to exchange environmental knowledge (Hajer and Versteeg 2005). An example of this is how intersectionalities within environmental issues such as race, class, and gender are framed in a way that implies desired social change (Ho and Ang 2018; Kaijser and Kronsell 2013; Balgopal et al. 2016; Ravera 2016). Therefore, in the case of student writing, discourse analysis may be used to observe the blend of recurring (yet evolving) and emerging content that exist within UC Berkeley ES senior theses as they establish new knowledge on with the help of institutional ES research and its already established knowledge.

METHODS

To address my research questions regarding the identification of changes to environmental topics and discourse within the senior theses, I used discourse analysis on seminar theses in intervals of five years since 1990. I focused on chronological changes to different research topics' discourse via frameworks used and outlined broader implications. I also used surveys of past and current seniors and interviews of current and previous seminar instructors to elucidate the seminar and larger ES major pedagogical structure.

Data Collection

To observe content over time, I began by collecting cross sections of the online senior thesis archive, which stores every seminar cohort's projects beginning from 1972 to 2016. These cross sections of the seminar archive were class cohorts taken in five-year intervals beginning in 1990 and ending in 2015 (Table 1). Once I obtained these cross sections, I read through each thesis to identify the title and abstract (and eventually by 2010, I also identified their own key words list which was at the bottom of their abstract). Using the content analysis software Atlas T.I., I then used their titles and abstracts to create specific quotations from components such as the title, the objective statement, methods used, and implications/ recommendations. If a summary of methods

was not clearly stated in a given thesis abstract, I searched the thesis methods section to identify the research methods used and created a quotation for methods used there.

Coding

To identify the content of theses and detect changes within discourse, I created and organized content codes regarding subject area, approach/methods, and future implications using the quotations I collected from each sampled thesis. For subject area, I organized codes into the three ES major concentrations, major fields/ concepts, and specific topics within those fields (Table 1). I then categorized the approaches and methods codes into frameworks, specific methods used, types of data (quantitative and/or qualitative), and locations (Table 2). Finally, for future implications, I categorized the codes into key players and stakeholders and future outcomes/recommendations (Table 3). As I went through the theses, I created more codes as I identified more topics and fields I may have missed in my initial creation of the codes.

Surveys and Interviews

To identify student motives for selecting and researching their thesis topics, I used online survey software, qualtrics, to design and administer my survey to past and current ES students on their demographics, what their thesis topic was, which concentration they thought their thesis fell into, what motivated them to select and write their topic, and also more questions on the institutional support they may have felt they received (Appendix A).

In order to learn more about the student motivations and changing composition of the senior seminar, I interviewed three past instructors of ESPM 175/196 (Appendix B) from different periods of the class. One instructor had taught the course for twenty years, another taught for three, and the other instructor taught for seven years. I asked about their background such as what they specialized in, how long they had taught the seminar for, as well as what other classes they have taught. I also asked about their perspectives on students and their work, such as what they thought motivated and challenged students the most and how they might have seen student topics and interests change.

RESULTS

General Science Concentrations

Textual analysis of the content revealed increasingly complex topics that reflected students' most popular interests at the time. As expected, new topics emerged every year while the consistently represented topics flourished in complexity and multidisciplinary methods. **Figure 1** demonstrates this at a larger scale tracing the science concentrations students chose to use alone or as a combination for the background knowledge of their research. Biological/physical, biological, and social science centered topics were the three most prevalent concentrations, albeit with biological and social science centered theses developing gradually behind. On the other hand, physical science alone along with the integration of all three concentrations, also thought of as the interdisciplinary approach, remained low, although the interdisciplinary approach is on an upward trend.

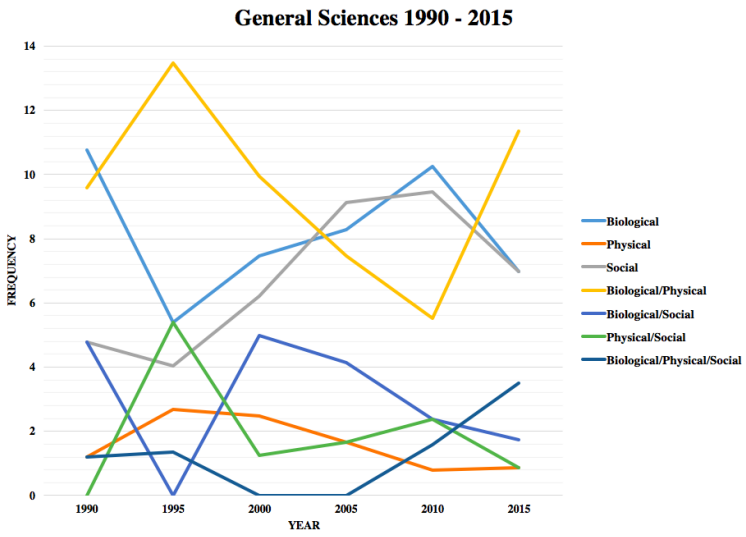

Figure 1: Trend of combining general sciences

One striking observation is the inverse relationship between the frequencies of social or biological science centered theses against the biological/physical science centered theses. Physical/social science and biological/social science also showed fluctuation and eventual decline in 2015. Biological/physical sciences, however, faced the most amount of fluctuation, particularly

as social and biological sciences centered theses gained traction becoming the most prevalent amongst concentrations in 2005 and 2010, respectively.

Popular Topics and Frameworks

New topics and language emerged every year while the consistently represented research topics and concepts flourished in complexity and background knowledge. **Table 1** lists the top 20 most popular topics and general concepts chosen per year. The most common and popular topics

Table 1: Top 20 Topics 1990 – 2015

1990	1995	2000	2005	2010	2015
Restoration	Pollution	Public Health	Wildlife Ecology	Wildlife Ecology	Wildlife Ecology
Wildlife Ecology	Water Systems	Restoration	Attitudes & Behavior	Attitudes & Behavior	Climate Change
Human Impacts/ Activities	Conservation	Wildlife Ecology	Conservation	Economics	Toxicology
Baseline Data	Restoration	Water Systems	Water Systems	Food Systems	GIS
Food Webs	Wildlife Ecology	Agriculture	Food Systems	Water Systems	Water Systems
Conservation	Agriculture	Chemistry	Economics	Climate Change	Modeling
Urban Development	Attitudes & Behavior	Education	Government	Conservation	City Planning
Public Health	Toxicology	Environmental Justice	Chemistry	Government	Economics
Marine Biology	Economics	Toxicology	Education	Public Health	Restoration
Water Systems	Energy Consumption	Attitudes & Behavior	Energy Consumption	Consumerism	Soil Science
Bacteriology	Global Warming	City Planning	Pollution	Genetics	Food Systems/ Justice
Education	Aquatic Ecology	Conservation	Public Health	Media Discourse	Energy Consumption
Fossil Fuels	City Planning	Food Webs	Restoration	Toxicology	Pollution
Toxicology	Government	Forestry	Transportation	Restoration	Public Health
Attitudes & Behavior	Public Health	Pesticides	City Planning	Education	Education
Environmental Health	Transportation	Pollution	Genetics	Sustainability	Sustainability
Environmental Degradation	Atmospheric Science	Technology	GIS	Energy Efficiency	Drought
Forestry	Biochemistry	Atmospheric Sciences	Environmental Justice	Botany	Environmental Justice
Infrastructure	Botany	Bioremediation	Marine Biology	Chemistry	Carbon Sequestration
Media Discourse	Chemistry	Consumption	Recycling	Drought	Media Discourse

included wildlife ecology, education, public health, conservation, restoration, and water systems, and urban development but it became more engrossed in city planning. Some emergent topics include environmental justice, food systems and food justice. This illustrates how student interests in the most pressing environmental challenges can change with time. As for the subtopics and language students implemented into their research, it consisted of buzzwords and existing terminology of theoretical concepts they would introduce. **Table 2** highlights the progressively complex topics and language associated with water, food, and development per year. There are overlaps between these concepts, exposing the interdisciplinary developments students recognize within their environmental inquiries.

Table 2: Developing Concepts and Language

Year	Water	Food	Urban Development	"Eco-"
1990	Water Quality Water Holes Waterfront Water Systems Waterfowl Water Shed Waterways Rising Sea Temperatures	Food Supplements Animal Feed Food Webs	Urbanization City Development Parks Departments Developers	Ecological Ecology Ecosystem
1995	Waste Water Water Conservation Water Quality Water Systems Waterways Water Safety Waterfront Waterfowl	Community Gardens Food Storage Agriculture Nutrition Mobilization Food Crops Foraging	Residential Development Industrial Development Community Garden Spaces Developers Urbanization City Planning	Ecological Ecology Ecosystem
2000	Department of Water Resources Urban Storm Water Urban Streams Urban Creeks Waste Water Watershed Water Quality Water Systems Waterways	Farmworkers Agriculture Food Webs Agribusiness Pesticide Exposure Feeding Ecology Cooking Fuel	Transportation Development Urban Heat Island Effect Urban Pollution City Planning Developers Urban Streams Urban Creeks Urban Storm Water	Ecological Ecology Ecosystem Ecodevelopment Ecophysiological Ecotourism Ecotoxicology
2005	Waste Water Water Consumption Water Quality Watershed Urban Runoff Waterbodies Waterfowl Waterfront Watercourses Water Science Waterways	Genetically Modified Foods Food Security Food Waste Food Systems Restaurants Food Web Agriculture Agricultural Drainage	Urban Environment Urban Forestry Urban Landscape Urban Wildlife Urban Runoff	Ecological Ecology Ecosystem Ecocentric Ecography Ecotoxicology Ecotype
2010	Waste Water Water Conservation Water Consumption Water Quality Water Demand Water Engineering Water Availability Water Content	Food Access Food Insecurity Food Quality Food Systems Food Waste Food Initiatives Food Policy Food Education Farmworkers Food Contamination Genetically Modified Foods Cooking Fuel & Equipment Urban Agriculture	Urban Water Demand Urban Agriculture Urban Ecology Urban Forestry Urban Food Waste Transportation Development Developers	Ecological Ecology Ecosystem Ecoscience Ecotoxicology Ecotype
2015	Rising Sea Temperatures Stormwater Water Quality Flooding Hydrological Properties Freshwater Ecology Watershed Water Systems	Consumer Food Perceptions Food Webs Food Supply Food Systems Food Waste Food Safety Urban Agriculture	Urban Agriculture Urban Water Demand Urban Ecology Urban Forestry Urban Food Waste Urban Land Use Urban Planning City Planning Urban Climate Resistance Urban Sustainable Development	Ecological Ecology Ecosystem Ecocentric Ecography Ecotype Agroecology

One example not included in this list but is quintessential to observing developments to discourse is the case of climate change. Students initially discussed rising sea temperatures in order to show evidence for 'global warming.' By 2000, however, students, researcher, and politicians were no longer using 'global warming' to describe such manifestations of changes in the physical and biological world, and instead, referring to this phenomenon as 'climate change.'

These topics are coupled with developments in applied frameworks by students ranging from economic, to reformist, to philosophical approaches. From **Table 3**, there are notable developments in economic, reformist, and political frameworks. The managerial framework was sustained as the most prevalent approach to ground theses and conduct research.

Table 3: Frameworks used to approach research discussion

Frameworks	***1990***	***1995***	***2000***	***2005***	***2010***	***2015***
Managerial	21	19	23	25	24	28
Reformist	6	3	5	9	13	8
Economic	5	10	9	13	24	19
Political	3	2	4	9	13	10
Theoretical	0	2	2	3	6	4
Philosophical	0	0	0	1	3	2

Applied Methods

With the topics and frameworks to outline and facilitate the rest of the research projects, the appropriate methods are determined by the student. **Table 4** shows the expansion of applied methods per year. Students introduced more software and digital methods of collecting data as time went on coupled with the continued and traditional methods of research like surveying and water quality testing for contaminates. This showcases how ES students have developed a plentiful repertoire of methods in order to pursue their environmental inquiries.

Table 3: Applied Methods for Conducting Research

YEAR	*METHODS*
1990	Comparative Analysis, Experimental, Survey, Census, Field Study, Monitoring, Interviews, Modeling
1995	Comparative Analysis, Experimental, Survey, Field Study, Monitoring, Interviews, Modeling, Water Quality Testing*, Cost-Benefit Analysis*, Air Quality Testing*, Greenhouse Study*, Optimization*
2000	Comparative Analysis, Experimental, Survey, Census, Monitoring, Interviews, Water Quality Testing, Air Quality Testing, Greenhouse Study, Optimization, Case-Study*, Bio-assessment*
2005	Comparative Analysis, Experimental, Survey, Field Study, Monitoring, Interviews, Modeling, Water Quality Testing, Cost-Benefit Analysis, Air Quality Testing, Greenhouse Study, Life Cycle Analysis*, GIS*
2010	Comparative Analysis, Experimental, Survey, Interviews, Modeling, Water Quality Testing, Cost-Benefit Analysis, Greenhouse Study, Case-Study, Gene Sequencing*, Discourse Analysis*, Inventory*
2015	Comparative Analysis, Experimental, Survey, Census, Field Study, Monitoring, Interviews, Modeling, Water Quality Testing, Cost-Benefit Analysis, Air Quality Testing, Greenhouse Study, Case-Study, Life Cycle Analysis, GIS, Discourse Analysis, Content Analysis, Mapping*, Optimization*, Remote Sensing*

Identifying Stakeholders and Key Players

As students began introducing the environmental challenge they would be investigating, they would identify stakeholders and key players of the issue at hand. **Table 5** lists stakeholders and key players students identified per year. Overall, there was an emergence of general awareness for the social aspect to environmental challenges as more stakeholders and key players involved in environmental issues were identified. These players also derived from different scales of power and knowledge from within the same communities or entities.

Table 5: Identified Stakeholders and Key Players

1990	1995	2000	2005	2010	2015
General Public	General Public	General Public	General Public	General Public	Community/Neighborhood
Children	Community/ Neighborhood	Children	Community/Neighborhood	Children	Government (Agencies)
Community	Government Agencies	Community/Neighborhood	Government (Agencies)	Community	Business/Industry
(City) Government	Business/ Industry	Government (Agencies)	Business/ Industry	Government (Agencies)	NGO's
Business/ Industry	Science Community	Business/ Industry	College Students	Business/ Industry	High School Students
NGO's	Consumers	Elementary Students	Consumers	Elementary Students	College Students
Students	Academic Institutions	Science Community	Academic Institutions	College Students	Citizen Scientists
Developers	Developers	Academic Institutions	Farmers	Consumers	Consumers
		Farmworkers	Voters	Academic Institutions	Academic Institutions
		Educators	Native Americans	Voters	Farmers
			Media Outlets	Media Outlets	Educators
			Households	Immigrants	Media Outlets
			Work Force	Minorities	Education System
			Pastors	Households	Ranchers
				Work Force	Small Business Owners
					Municipal Employees
					Women

Outlined Broader Implications and Recommendations

Because of broadening topics and stakeholders, students could begin to make more dynamic and specific recommendations while outlining more holistic implications involved in the conclusions of their research. In **Table 6**, the progression and more specified environmental impacts and recommendations posed by students are listed per year.

Table 5: Outlined Broader Implications and Recommendations (*) indicates new appearance; italicized = recommendation

1990	1995	2000	2005	2010	2015
Public Health	Public Health	Public Health	Public Health	Long-Term Impact	Public Health
Long-term Impact	Restoration	Restoration	Long-term Impact	Restoration	Long-term Impact
Restoration	Recreation	Stewardship	Recreation	Stewardship	*Change* in Practices
Recreation	*Change* in Practices*	*Change* in Practices	*Change* in Practices	Lifestyle	Environmental Justice
Human Impacts	Collaboration*	Environmental Justice	Environmental Justice	Conservation	*Reduce* Human Impacts
Stewardship	Eradication*	*Improve* Communication	*Improve* Communication	*Change* in Practices	*Incentivize* *Change* in Attitudes & Perspectives
Improve Education	Environmental Justice*	*Reduce* Human Impacts	Global Perspective	Environmental Justice	*Change* Pricing*
Ecological Impact	*Improve* Communication*	*Improve* Education*	*Improve* Education	*Improve* Communication	*Change* Government Regulation*
Lifestyle	*Provide* Resource Access*	*Improve* Technology*	*Reduce* Consumption	*Provide* Resource Access	*Change* in Diet*
Conservation	*Reduce* Emissions*	*Reduce* Consumption*	Waste Reduction*	Waste Reduction	*Improve* Science Literacy*
	Reduce Human Impacts*	*Incentivize**	*Invest**	*Change* in Attitudes & Perspectives*	*Increase* Land Cover*
	Global Perspective*			*Change* Policies*	*Increase* Awareness*
				Outreach*	*Increase* Support *
				Reduce Emissions*	*Reduce* Food Waste*
					Inform Decision Makers*

Similar to the classified stakeholders and key players, students progressively made more direct and personalized recommendations that were solutions the audience could more easily act on than more systematic and institutional changes stipulated like improvements to education. Overall, content and discourse analysis were able to convey how students are incorporating and merging together distinctive sectors of environmental research.

DISCUSSION

This section examines the notable details and potential factors that affected the progression and developments in the content of every sampled year of senior theses. Furthermore, changes to pedagogical structure occurring throughout the senior seminar are also traced in this discussion. Throughout these sampled years, 14 different instructors had taught the seminar, of which four were interviewed to inform their pedagogical organization of the seminar as well as their perspectives of changes to students' topics of interest and general experiences in the seminar.

The Content

1990

This year was the last year students collectively voted on a narrower environmental subject that would guide them to choose their individual research topic. 'Conservation and Restoration in SF Bay' was the theme of this year, mostly centered around natural science and human impacts and interactions with the environment throughout the Bay Area. Tod Fletcher, Ph.D. and Doris Sloan, Ph. D. instructed this cohort of seniors with Doris, stating an interview, that she specialized in geology and physical science. Student topics collectively identified restoration and conservation as a way to ensure stewardship of the local parks and recreational sites with the added long-term goals of changes to areas like education, behaviors, and public valuation of the environment. Frameworks were mostly managerial yet contained an element of a reformist attitude in approaching management systems and policy recommendations.

Research methods focused primarily on creating baseline data to assess human and ecological impacts around local marshes, ponds, and lakes. No students used formal interviews, however, some did explicitly refer to conversations they had with specialists and experts in building their arguments and discussions. The identified stakeholders and key players, introduced at different scales of power and behavior but comprised who would typically be identified in an environmental problem at local scales (Bartone et al. 1994). Greater implications that students outlined in their concluding remarks were aimed mostly at encouraging stewardship of recreational spaces and increasing public awareness of long-term ecological impacts.

From this content, I consider this year to be what I would call the 'usual suspects' within conservation and restoration efforts of the Bay Area. This is due to environmental researchers of the time largely speaking to concerns of human-centered environmental impacts of the growing human population and as being further effected by extremely sensitive to economic and technological conditions (Stern 1993). This sampled year then sets the tone for the rest of the years to follow as the baseline topics, stakeholders and key players, and implications students incorporate into their theses.

1995

Just after 1990, the classes were starting to get too big in size and Professor Sloan decided to divide the class into two halves. One group worked under one of the last umbrella topics used in the seminar, "Environmental Issues in the Bay Area: Local to Global," and the other group was allowed to choose their topic completely independent from any umbrella topic. This year saw an increase in biological/ physical and physical/social science centered topics and a decline in biological and social science centered research projects. These thesis topics were still positioned largely around conservation and restoration in wildlife ecology, however, the methods being used are more diverse and more sophisticated like formal interviews, greenhouse studies, cost-benefit analyses, modeling, etc.

Frameworks started to incorporate a global perspective and used a managerial and economic approach. This could be because of the historically growing neoliberal approaches in research, policy, and management toward mitigating environmental challenges (Hoeg and Bencze 2017). This is further supported by students identifying stakeholders and key players that included consumers. At the same time, while there was a decrease in the social and biological science centered works, there is further evidence of students beginning to utilize interdisciplinary research topics. Their outlined implications and recommendations students identified more reflective community oriented goals like providing communities with access to necessary resources and even addressing environmental justice concerns.

2000

By 2000, Doris Sloan had retired after teaching the seminar for 20 years, leaving Tom Dudley and Kevin Kennedy to lead the seminar. In an interview with Tom Dudley, he stated that he tried to focus the class more on appreciating the experiential learning process by slightly devaluing the grading process to take off some of the pressure for students. Topics in this cohort continued to diversify in many fields like botany, fire practices, medicine, pharmaceuticals, recycling, tourism, toxicology. The identified frameworks were again, mostly managerial based and economic based with some attention to a theoretical background that create a wide stratification of implications and recommendations. Stakeholders and key players exist at many scales with a lens of inclusion and acknowledgement of importance of community based knowledge and participation in environmental problem solving. Implications and

recommendations were a spectrum of outlooks outlined by actions different entities can achieve such as improvements to education practices, identifying inconclusive results, more policy recommendations, decreasing consumption, and implementing specific conservation practices.

2005

This year was taught by John Latto and Cristina Castanha. Dr. Latto, as detailed an interview with Tom Dudley, was responsible for helping improve certain technological resources like internet access and emailing starting in 2000 to students. This year saw a significant surge in new topics while students also expanded their scope to look throughout the state of California to work on projects. Topics primarily focused on the human dimension in environmental impacts in a participatory way, rather than just their listed and well known impacts. Methods in this year catered to cost-benefit analyses and comparative analyses which can be seen from the spike in economic language and identified methods. Frameworks overwhelmingly managerial although there is one thesis that frames itself philosophically. With the notable increase in social and physical science identified projects, broader implications tended to be far more diverse, to the point of contradiction. This could be supported by outlooks on issues of the time involving a presidential administration who did not support most environmental measures and so perhaps students tried to work with that mind frame at the time by using an economic framework in order to make stronger arguments that could appeal to an economic/ supply driven policy makers. With stakeholders and key players, there is continued acknowledgement of diverse actors such as Native Americans and hazardous waste facilities. Implications and recommendations were more reformist yet some still called for no need or change for certain practices, but in this instance that was because they wanted to keep seeing how the process was developing without any interruption.

2010

This year is significant because it marks the introduction of the most recent pair of seminar instructors, Patina Mendez and Kurt Spreyer, who come from different, but complementary backgrounds in ecological and environmental historian concentrations respectively. This pair of instructors have been teaching the seminar for the longest amount of time, second to Doris Sloan so they have the most accurate insight on the last 10 years of student projects and trends. This is also the beginning of a new era for CNR since there was a growing demand of coursework for

food related issues. Topics continued to diversify and were very relevant to issues of the time including work on native bees, cannabis, impacts from the California drought, and immigration.

Methods were diverse and helped conduct cost-benefit to gene sequencing research. Frameworks had a much more reformist perspective despite continual dominance in managerial approaches. There was sustained attention to immigrants and minority groups with a stronger sense of social justice in the implications and action items regarding these actors.

2015

This most recently sampled year was overall the most diverse and complex in topics, geographical locations, identified stake holders and key players, methods, and broader implications. This year is where the most multidisciplinary work has been observed and involves multifaceted and dynamic topics that started as more nebulous and vague concepts to become full blown fields such as urbanization (especially with respect to urban ag, forestry, wildlife, and vegetation), food systems, and climate change. Methods were, however, just as complex, but not more than in 2010. Frameworks, on the other hand, went back to being much more managerial than was seen before, but the theses still had some element of reformist approach. Curiously enough, stake holders and key players were also back to being as "traditional" as they were in 1990, however, there was much more introspective inquiry on their identities and more specific action items for these actors who reside at different scales of power. Implications and recommendations were pretty scattered for this year as well, and yet, most of the action items students outlined revolved around human benefitting outcomes within a greater ecosystem.

- The rise of "data" being the metric used to assess all of our issues [Nimmagadda et al. 2017]

Student Motivation and Influence

There were 31 respondents to the survey with almost half being man and woman identifying. Most respondents grew up throughout California while some came from different

states like Texas and Florida, and a few came from abroad like Mexico and Vietnam. Most current students and alumni live in California or the west coast.

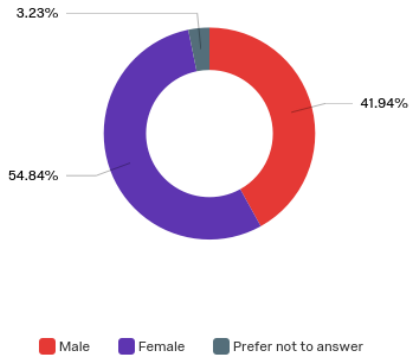

Figure 2: Gender breakdown of respondents

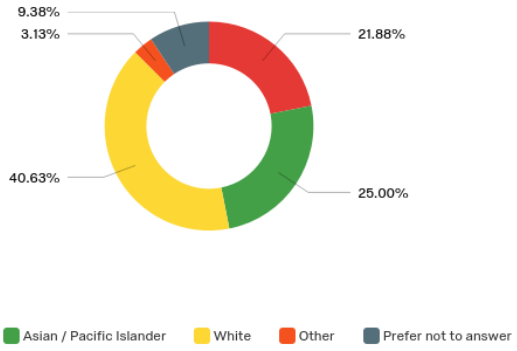

Figure 3: Race and Ethnicity breakdown of respondents

Survey respondents identified their diverse majors and minors which is what allows them to also gain exposure to potential topics they would want to pursue and can also inform them of the latest research or issues occurring in those fields.

MAJORS	MINORS
Southeast Asian Studies	Geospatial Information Systems
Comparative Literature	Spanish
Society and the Environment	Energy Resource Group
Geography	Forestry and Natural Resources
Conservation and Resource Studies	Environmental Economics and Policy
Economics	Forestry
Environmental Economics and Policy	Conservation and Resource Studies
Atmospheric Science	Demography

The biggest take away from this survey is that students understand that while the seminar is intended to be a positive, yet challenging experience that will demand a lot of their time, patience, and devotion, they still highlighted their need for more overall support and from a much earlier standpoint. On responses regarding suggested improvements, students proposed changes to the prep 100ES course taken before the ESPM 175 seminar. They also identified a need for modifying the structure of the entire ES program to allow students more time and opportunity to better prepare for such a daunting task. On the other hand, students reinforced the necessity of the seminar for as an opportunity to get research experience and improve their writing skills. To which Doris Sloan reinforced this claim when she stated in her interview that students would sometimes

come to her with little to no experience getting papers edited for them, much less for papers of this scope. She stated that they would vastly improve their writing skills by the end of the seminar yet she was surprised and worried for the lack of attention UC Berkeley gave to ensure students were submitting adequate works of writing. Beyond those two experiences, students saw how beneficial this was to making decisions about their career endeavors as well as preparing them for their lives ahead in graduate school.

Recommendations and Further Implications

In the following section, I recommend a few changes and ideas for improving the ES seminar student experience and outcomes. One recommendation is to give a teaching credit to encourage faculty to stick with students throughout the whole process, this could also be extended to graduate student instructors taking time from their schedules to do the same.

Another area of support could be from an ES alumni endowment for research so that students have more financial support if they have to purchase equipment or travel. Granted, there are existing options like reimbursements and grants provided by CNR, however, an alumni foundation for ES majors could also help them network with alumni and familiarize themselves with different career paths ES alumni have forged.

Additionally, considering the 100 ES prep course students must take the semester prior, the instructor of that course should consider inviting more professors, GSI's, ES alumni, and researchers on campus to talk to the cohort of the year. This way, students get more exposure to a variety of research projects and ideas to pursue for their own projects. While changes to this course could be helpful, more survey design courses in the ESPM department should be added or provide more survey design and/or research theory courses for social-science track students.

Lastly, I recommend bringing back option of umbrella topics while conserving the option for students to fulfill individual research topics. 100ES professors and the ESPM 175 team could collaborate to survey students about their general interests by end of ES 100 to get a sense of what they would want to do. Then, by the beginning of the seminar for the new cohort, the ESPM 175 team could have a few umbrella topics people could join and they would also have working groups earlier on. Each student would figure out their own topic and still conduct independent research, but they would still have an umbrella topic to help guide them along with their research process

and finings. This would serve as a way for some students, particularly women identifying people and minority students to have an extra element of support because research shows they thrive in more collaborative research projects (https://doi.org/10.1016/j.jesp.2012.07.008, https://doi.org/10.1007/s11031-013-9388-8, https://doi.org/10.1186/s40594-018-0105-8). Additionally, having multiple people working on small components of a research area will be able to achieve higher levels of interdisciplinary research. This would help ES students also gain exposure to a blend of collaborative and independent research they could pursue later in their career.

Limitations

This project had limitations that impeded my ability to make more accurate analyses of the theses. Such limitations included taking cross sections of the thesis seminar in 5 year intervals over 25 years instead of looking at every year from 1972 to 2016. This led to a less than accurate interpretation to changes in the content. Survey results were also heavily limited by difficulty in contacting ES alumni before 2000. Therefore, the survey results are more indicative of recent motivations and experiences of the thesis.

Broader Implications

This project sets the groundwork for a larger scale, year-by-year analysis of the change in thesis contents over time to be conducted at a future date. Seeing how student writing evolves and developed and moves with the resources available to them would be advantageous for seminar instructors, other administrators, as well as prospective ES majors who would inquire early on about the major.

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APPENDIX A: Former Senior Survey Questions

What year did you complete your environmental sciences senior thesis at UC Berkeley?

Please list any majors and/or minors aside from environmental science

Please describe your ES senior thesis topic in two sentences or less.

Would you describe your thesis as primarily being concentrated in social science, biological science, physical science, or some other area?

Please select all relevant fields that related to your thesis topic

> *Biological Science:* Conservation/ Restoration, Biology/ Microbiology, Public Health, Forestry, Ecology, Botany/ Zoology, Toxicology, Not Applicable
>
> *Social Science:* Business/ Consumers, Environmental Justice, Economics, Behaviors/ Perspectives, Policy, Media/ Discourse, Education, Not Applicable
>
> *Physical Science:* Chemistry, Geology, Atmospheric Science, Climate Change, Water Systems, Soil Science, Energy Efficiency, Not Applicable
>
> *Other:* Transportation/ Infrastructure, Urbanization, Waste Reduction/ Management, Food Systems, Technology/ Engineering, GIS/Modeling, Sustainability, Not Applicable/ Topic Not Found

Please explain briefly how your thesis supported and/or challenged established ideas on your topic ? (Ex: supporting or critiquing a conservation action plan)

What motivated you to select your topic? Please rank from greatest to least motivation (1 = greatest, 9 = least). If you selected 'other', please rank first and briefly explain. If you had a personal experience, please explain briefly as well.

> I wanted to explore this topic as a potential career field
> I thought it would help me prepare for graduate school
> I had an interest in this topic
> It was a feasible topic, considering constraints of time, funding, skills, etc.
> Personal Experience (e.g. travel, work, volunteering experiences, etc.)
> A past job or internship
> A class/ classes I had taken inspired me
> I thought it would be good research experience
> Other:_____

Please explain the ways in which your senior thesis was a valuable and/or not valuable educational experience for you.

What specific goals did you hope to accomplish with your thesis? Please select all that apply.

Improve my writing
Get research experience
Publish my writing
Networking opportunities
Work with a certain entity (e.g. NGO, non-profit, etc.)
Wanted to learn about that field
I wanted to gain a specific skill
Help me address a practical or theoretical concept/issue
Other:_____

What were the most helpful source(s) for conducting the actual research and the writing process for your thesis?

Literature
My mentor
The ESPM 196/175 instructors
My ESPM 196/175 peers
Other professors
Previous coursework
Prior work (via internship, research experience, etc.)
The prep course, 100ES
Friends and/or family
Other

How valuable was your senior thesis in helping you with the following:

Getting research experience
Making a choice about my career
Making a choice for graduate school
Learning how to network
Improving my writing skills
Improving my public speaking skills
Other:_____

How well did the ES program prepare you to engage in researching and writing your senior thesis?

Did you find the ES program offered an inclusive community for you and others? Please explain briefly.

Based on your experience, how could the ES program be improved?

With which gender to you most identify?

Please specify your race/ ethnicity

APPENDIX B: Former and Current Instructor Survey Questions

What other courses have you taught?

What is your concentration?

Why did you choose to teach ESPM 196/175?

Do you remember what students were most interested in at the time in terms of topics?

What do you think could have motivated or influenced students the most in selecting their topic?

Do you remember some of their biggest challenges or constraints?

Did you happen to see any trends or patterns in how students selected their categories?

Do you think there was any difference in the theses between the students who had you as a mentor versus those that had someone else?

Do you remember what kinds of mentors students usually had?

Was there anything that surprised you about the students' topics and/or approaches?

What did you hope students would take away from your knowledge and expertise?