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PRACTICE

Socio-environmental Synthesis: Linking Biology and Political Science Courses to Assess Hydroelectric Dam Relicensing

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ABSTRACT

This module uses a "linked-classes" approach to teaching socio-environmental synthesis. A three-week (6 class) module is taught in two different classes (one in biology, one in policy studies). Students conceptualize and conduct research around a common focal question from specific stakeholder/expert positions. Our focal question was: "Should the Federal Energy Regulatory Commission relicense the hydroelectric dams on the Cowlitz River? If so, should the dams be modified?" Using a two-step "jigsaw" approach, students first meet in their expert group, then are mixed with students from both classes and all expert groups together in a joint conference to address the original focal question. Students submit final written assignments demonstrating their contribution of expert/stakeholder knowledge and reflecting on the synthetic interaction in the conference.

KEYWORD DESCRIPTORS

- **Ecological Topic Keywords:** abiotic factors, aquatic ecology, biocomplexity, biotic factors, community ecology, ecosystems, fisheries management, human impacts, landscape ecology, population ecology, stream ecology

- **Science Methodological Skills Keywords:** data analysis, library research, natural history, oral presentation, quantitative data analysis, use of primary literature

- **Pedagogical Methods Keywords:** assessment, background knowledge, brainstorming, citizen's argument, cognitive skill levels, cooperative learning groups, concept mapping, evaluation, formal groupwork, jigsaw, problem-based learning (pbl), role playing

CLASS TIME

Three-week module, approximately 8 hours of class time.

OUTSIDE OF CLASS TIME

Students conduct literature and internet research to find data sources, and write a conference report; 6-12 hours, varies with student capacity.

STUDENT PRODUCTS

1) "What Do You Need To Know?" (WDYNTK) list and pre-synthesis system map. As a pre-activity homework assignment, students prepare a list of ideas about what they would need to know in order to answer the dam re-licensing question. Students then use their lists to create a system map depicting their own visualization and conceptualization of who would need to be involved, what information would be needed, and how to connect different stakeholders in the pursuit of an answer to the focal question.

2) Final synthesis report. Each student submits a 5-page report describing the results of their research as an "expert" and results of their collaboration and discussion with other "experts" representing different stakeholders and points of view during the Joint Conference.

3) Post-synthesis system map. After completing their research, group discussion and submission of their synthesis paper, students revise their pre-synthesis system maps to reflect their new knowledge and understanding of the issues, stakeholders and perspectives on the dam re-licensing question.

SETTING

Classroom. No special resources or infrastructure needed.

COURSE CONTEXT

Biology (Bio) 106 is the first course in a two-semester sequence required of all BS Biology and BS Environmental Science students at Washington State University Vancouver. This course is aimed toward freshmen new to the major and to the university, but there are also a substantial number of upper classmen

who have decided to switch majors or are fulfilling the requirements for health-related professional programs. As a required course for Bio and ES majors, and a pre-requisite for many upper-division courses, the syllabus is somewhat constrained. But there is some flexibility to organize the course, so long as it aligns to the learning goals and outcomes established by the School of Biological Sciences.

Political Science (PolS) 430 is an elective designed for upper division (and some graduate) students with a background or interest in public policy. There is flexibility in defining the goals of the course and the design of the syllabus. The role of environmental science in environmental policy and politics has traditionally been just one of many factors considered in the course. Students are not required to have an environmental science background.

INSTITUTION

Washington State University Vancouver (WSUV) is one of 5 campuses in the WSU system, a land-grant R1 university. The student demographic at WSUV is dominated by older (mean age ~30 years), female (~60% of students), place-bound individuals, who are often the first in their families to attend college, have at least part-time but more often full-time employment while attending college, and often have families. PolS 430 students tend to meet this non-traditional profile. About half of the students are Public Affairs majors (preparing for careers in governance) and half come from a variety of majors including some undergraduate and graduate students in Environmental Science. The Bio 106 course tends to have a slightly higher proportion of “traditional” freshmen (i.e. in early 20’s, single, recent high school graduate) since most of the students who enroll at WSUV right out of high school are seeking a Biology degree. However, enrollment in both classes is usually reflective of the WSUV student demographic.

TRANSFERABILITY

The linked classroom approach brings together students from different disciplines working on different class contents to work together on a socio-environmental synthesis project. This module could be used by any two instructors teaching two different courses, one in biology or environmental science and the other in policy studies, political science or environmental sociology.

ACKNOWLEDGEMENTS

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variety of undergraduate institutional settings. We thank all of our colleagues from the participating institutions (University of Maryland College Park, Coppin State University, Gallaudet University, Widener University) and Alan Berkowitz of the Cary Institute of Ecosystem Studies. This work benefited from support from the National Socio-Environmental Synthesis Center (SESYNC) NSF award DBI-1052875.

SYNOPSIS OF THE MODULE

Principal Ecological Question Addressed

Focal Question

Should the Federal Energy Regulatory Commission (FERC) relicense the hydroelectric dams on the Cowlitz River? If so, should the FERC require modifications of the dams?

Overview

The Federal Energy Regulatory Commission (FERC) wants recommendations from a technical advisory group (TAG) to help it decide if, and under what conditions, it should re-license the dams along this tributary of the Columbia River. FERC Chairman John Wellinghoff has requested that the TAG weigh these three alternatives: 1) should they be re-licensed as is, 2) should they be relicensed but modified to improve fish passage (e.g., improved fish ladder, barging, etc.), and 3) should one or more of the dams be removed.

What Happens

In this 3-week teaching module students in a Biology course and an Environmental Policy course work on answering our common focal research question. Within each class, students form “expert” groups to research the position of one stakeholder (such as a biologist with the State Department of Fish and Wildlife, a representative of the Cowlitz Native American tribe, or a manager for Tacoma Public Utilities, who operate the hydroelectric dam), using internet and literature searches for quantitative and qualitative data that would be relevant to the stakeholders’ expertise. We then use a “jigsaw” method to create a joint conference in which students from both classes form teams that represent the positions of various stakeholders and experts to draft a recommendation to the FERC about dam relicensing. Over the course of the module, each student produces pre-synthesis and post-synthesis concept maps of the socio-environmental system related to dam re-licensing, and a synthesis report outlining their research and results.

Module Objectives

Bio 106 course objectives:

Students who successfully complete Biology 106 will be able to:

- Understand the central concepts in evolution and ecology, as well as the structure and function of living organisms.
- Use the scientific method and critical thinking skills to explore and understand biological systems, through observation, quantitative data analysis and interpretation.
- Better communicate scientific concepts and results to a range of audiences through written assignments and oral presentations.

PolS 430 course objectives:

Students who successfully complete Political Science 430 will be able to:

- Analyze and critique public policies and political activities related to the environment.
- Identify environmental discourses and understand the implications of those discourses for who counts, who wins and who loses.
- Use theory and evidence to support and present a strong argument about environmental choices faced by local, national and global societies.
- Anticipate how environmental science and environmental politics might interact in specific policy debates.

Shared objectives for linked module:

- Develop competencies in inquiry and synthesis, including building arguments from synthesis arguments and using synthesis evidence to evaluate arguments.
- Build skills in critical and creative thinking, to see “problems” and not “disciplines.”
- Gain experience in communicating with people in other disciplines.
- Develop increased awareness, motivation and self-efficacy in socio-environmental synthesis inquiry and critique.
- Practice using visualization tools to better understand a complex and dynamic system.
- Build proficiency in making science actionable.

Equipment/ Logistics Required

No special equipment is required to teach this module, although students should have easy access to computer resources.

Summary of What is Due

1. "What Do You Need To Know" List and Pre-Synthesis System Map (See Appendix A)
   Introduce focal question, students prepare list of WDYNTK
   Meet in small groups to develop system map
   Students draw individual system map and turn in at the end of class

2. Participation in Expert Research and Analysis and Expert Group Meeting (Jigsaw One)
   Students assigned to expert/stakeholder groups
   Students individually research focal question from the perspective of expert/stakeholder
   Students meet to present and collaborate with others in the same expert group

3. Participation in Joint Conference (Jigsaw Two)
   Students prepare materials for Dam Relicensing Conference
   Students participate in joint conference (Jigsaw exercise)

4. Final Synthesis Conference Report and Post-Synthesis System Map (See Appendix B)

DETAILED DESCRIPTION OF THE MODULE (FOR STUDENTS)

Introduction

The issue:

The Cowlitz River is a major tributary of the Columbia River, and has historically supported large seasonal runs of several Pacific salmon species and steelhead trout. Tacoma Public Utilities, the city-owned company that provides electricity service to Tacoma and its surrounding area, owns and operates two hydroelectric dams that were built in the 1960's on the Cowlitz River.

All utility-owned hydroelectric dams in the United States are under the jurisdiction of the Federal Energy Regulatory Commission (FERC), and must be licensed to ensure the dams are operated safely and with sufficient environmental protections and resource improvements. Dam licenses are issued for up to 30-50 years. When the hydropower dam license expires, the dam owner must renew it through an administrative process called re-licensing.

In the re-licensing process, the FERC must consider not only the power generation potential of a river, but also give equal consideration to energy conservation, protection of fish and wildlife, protection of recreational activities,

and preservation of environmental quality. Dams may be re-licensed "as is" or they may be re-licensed after modifications that improve protections for fish and wildlife. Dams may also fail to receive re-licensing approval, which may necessitate substantial modification or complete dam removal.

The question to consider:

Should the Federal Energy Regulatory Commission (FERC) relicense the hydroelectric dams on the Cowlitz River? If so, should the FERC require modifications of the dams?

Your assignment:

Your assignment consists of four parts. In Part 1, you will construct a pre-synthesis "system map" to visualize the range of information and stakeholder positions you would want to know related to the focal question. In Part 2 you and several other students from your class will be assigned to one of the stakeholder groups that you identify in your system map, and then each of you will write a short paper (about 4-5 pages including references) summarizing the interests and positions of your stakeholder on the issue of re-licensing the Cowlitz River dams.

Parts 3 and 4 of the assignment are two phases of a "Salmon and Dams Conference." During Phase 1 of the conference, you will present and discuss the position of your assigned stakeholder group with others in your class who have researched the same position. For example, you may be a member of the group representing biologists from the US Department of Fish and Wildlife; therefore, your group will need to find and present data and information related to the abundance, diversity and reproductive capacity of salmon populations in the Cowlitz River. Or you could be assigned to the group representing the management of Tacoma Public Utilities, and be prepared to show data regarding power generation of the dams and existing systems for allowing fish passage through or around the dams. This is your "expert" group.

At the next class meeting, you will then participate in Phase 2 of the conference, in which students from both classes (Biology 106 and Political Science 430) will meet together. You will be re-assigned into new groups made up of representatives from each expert group to discuss the question of dam re-licensing, and ultimately make an argument to the FERC about how they should proceed. After the culminating conference, you will have two days to make edits and additions to your original expert report, and add a summary of the conference. You will also revise your initial system map, based on knowledge gained from the conference, and include the post-synthesis map as an appendix to the report.

Materials and Methods

Overview of Activities and Assignments

1) **Introduction to the Problem and Framing the System**
   Before you can propose answers and solutions to the question of whether the Cowlitz River dams should be re-licensed, you need to first understand and conceptualize the socio-environmental system that surrounds this issue. In this step you will first develop a list of ideas about what you would need to know about the issue in order to find solutions. Then you will participate in a small group exercise to visualize these ideas and place them into a pre-synthesis "system map."

2) **Expert/Stakeholder Group Work**
   You will be assigned to a small group with other students in your class that represents a particular "expert" perspective or "stakeholder" in the dam re-licensing issue. You will work within your "expert" group to identify what the perspectives of your stakeholder would be relative to the question of dam re-licensing, and devise a plan to identify the data and information you will need in order to represent that stakeholder position at the joint conference/presentation to the FERC.

   You will be guided through this process in your respective class (Biology or Political Science), including lectures and discussion about the topic, and reading assignments to support the discussions.

3) **Joint Conference**
   Students from both classes (Bio 106 and PolS 430) will gather together, and form new teams that have representation from each expert/stakeholder group. In these teams, you will describe your results from the expert group you represent as well as listen to and discuss the results from the other stakeholder positions. Together your team will develop a recommendation about whether the dams should be re-licensed.

4) **Synthesis Paper and Post-Synthesis System Map**
   As a culminating assignment, you will write a 4-5 page paper that synthesizes your results from the research conducted in your expert group, as well as the discussion and results from the joint conference. You will also revise your original system map to reflect any new ideas and conclusions you gained through the conference process.

Table 1 below outlines the topics, activities/assignments, and readings within each class leading up to the joint conference.

Table 1. Schedule of topics, activities and reading assignments for the 3-week socio-environmental synthesis teaching module. Note: both Bio 106 and PolS 430 are taught on a Tues-Thurs schedule, with two class meetings per week.

Date	Biology 106	Political Science 430
	Topics, Readings & Assignments	**Topics, Readings & Assignments**
Week One: Introduction to Socio-Environmental Synthesis and the Focal Question		
Day 1	**Introduction to Synthesis Case Study** Overview of problem and assignment **Reading:** Quinn T. (2011) The Behavior and Ecology of Pacific Salmon & Trout. University of British Columbia Press. Vancouver, Canada. Chapter 1 (pp. 1-12) **In-class assignment:** What do you need to know? Pre-synthesis system map	**Salmon Politics One:** Intergovernmental Relations and the ESA **Reading:** Volkman and McConnaha. 1993. "Through a Glass Darkly: Columbia River Salmon, the Endangered Species Act, and Adaptive Management." *Environmental Law*, 23. **Assignment:** What do you need to know? Salmon Politics pre-synthesis systems map
Day 2	**Salmon population ecology** Population abundance and growth rates **Reading:** Reece J, et al. (2013) Campbell's Biology, 10th edition. Pearson, New York, USA. Chapter 53.4; Quinn Ch. 1 (pp. 12-23) **In-class assignment:** • Visualize and interpret salmon pop data • Consider factors that might explain decline in pop size in PNW/Cowlitz	**Salmon Politics Two:** The Importance of Native American Treaties **Reading:** Brown and Footen. 2010. "Pacific Northwest Salmon Habitat: The Culvert Case and the Power of Treaties." Evergreen State College. http://nativecases.evergreen.edu/collection/cases/pacific-northwest-salmon-habitat.html **Film:** "As Long as the Rivers Run" https://archive.org/details/AsLongAsTheRiversRun
Week Two: Hydroelectric dams and salmon; Expert group discussions		
Day 3	**Community and ecosystem ecology of salmon** **Reading:** Reece et al. Chapter 54.1-54.2 **In-class assignment:**	**Courts, Science and Co-management** **Reading:** Footen, Brian. 2009. "Co-Management of Puget Sound Salmon: How well does the Use and Collection of Shared Fishery Science between Tribes and the State Guide Resource

	Expand on concept map of salmon biology to include biotic and abiotic components to system	Protection?" Evergreen State College. http://nativecases.evergreen.edu/collection/cases/co-management.html
Day 4	**Landscape ecology of salmon in PNW and Salmon Conference Preparation in Expert Groups (Jigsaw Step One)** **Assignment:** • Write compiled statement to the FERC with a prediction of how salmon populations would be impacted by each relicensing option. **Reading:** McGarigal, Kevin. "What is landscape ecology?" http://www.umass.edu/landeco/about/landeco.pdf.	**Salmon Conference Preparation in Expert Groups (Jigsaw Step One)** **Assignment:** Salmon Politics 2nd Draft of Systems Map Due in Class **Reading:** "Tacoma Power gets renewed license for Cowlitz River powerhouses." The Associated Press, March 19, 2002. Pearson, Adam. 2011. "State Department Urges Tacoma Power to Improve Fish Passage for Small Salmon, Steelhead Whose Access to Ocean Is Blocked by Three Dams." *The Chronicle* (Centralia, WA), August 26, 2011. Certification of the Cowlitz Indian Tribe
Week Three: Joint conference on dam re-licensing; Reflection on process		
Day 5 Combined Bio and PolS classes	**Dam Relicensing Conference (Jigsaw Step Two)** • Jigsaw: form heterogeneous groups from each of 6 expert groups; share data and perspectives • Discuss pro's and con's of each relicensing alternative from the perspective of different technical experts • Write report for judge on how "sellable" each option would be for the multiple constituents that use Cowlitz River **Assessment:** post-survey **Background paper (Expert group report) due**	
Day 6 Combined Biol and PolS classes	**Discussion of synthesis activity and reflection on process** **Due in class:** Technical Group recommendation to FERC Final concept map **In-class assignment:** • Revise and submit the pre-synthesis system map. • Write compiled statement to the judge with a prediction of how salmon populations would be impacted by each relicensing option, as addendum to expert group report. • Write personal opinion about which option judge should choose; explain how came to this conclusion; how did conference influence decision	

Questions for Further Thought and Discussion:

1. Using the concept map you outlined at the beginning of this module, who are the major stakeholders in the question of whether the Cowlitz River dams should be re-licensed? How would you categorize these stakeholders (e.g., those with economic interests, those with cultural interests, etc.)?

2. Once you have chosen or been assigned to a particular stakeholder, what are your predictions about their position on the re-licensing question? Would they be in support of re-licensing or would they want modifications made to the dams before allowing continued operation?

3. Where would you look to find information that illustrates and supports the position of your stakeholder group?

4. Once you have found some data about your stakeholder position, do these observations align with your initial predictions about how these stakeholders would view the question of dam re-licensing? Why or why not?

References

References may be found in Table 1.

Tools for Assessment of Student Learning Outcomes

Much of your work on this module, in both the Biology and Political Science courses, will consist of class discussion and participation in small and large group activities, most of which will not be formally graded. The instructors will qualitatively review the pre- and post-module system map to observe how each student's perceptions of and sophistication in conceptualizing the dam relicensing process and stakeholders changes over the module. We will also formally assess the final conference reports, using a quantitative rubric with the freshmen/sophomore Biology course (see below) or through qualitative review and grading for the more senior Political Science students.

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Assessment rubric for Final Conference Report (Biology students)

Evaluation area	D range	C range	B range	A range
General biology of Coho or Chinook salmon (6 pts)	**Score: 3.5-4.2** Mostly unclear and inaccurate description of biology of Coho or Chinook.	**Score: 4.2-4.8** Somewhat clearly described morphology, diet, reproduction, and range of Coho or Chinook.	**Score: 4.8-5.5** Reasonably accurately described morphology, diet, reproduction, range of Coho or Chinook.	**Score: 5.5-6** Clearly and accurately described morphology, diet, reproduction, and range of Coho or Chinook.
Description of Coho or Chinook salmon migration and use of Cowlitz (5 pts)	**Score: 3-3.5** Provided incomplete and inaccurate description of migration behavior and timing of use of Cowlitz/Columbia rivers by Coho or Chinook salmon.	**Score: 3.5-4** Provided somewhat complete description of migration behavior and timing of use of Cowlitz/Columbia rivers by Coho or Chinook salmon.	**Score: 4-4.5** Provided reasonably complete and accurate description of migration behavior and timing of use of Cowlitz/Columbia rivers by Coho or Chinook salmon.	**Score: 4.5-5** Provided complete and accurate description of migration behavior and timing of use of Cowlitz/Columbia rivers by Coho or Chinook salmon.
Description of status of Coho or Chinook salmon (4 points)	**Score: 2-2.5** Provided incomplete and inaccurate description of the current status of Coho or Chinook.	**Score: 2.5-3** Provided somewhat complete description of the current status of Coho or Chinook in Cowlitz.	**Score: 3-3.5** Provided reasonably accurate description of the current status of Coho or Chinook in Cowlitz.	**Score: 3.5-4** Provided complete and accurate description of the current status of Coho or Chinook in Cowlitz.
Description of Tacoma Public Utilities' Cowlitz River Project (4 pts)	**Score: 2-2.5** Incomplete or inaccurate description of TPU's Cowlitz River Project.	**Score: 2.5-3** Somewhat clearly described TPU's Cowlitz River Project.	**Score: 3-3.5** Reasonably accurately described TPU's Cowlitz River Project, including dams, power generation and environmental protections.	**Score: 3.5-4** Clearly and accurately described TPU's Cowlitz River Project, including dams, power generation and environmental protections.
Description of impacts of dams on salmon and remedies (4 pts)	**Score: 2-2.5** Incompletely described the impacts of dams on salmon or remedies to accommodate salmon	**Score: 2.5-3** Somewhat clearly and accurately described the impacts of dams and at least 1 remedy to accommodate salmon.	**Score: 3-3.5** Reasonably learly and accurately described the impacts of dams on salmon and at least 2 remedies to accommodate salmon.	**Score: 3.5-4** Clearly and accurately described the impacts of dams on salmon, and at least 3 remedies to accommodate salmon.
Arguments FOR relicensing dams as they currently exist (5 pts)	**Score: 3-3.5** Does not clearly present three compelling arguments, with limited description of justification; may be missing arguments	**Score: 3.5-4** Somewhat clearly presents three arguments, with some supporting justification; may be missing an argument	**Score: 4-4.5** Reasonably clearly presents three compelling arguments, with reasonably well described supporting justification	**Score: 4.5-5** Clearly presents three compelling arguments, with well described supporting justification
Arguments AGAINST relicensing dams (including remedies) (5 pts)	**Score: 3-3.5** Does not clearly present three compelling arguments, with limited description of supporting justification; may be missing arguments	**Score: 3.5-4** Somewhat clearly presents three arguments, with some supporting justification; may be missing an argument	**Score: 4-4.5** Reasonably clearly presents three compelling arguments, with reasonably well described supporting justification	**Score: 4.5-5** Clearly presents three compelling arguments, with well described supporting justification

Evaluation area	D range	C range	B range	A range
Use of sources and citations in background report (4 pts)	**Score: 2-2.5** Rarely cited facts and ideas that came from outside sources; rarely used correct citation format.	**Score: 2.5-3** Appropriately cited only a few facts and ideas that came from outside sources; usually used correct citation format.	**Score: 3-3.5** Appropriately cited most facts and ideas that came from outside sources; mostly used correct citation format.	**Score: 3.5-4** Appropriately cited all facts and ideas that came from outside sources; used correct citation format.
Technical issues in background report (4 pts)	**Score: 2-2.5** Several grammatical errors; spelling and punctuation often incorrect; essay structure not clear or in good sequence; did not follow guidelines.	**Score: 2.5-3** Several grammatical errors; several spelling and punctuation errors; essay structure minimally clear; did not follow guidelines.	**Score: 3-3.5** Grammar is mostly correct; spelling and punctuation mostly correct; essay structure relatively clear and in sequence; followed guidelines.	**Score: 3.5-4** All grammar is correct; spelling and punctuation correct; essay structure clear and in good sequence; followed length/margin guidelines.
The following elements will be assessed ONLY on the portion of the report completed after the conference.				
Group arguments (6 pts)	**Score: 3.5-4.2** Listed only 1 group argument FOR or AGAINST, without ranking.	**Score: 4.2-4.8** Listed an incomplete list of group arguments, without ranking.	**Score: 4.8-5.5** Listed compiled arguments of group, including rankings, but less than three FOR or AGAINST.	**Score: 5.5-6** Listed compiled arguments of group (at least three FOR and three AGAINST), including rankings.
Group vs. personal arguments (6 pts)	**Score: 3.5-4.2** Minimally described how group arguments differed from personal arguments, and did not state why.	**Score: 4.2-4.8** Provided minimal description of how group arguments differed from personal arguments, and why.	**Score: 4.8-5.5** Provided reasonably clear description of how group arguments differed from personal arguments, and why.	**Score: 5.5-6** Provided clear description of how group arguments differed (or not) from personal arguments, and why.
Personal position (6 pts)	**Score: 3.5-4.2** Provided minimal description of personal opinion about eradication.	**Score: 4.2-4.8** Provided somewhat clear description of personal opinion about eradication.	**Score: 4.8-5.5** Provided reasonably clear description of personal opinion about eradication.	**Score: 5.5-6** Provided clear description of personal opinion about eradication.
Personal position justification (6 pts)	**Score: 3.5-4.2** Provided minimal description of how author arrived at personal view.	**Score: 4.2-4.8** Provided somewhat clear description of how author came to personal view.	**Score: 4.8-5.5** Provided reasonably clear description of how author came to personal view.	**Score: 5.5-6** Provided clear description of how author came to personal view.

NOTES TO FACULTY

Challenges to Anticipate and Solve

Challenge 1: Finding the right teaching partner

The key to this teaching module is to have an active and collaborative pair of faculty who are committed to the project and are teaching courses in the same semester that are good “fits” to engaging students in socio-environmental synthesis.

We had co-taught a class prior to this experiment, and were co-investigators on an inter-disciplinary research project, so we knew each other well and shared many content and pedagogical goals for our students.

Linking two college courses in this way also requires flexibility on the part of the faculty's respective departments to allow for variation in the content of each course to accommodate the module. In the case of upper-division courses this is usually not a problem, but it can be a challenge if one or both of the classes are lower-division courses required of a major. In the case of Biology 106, which is the required pre-requisite course for nearly all upper division courses in Biology, the focal question had to be relevant to the course content so that the students would be prepared for their next Biology course. For PolS 430 the question only had to be one that lent itself to research and discussion about the role of science in environmental policy and institutions.

Challenge 2: Incorporating the focal question into the course

As noted in Challenge 1, the focal question needs to be broad enough to allow for meaningful engagement of students in two different classes, but also specific enough for the students to identify and find relevant information about a range of potential stakeholder perspectives. Remembering that students will begin the module by asking "what do you need to know" can help with selection and development of the right focal question. It also helps to choose a question that relates to a local or regional issue or problem, so that undergraduate students may have a context in which to explore the question. In the Pacific Northwest, the question of salmon politics is front and center in most peoples' lives, and has numerous elements that naturally bring natural, social and political scientists together.

Challenge 3: Pairing a 100-level course with a 400-level course

As discussed above, we had a long-standing collaboration in both teaching and research that we drew from to develop this teaching module. This allowed us to focus most of our efforts on adapting our existing courses to fit the type of synthetic activities we envisioned and planned for. In addition, we had each been teaching our respective courses (Bio 106 and PSci 430) for several years prior to our teaching "experiment" and therefore knew very well the opportunities and challenges that our respective student populations would present in the implementation of the paired classes. The result in both years that we taught this module was quite satisfying with respect to how the students interacted between classes, how they listened to each other and how they questioned each other about the dam re-licensing problem and the broader issues of integrating and synthesizing scientific, political and social perspectives to environmental problem-solving. The only significant logistical issue that we needed to manage with the difference in enrollment between the Biology 106 course (~150) and the Political Science 430 course (~25-30). In year one of our study, we requested ~25 volunteers from the Biology course to participate in the Jigsaw Two (joint conference) portion of the module; in year two the entire

Biology course participated in the Jigsaw Two conference, and the Political Science students were distributed mostly one to a group of Biology students. Both approaches had benefits and challenges, but both resulted in very positive outcomes for the students and faculty (based on reviews from students).

Module Description

Introducing the Module to Your Students:

We found the majority of students in both classes were eager to dive into a rather controversial issue, with many valid perspectives to consider and information to evaluate. Placing the module late in the semester probably helped with this as well. The key was to provide sufficient guidance and support for the more naïve students in how to identify the elements of the focal question and how to find information related to the problem. This was more challenging for the Biology class, since it was large enrollment, and not every student could get individual attention. But working in groups was a good way to have the students share in tasks and be sounding boards for each other. The first day of the jigsaw was a good opportunity for the more advanced students to help others catch up and become more motivated.

Comments on Questions for Further Thought

1. *Using the concept map you outlined at the beginning of this module, who are the major stakeholders in the question of whether the Cowlitz River dams should be re-licensed? How would you categorize these stakeholders (e.g. those with economic interests, those with cultural interests, etc.)?*

   We found it useful to roam the classroom and talk with small groups as they worked on developing their concept maps. Many students had difficulty at first sorting their ideas into coherent categories, but as they moved their post-it notes around the page and as they discussed why they were moving the notes, their ideas began to coalesce. This required time in class, but was a critical part of the initial process to encourage students to develop their own ideas and questions to pursue. (See Appendix A for an example of the instructions for this activity.)

2. *Once you have chosen or been assigned to a particular stakeholder, what are your predictions about their position on the re-licensing question? Would they be in support of re-licensing or would they want modifications made to the dams before allowing continued operation?*

Many students had preconceived ideas about what their stakeholder group's position would be relative to dam re-licensing. Most of these ideas were borne out in their research, but not all of their predictions were supported. This was a rich area to discuss and to analyze: Why did they assume a particular viewpoint, and what information did they find that challenged these assumptions?

3. *Where would you look to find information that illustrates and supports the position of your stakeholder group?*

   Finding relevant data and information was the hardest part of this teaching module, and required a lot of time outside of class, which made assisting students more challenging. We did set up at least one "lab" session in which students could come with their computers (or use some provided) and get help with searching and evaluating content. This was very helpful for the students that took advantage of the opportunity. In PolS 430 we continued to stress the "what do you need to know" frame to facilitate out of class research. We also encouraged students to bring computers to the first jigsaw session so that they could show others in their stakeholder/expert groups some of the materials they had found on-line.

4. *Once you have found some data about your stakeholder position, do these observations align with your initial predictions about how these stakeholders would view the question of dam re-licensing? Why or why not?*

   We were able to assess this question by reading their final papers, and also by listening to their conversations during joint conference. It was not often that students were surprised by the information they found regarding their stakeholder group. In most cases, particularly for the natural scientist and manager stakeholder groups, students' original conception of how these individuals would view the dam question was further enhanced by the data on low salmon returns and the specifications of the dams for fish passage (or lack thereof).

Comments on the Assessment of Student Learning Outcomes:

Assessing student work in this paired-class model was a two-part process. First, since the modules were embedded into two different courses and needed to be

integrated into the overall curriculum of each course, each of us assessed the content of our own students' module assignments according to the norms of our disciplines and the overall learning goals of our two courses. However, we did work together at the end of the semester to review the results of the joint conference, and to assess qualitatively the level of engagement of the students in both classes. We discussed how the students' skills in socio-environmental synthesis were evident from their final reports, and we qualitatively assessed the strengths and weaknesses of our approaches (both within and between our two courses) to support students' gains in these skill areas. We recommend that faculty who plan to use this paired-class approach work together to develop rubrics for the final conference report to 1) meet the needs of the individual course, but also 2) allow for assessment of students' across both courses.

Comments on Formative Evaluation of this Module:

Since we were teaching our modules separately until the joint conference day, formal formative assessment relied mostly on our conversations about progress and challenges during the module. We were able to make adjustments in our own classes based on the experience of the other faculty partner working on the same or similar theme.

We also used a pre- and post-module online survey using SurveyMonkey to inquire about students' own perceptions of their skills and abilities in socio-environmental synthesis. This was helpful to observe how students' ideas changed as a result of their participation in the module activities, and we used these results in developing our plans for the second year of our module study. Indeed, having a second year in which to teach the module in our paired classes allowed us to make significant improvements over our first attempt, and we recommend that wherever possible faculty aim to incorporate this module approach for a minimum of two semesters to take advantage of the faculty learning taking place with repeated iterations.

Comments on Translating the Activity to Other Institutional Scales or Locations:

We believe this paired-class module approach could be adopted at any institution where two faculty members from different disciplines (preferably natural science and political science) have an interest in, commitment to, and support from their respective departments to engage their students in socio-environmental synthesis activities. Each of these three conditions are critical, however.

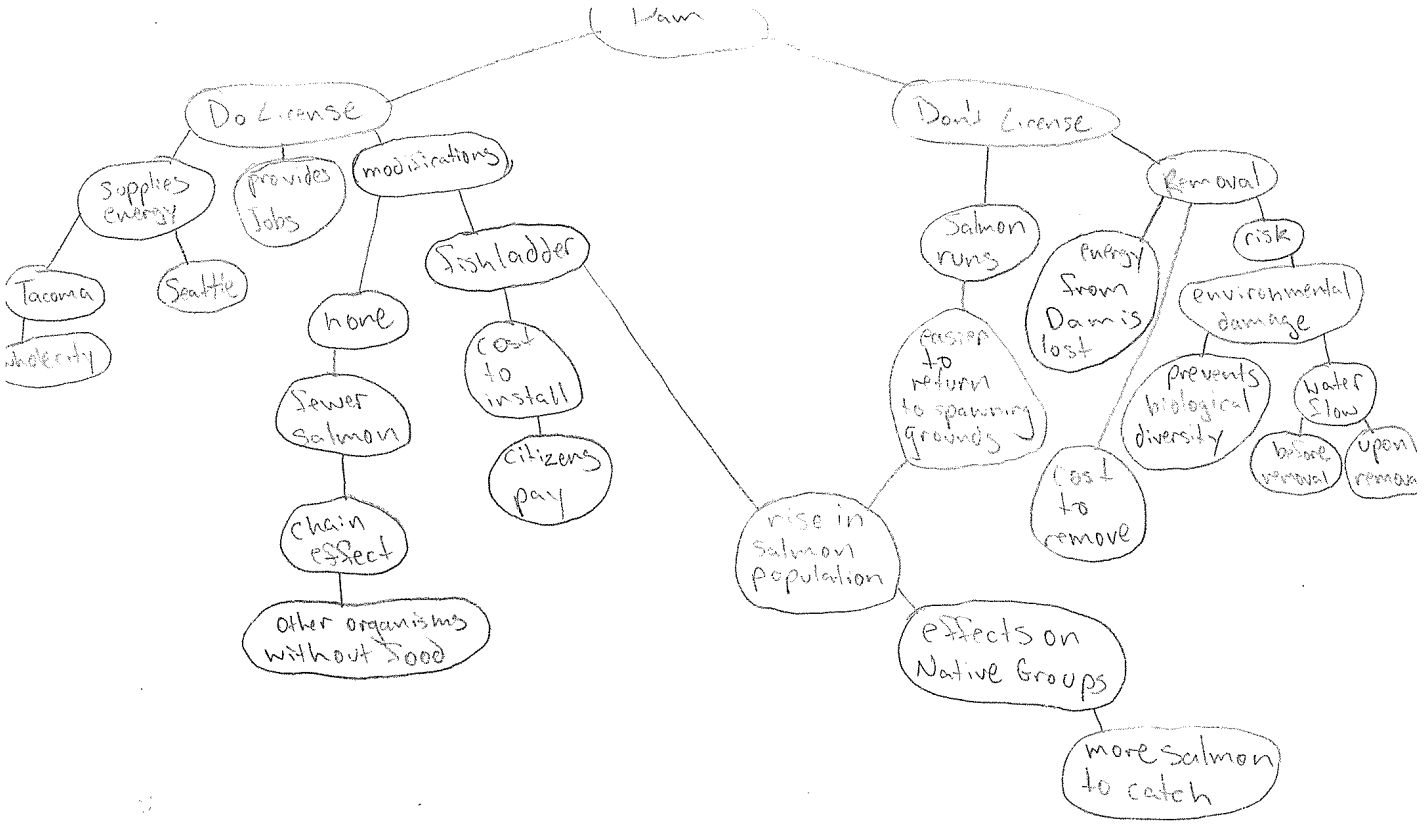
WSU Vancouver has a strong interdisciplinary culture and the specific faculty involved in this module have been leaders in that culture. We had been working together on interdisciplinary research for several years prior to developing and teaching this module, and had already co-taught two different courses together. This gave us a strong professional relationship to build upon as we developed this experimental teaching project. This does not preclude two interested faculty who have not worked together in this way from successfully adopting this approach, but we recommend setting aside sufficient planning time prior to the semester in order to learn each other's teaching styles and goals.

Support from each faculty member's home departments is also important, in order to get "buy in" for committing 4-6 weeks of the semester to this module in their respective classes. In our experience this can be readily justified in upper-division majors courses. There did need to be a willingness of the Program in Public Affairs to introduce biophysical subject matter into policy studies courses. Engaging students in lower division majors courses, particularly in natural sciences, can also be effective so long as the module focus question can be clearly related to the course content. Introductory Organismal Biology and Introductory Environmental Science are natural fits for many socio-environmental topics, and with the right focal question introductory courses in chemistry, molecular biology or physical sciences could also be appropriate.

STUDENTS COLLECTED DATA FROM THIS MODULE

Below are example systems maps from the beginning and end of the module.

Example systems map from the beginning of the module.



An example of a systems map from the end of the module

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