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CONCEPT MAPPING AND ENVIRONMENT AS CONNECTION

James D. Proctor, Lewis & Clark College, USA
Jennifer Bernstein, University of Hawai'i at Manoa, USA
Email: jproctor@lclark.edu

Abstract. What is environment? We follow recent scholarly literature in approaching environment as connection, not as some category of reality, and consider pedagogical implications via concept mapping. Concept maps potentially offer a visually explicit means of representing and analyzing the hybrid connections between actors that define environmental issues. We explore the utility of concept mapping as pioneered by Joseph Novak and others via the CmapTools application, in which concept maps (cmaps) consist of concepts (boxes or nouns) connected by propositions (arrows or verbs); both can include linked resources, and the resultant cmap can be collaboratively edited and shared online. We evaluate concept mapping in the context of a sophomore-level environmental methods course taught annually at Lewis & Clark College. The course includes a variety of concept mapping exercises designed for students to reflect on their environmental perspectives, synthesize course material, and explore a proposed topic for environmental research. These exercises were evaluated in fall 2010 using self-reports, assessment rubrics, and open-ended student responses. Results showed that higher-achieving students generally found concept mapping more demanding and attained more sophisticated understandings of connections. This suggests that concept mapping helps facilitate the intellectual struggle that characterizes engaged learning; yet in a larger sense, the study illustrates challenges in cultivating new approaches to environment among undergraduate students.

1 Environment as connection

1.1 The environment of ESS

As an interdiscipline, environmental studies and sciences (ESS) gathers a tremendous diversity of contributing fields, ranging from history and philosophy to economics and chemistry to sociology and ecology. What is shared across this broad spectrum is the term “environment.” But what is environment, and how shall practitioners of ESS develop approaches to learning so that their students effectively grasp and communicate this common thread?

In this paper, we approach ESS from the premise of environment as connection, not a category. This approach is more etymologically true to the root of environment as, roughly, that which surrounds (Proctor 2009), and potentially affords fuller and more novel explorations of environmental issues by our students without importing too much baggage associated with concepts of nature. To us, the connections that comprise environment are not so much between some overgeneralized “human” and “nonhuman” or “natural” realms as between all the specific actors— lizards, laws, ocean currents, spiritual movements, structural adjustments—that come into relation in the context of what we have received as environmental issues, whether relatively longstanding (e.g., water pollution, wilderness) or more recent (e.g., endocrine disruption, environmental justice). There is no clear line separating environmental issues from other issues, which our definition of environment affirms; but there is plenty of good work to be done by practitioners of ESS to shed greater scholarly light on the issues we have inherited, primarily by elucidating the connections that matter in tracing issue-related problems and solutions.

1.2 Reframing environmental research

Approaching environment as connection demands new analytical methodologies, as it generally approaches environmental problems and solutions more with a fine-tipped felt pen than a foot-wide paint roller. Gone—if the above critiques of environment are at all valid—are the easy truths of listening to nature, going green, or caring for the earth. There are no *a priori* problems and villains, no *a priori* solutions and heroes. What replaces these shortcuts is educationally rich: a more open-ended focus on connecting the details that matter in a given environmental issue; a valorization of curiosity and careful research; and a sense that there is still much of value to be contributed by the current and future ESS community.

Approaching environment as connection and not just a category of nonhuman stuff also challenges notions of cause and effect fundamental to our understanding of environmental issues. Far too often, the nonhuman realm has been understood as a passive recipient of human injury, thus leading to the curious conclusion (sometimes celebrated in “green” product advertisements) that the ideal human impact is to have none at all.[1] If, however, environmental reality is understood as fundamentally entangled, notions of cause and effect become

[1] See e.g. noimpactproject.org.

more complex and interesting, and environmental solutions encompass change—or resistance to change—in a host of related human and nonhuman actors. Ultimately, ESS research can remind us that though—as Barry Commoner reminded us (1971)—everything is indeed connected to everything else, some connections are more significant, some are better understood, some are more tractable to change…in short, certain connections matter more than others. Discovering, explaining, and elucidating these special connections becomes the value added to contemporary discourse on environmental issues via ESS scholarship.

2 Connecting via concept mapping

2.1 Concept mapping and related approaches

With the advent of web2.0 interactive tools, a host of possibilities arises for ESS instructors interested in helping their students explore environmental connections. Some of these offer web-based simulation: one example is climateinteractive.org, an online climate simulation community serving users ranging from high school to government. Another class of web2.0 social bookmarking tools (e.g., Digg, StumbleUpon, Delicious, Diigo) provides for readily connecting online resources by allowing users to store, aggregate, share, rate, and comment on anything they find online.

A final class of web2.0 interactive tools deserves greater attention, as it very closely resembles concept mapping: this is what is generally known as mind mapping. Mind maps are hierarchical, generally starting with a core idea in the center of the map, then branching in treelike fashion out to subcategories. In this regard, mind maps reproduce a typical text outline structure, and in fact text outlines can be exported for visual display as mind maps. A wide variety of desktop and online mind mapping tools is currently available,[2] some of which allow for online collaboration and presentation. Some (not all) mind mapping tools allow for resources (hyperlinks, documents, notes, etc.) to be added to components, and some (not all) allow for nonhierarchical connections to be drawn between components. For all, however, the user interface is optimized for tree-like hierarchical entry of elements at either a parallel level in the hierarchical structure, or a lower level.

Concept mapping is similar in many ways to the more ubiquitous mind mapping, with one crucial difference: concept maps are not necessarily hierarchical in structure. The difference proves fundamental when one wishes to use these tools to help students explore connections. If ESS were approached as a *multi*discipline, hierarchical mapping may in many ways be sufficient, as each contributing field (and related system, e.g., hydrology or politics or culture) could be viewed as offering its relatively distinct perspective on an environmental issue. Approached as a mind map, an environmental issue would be the core idea, then each contributing field would define a first-level subcategory, with its attendant details under that subcategory. All contributing fields would be related in the context of this environmental issue, but only contingently so: there would be no significant connections outside of this root-level connection to the issue.

In approaching environment as connection, however, hybrids and heterogeneity tend to be the norm, where surprising and persistent entanglements of politics and climate, or culture and charismatic species, or economics and energy, challenge any hope of separating constituent processes. This, to the *inter*disciplinary ESS practitioner, is the reality to be analyzed, with connections that are often more necessary than contingent: the current climate system, or state of charismatic megafauna, or rate of alternative energy development, are necessarily entangled with issues of politics, culture, and economics. These relations are, for the most part, nonhierarchical, as the overall set of interactions is more of a diffuse network than a hierarchy. This is why, no matter what sort of tool or pedagogical approach is employed, care must be taken to allow for nonhierarchical as well as hierarchical relations in mapping out connections in ESS. In a similar vein, Kinchin (2001) argues that appreciation of nonhierarchical connections—what he calls a “net” concept map—generally suggests a more complex student understanding of biological processes than simple hierarchies, which he calls a “spoke” concept map.

Though the above suggests that concept mapping was developed as an alternative to hierarchical mind mapping, the most commonly cited origins of these two approaches suggest otherwise. Mind mapping is generally attributed to the work of educational consultant Tony Buzan dating from the 1970s,[3] whereas concept mapping is attributed to Joseph Novak dating from the same period (Novak and Cañas 2008), and in much of his work Novak recommends building concept maps hierarchically—by which he appears to mean a flow of

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[2] See for instance www.mindmeister.com, www.mindnode.com, www.mindomo.com, www.thinkbuzan.com.
[3] See www.thinkbuzan.com.

ideas from general to specific, though not necessarily a strict tree-like hierarchy as in mind mapping.[4] Yet CmapTools,[5] the concept mapping tool Novak helped develop and the one we have utilized at Lewis & Clark College, can be deployed to build any sort of diagram, so we do not necessarily follow Novak's recommendation, especially in what we call process concept maps below.

As elaborated by Novak and others, concept mapping has strong roots in educational theory and is regularly deployed in classrooms worldwide.[6] Novak originally designed concept mapping as a means of evaluating student achievement in the sciences. He was strongly influenced by the work of psychologist David Ausubel, whose theory of cognitive learning proposes that students do not simply assimilate new information, but rather connect and integrate it into their pre-existing mental structure (Ausubel 1963). Novak aspired for concept mapping to facilitate Ausubel's notion that truly meaningful learning occurs when students are motivated, clearly comprehend root concepts, and find meaning and relevance in the new material. According to this theory, education is not a cognitive, one-directional model of information assimilation, but rather the significance of the student's individual learning experience is critical to the learning process. Says Novak, "The central purpose of education is to empower learners to take charge of their own meaning making…involving thinking, feeling, and acting, and all three of these aspects must be integrated for significant new learning" (Novak 2010, 13). From an assessment perspective, this necessitates scoring concept maps for more than just "correctness," attending to each map's individual morphology (Kinchin 2001)—though others have attempted to create more generalized normative rubrics for "good" concept maps (Moon et al. 2011a).

2.2 Concept mapping and environmental studies at Lewis & Clark

Concept mapping has been applied in a variety of educational and corporate settings, including cases related to ESS such as national parks (O'Brien 2002), grassland management (White 2011), and ecosystem services (Yee et al. 2011). Given the flexibility of the concept mapping approach and its potential relevance to environmental analysis, the Environmental Studies (ENVS) Program at Lewis & Clark College introduced concept mapping into its curriculum as a visual tool to more clearly specify connections in environmental processes. To aid this approach, we have developed online documentation to guide students in use of the technology.[7]

Students use the CmapTools application to develop their concept maps (cmaps). We selected this application as it is freely available for a variety of platforms, well maintained, and easy for our students to learn. In CmapTools, concept maps consist of concepts (boxes or "nouns") and linking propositions (lines or "verbs" defining associations); CmapTools-based concept maps are thus designed not only as visualizations, but as structured textual descriptions of processes. One special CmapTools feature our students utilize involves its ability to associate concepts or propositions with resources such as documents, references, or websites, which are simply dragged onto the cmap; these resources, for instance, can be used to justify, or summarize the state of knowledge on, a connection. Another feature students use involves a CmapTools server, whereby they readily save and edit their cmaps in a cloud environment, providing opportunities for live collaboration. In addition, all cmaps saved on the server are immediately rendered into viewable images for web visualization. thus affords a means of reinforcing an approach to environment as connection, and offers a social learning approach for students to work together and compare their efforts.

When we originally introduced concept mapping into our ENVS Program, we gave students a great deal of latitude in how to use it. Their early forays proved useful toward refining our pedagogical approach, as in many ways this laissez-faire approach promoted as much frustration and muddled thinking as clarity in analysis among students. Two challenges arose in particular: first, students tended toward inclusion of overly broad concepts and propositions, such as identifying "population growth," "climate change," or "capitalism" as key drivers of environmental processes. Concepts or propositions at this level of generality may be helpful for preliminary work, but typically do not afford the more nuanced understandings we seek among our students. Second, students would generally include a large number of concepts and propositions, such that their resultant concept maps complexified rather than clarified environmental processes.

We eventually realized that overly broad concept map elements, and overly complex concept maps, are understandable and useful in early stages of student thinking about an environmental process, yet devised a

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[4] The hierarchical nature of Novak-inspired concept maps also seems to be interpreted differently by those who have applied this approach in a variety of practical settings; see Moon et al. (2011b).
[5] See http://cmap.ihmc.us.
[6] As one estimate, the CmapTools server network includes over 150 publicly available servers distributed across the globe; see http://cmapdp.ihmc.us/servlet/HtmlViewServlet?viewhtml.
[7] See http://sge.lclark.edu/social-learning-tools/#Concept_Mapping.

contrasting later-stage approach built on actor-network theory (ANT) to address these limitations. ANT has been well documented elsewhere (e.g., Latour 2007; Law and Hassard 1999): as applied to environmental processes (e.g., Castree 2002), it reinforces a more hybrid and fluid notion of environment as unfolding connections. Actor-networks map readily onto our use of concept maps, and ANT theory addresses the two student challenges noted above, in that actors-networks are ideally specific and concrete, and given the implicit notion underlying actor-networks that some connections matter more than others. These ANT principles have led students to work toward concept maps—and thus understanding and communication of connections in environmental processes—that are clearer and more forceful. Our resultant approach to student concept mapping thus progresses in multiple phases, from relatively rough, general, and complicated initial concept maps to relatively refined, specific, and elegant concept maps including related resources.

We also have realized that concept maps can be applied toward two different sorts of needs. The first concerns clarification of ideas, which we call "perspectives" concept maps. Students create perspectives concept maps, for instance, to clarify ideas presented in a reading, or to draw together material learned in a class. The second concerns clarification of processes occurring in the world, which we call "process" concept maps. Process concept maps are designed in ANT fashion to represent networks of associations between a wide array of biological, technological, legal, and other actors. These initial and refined concept maps, and perspectives and process concept maps, were all implemented in the course we will analyze below.

3 Learning concept mapping at Lewis & Clark College

3.1 What we did

We conducted an evaluation of concept mapping during a semester-long sophomore-level environmental analysis course in fall 2010. The objectives of this course are to equip students with a wide array of methodological approaches for empirical and conceptual analysis of environmental issues, and to apply these tools to the process of doing environmental research, from formulating initial questions to documenting final results. Though students had previously been introduced to concept mapping in our freshman introductory course, this sophomore-level course explores it in much greater detail, and offers feedback to enable improvement in student use of the tool for environmental analysis.

In line with our general approach to teaching concept mapping introduced above, we developed three different types of concept mapping assignments in this course (see Table 1). The first builds on Novak's theory of learning summarized above via what we called a MyTFA assignment. In this assignment, students identified and connected their major thinking, feeling, and acting elements in the context of a chosen environmental issue, then compared their resultant concept maps in terms of areas of emphasis and overall coherence. This MyTFA assignment was repeated at the end of the course, and students compared their two MyTFA concept maps to see how their key thinking, feeling and/or acting elements had evolved over the semester. The second type of assignment was a unit synthesis concept map, designed to help students review, analyze, and make visual connections between topics, terminology, skills, or other material covered in main instructional unit in the course. Students began with an overview unit synthesis map incorporating a wide variety of brainstormed elements, then selected a small subset of elements to relate in a more detailed way. These two assignments illustrate the perspectives concept mapping approach introduced above, as the main objective was to relate ideas.

The third type of concept mapping assignment in our sophomore level environmental analysis course gets to much of the theory about environment and connection introduced above: we called it an ANT cmap, following actor-network theory. Students produced these (process) ANT cmaps in teams assembled around a proposed research topic located in one of six international sites our ENVS Program focuses on as part of its situated research approach.[8] They developed these ANT cmaps in two stages. First, after collecting and perusing resources (publications, organizational websites, data sources, etc.) for their research topics, they developed an initial ANT cmap and added these resources to the concept map. The objectives at this stage were for student teams to begin to visually identify connections as elaborated in the resources they had compiled, and to document these connections via the resources they added to their concept maps. In the second stage, following several weeks of additional focus on their research topics, they revised these initial ANT cmaps with the goal of preserving only the most important concepts, propositions, and related resources. As suggested above, the idea here was for students to use concept mapping to help them focus their research goals relative to the vast array of potentially relevant connections as elaborated in their initial ANT cmaps: as one possibility, they were

[8] See https://sge.lclark.edu/about-the-sge-initiative.

recommended to focus their proposed research on connections that are potentially significant but not yet well documented.

Type of Cmap	Cmap assignment	When conducted	Repetitions
Perspectives	MyTFA	At beginning and conclusion of course	2
Perspectives	Unit synthesis	At the end of each unit	4
Process	ANT	Initial and refined during situated research unit	2

Table 1: Cmapping assignments in ENVS 220

We conducted this study within the general framework of action research, which aims to improve student learning and educational performance through teacher inquiry. Action research aims to release educational research from the confines of academia and make it accessible to practitioners (Mills 2010). Out of a class of 35 total, 23 students elected to participate in an extended evaluation of concept mapping; the rest did the above assignments as well, but did not participate in evaluation activities. Following the action research model, we did not let this relatively small sample prevent us from trying to improve student learning, yet refrained from deploying certain analysis techniques (t-tests, ANOVA, factor analysis, etc.) that we would typically use in a formal assessment.

For these participating students, we conducted a pre-assessment including an entry quiz, a background interview, and compilation of past grades in environmental studies courses. From these data, we created an individual and collective baseline by which to evaluate student achievement in the course overall, and in their concept mapping skills.

All concept maps created by participants in our evaluation were assessed using a rubric examining concept map qualities as suggested above (e.g., level of specificity in named concepts and propositions), and feedback was given through online discussion forums and in class. After each concept mapping exercise, participants completed a self-assessment questionnaire which measured their impression of the mapping assignment, including its perceived technical and intellectual difficulty and learning value. At the completion of the course, concept map scores and self-assessments were analyzed longitudinally to determine whether there was overall improvement, whether changes occurred in attitudes toward the concept mapping process, and whether certain exercises proved more beneficial than others. The concept mapping exercises as well were evaluated via the rubric and self-assessment questionnaires. Self-assessment questionnaires were analyzed using descriptive statistics. Students were also assessed as to their overall achievement in the course, as measured through success on their final project (which included an ANT cmap), and their final grade.

3.2 What we learned

At the conclusion of the project, we analyzed our data, both qualitative and quantitative, to better understand the degree to which concept mapping facilitated student understanding of environment-as-connection. First, we assessed whether confounding variables were impacting the ability of students to engage with concept mapping as a learning tool. Students generally reported being comfortable with technical aspects of the concept mapping process, had sufficient time to complete assignments, and felt that assignment instructions were sufficiently clear; thus, these issues did not appear to skew our analysis.

Based on student self-reports, some positive effects of concept mapping emerged: concept mapping helped students “better understand the significance of actors and their relationships“ and “better understand actor-network theory” (text in quotes from evaluation instrument), both critical in ameliorating broad, unwieldy cmaps and fuzzy articulation of environmental connections. Said one student, “This [ANT] cmap was very helpful in organizing all the different actors that were a part of this issue and what connections we need to focus on to address the influence of safaris in the Serengeti.” Students reflected on the increased sophistication with which they grappled with environmental problems when revising their MyTFA cmaps. Said another student, “In my new cmap, I do not explicitly say that complete removal of oneself from the conventional agricultural system is an option. It may be possible, but in this class I have learned that there are many complex interactions going on at many different scales, and that elements of a system are so strongly interconnected that completely changing the system could be impossible.” In general, most students reported that concept mapping improved their nonhierarchical thinking skills and increased their appreciation of environmentally significant actors as enmeshed in networks of relationships.

Student reports also indicated that concept mapping proved useful as a project design and research planning tool. As part of their collaboration process, it helped "clarify areas that need[ed] further research," "organize [my] ideas," "recognize gaps in [my] understanding," and "pare down or expand" their topic into one with an appropriately focused scope. Said one student, "Overall, this type of concept mapping is a good idea and has helped my group layout the specifics of our research question, along with determining what areas of research need more information and what areas we could focus on for collecting data." Interestingly, however, students did not report that the process helped much with explaining the environmental issue to others or clarifying possible solutions, pointing to a perceived limit to the usefulness of concept mapping in communication or policy contexts.

The above results suggest that concept mapping was not overly challenging technically, and proved helpful in attaining certain key learning objectives. Yet additional results indicate that some students struggled with reducing the scope and increasing the clarity of their cmaps. Despite the relative ease with which they took to the mechanics of concept mapping, they reported that the "intellectual material addressed" and "assembling the material into a concept map" were the most challenging parts of the concept mapping process. Said one student, "It was difficult to connect the frameworks [broad philosophical positions related to environment] to the theories [more specific explanatory notions for environmental problems] since the frameworks tend to deal with two ways of looking at one issue. While I was able to find connections, it was difficult to find the words to explain how they connected with arrows." However, not all students perceived this as negative: as one student stated, "I found it challenging to link class concepts and theories/frameworks with this particular set of tools. This was a good challenge, though, as it made me put statistics into context and think about how we use them." To the students, the challenges posed by the mechanics of concept mapping paled in comparison to the challenge of specifying, clarifying, and elucidating the relationships being mapped.

Most educational interventions aim to improve student comprehension and achievement. In this context, the sequence might go as such: students who create better concept maps would have a higher level of mastery over the material and subsequently achieve a higher course grade. However, based on the relationship between concept map quality (as scored via our rubric) and students' final grades, we surprisingly did not find evidence for this progression. While we did not find across-the-board grade improvement, we found that level of engagement moderated the benefit of using of cmaps. We deduced this via two proxies. First, certain students found the concept mapping process significantly more challenging than others, but these were not the low-achieving students. Rather, the students whose final course grades were *highest* reported being the most challenged by "the intellectual material [they] addressed" and "assembling that material into a concept map" ($r(21) = 0.44$ $p<0.05$ and $r(21) =0.61$ $p<.01$). Second, students who completed more required assessments than others found the concept mapping process more useful in general ($r(21)= 0.45$, $p<0.05$). Apparently, those who were more invested in the course were more likely to follow instructions, thereby achieving more by reflecting on the cmapping process more systematically.

We thus found that concept mapping did not engender individual student improvement universally but rather benefitted the students who were engaged in the learning process. Our research showed that the end product—the actual *concept map*—was not the critical outcome, but instead the struggle that generated that map. This is consistent with the constructivist philosophy from which concept mapping emerged (Kinchin 2001). The degree to which students took the concept mapping process seriously may have differentiated them into high and low achieving groups. This indicates that students with an increased level of buy-in and are willing to engage with the nuance and hybridity of connections reap the rewards. It appears that intellectual struggle, and the subsequent reflection on that struggle, is what increased student achievement.

One possible alternative explanation for this differing level of engagement in concept mapping could invoke the literature on learning styles, based on the intuitive assumption that so-called "visual learners" may preferentially engage in visually-based activities such as concept mapping. One of the most widely used instruments is the VARK (visual, auditory, reading/writing, kinesthetic) learning styles survey (Fleming and Mills 1992). Despite critique (e.g., Cain and Dweck 1989; Dunn 1993; Hargreaves 2004), it has penetrated mainstream consciousness. A background survey we did using Fleming's 2010 VARK 7.0 instrument,[9] however, does not corroborate this intuition. In fact, we found that visual learners found concept mapping less useful overall ($r(21)= -0.434$, $p<0.05$), and were more challenged by the procedural aspects of concept mapping assignments, finding the instructions unclear ($r(21)= 0.434$, $p<0.05$) and feeling they lacked the time to complete the assignments ($r(21)= 0.455$, $p<0.05$). Visual learners were also less successful in the course overall: of the 25% of students who had the worst grades in the course, 33% identified as visual learners. Conversely,

[9] Taken from www.vark-learn.com/documents/The%20VARK%20Questionnaire.pdf.

none of the students who achieved the highest course grades identified as visual learners. We thus do not believe that learning style, at least as theorized in this manner, was the reason underlying differing levels of engagement with concept mapping.

Given the lack of across-the-board longitudinal student improvement in our assessment, it's worth contextualizing concept mapping within educational innovation generally. If adding an e-tool or teaching technique to a course unfailingly improved individual student grades, educational improvement would be simple. We must be cautious not to make technological innovations our beasts of burden, saddled with rectifying the messy complexity of learning and problem solving with, quite literally, the click of a button. Given the complexity of variables potentially influencing student achievement, it is not surprising that our rising tide of concept mapping did not lift all boats. Additionally, there are inherently confounding variables in a classroom research setting, not all of which we addressed: for instance, we lacked a control group and the final cmap assignment was done as a team. Further research could isolate and rectify these relatively simple issues. Even in terms of our significant findings, correlation is not causation. Are higher achieving students more likely *a priori* to go beyond the deceptive simplicity of concept mapping, and recognize the delicate hand needed to treat environment as connection? Are higher achieving students more likely to complete all class assignments, bear the fruit of those assignments, and gain the means to do better in the course? It may simply be that students who are high achieving engaged more fully with what the course asked of them, and were subsequently rewarded by their engagement. Should this be the case, a valid concern could be that educational innovations such as concept mapping may further stratify high achievers from low achievers, widening the gap between students who thrive with increasingly challenging demands and those who do not.

4 Next steps, better practices

4.1 Better concept mapping, better connecting

Our implementation of concept mapping at Lewis & Clark College suggests possibilities and guidelines for use in ESS instruction. For instance, both perspectives (e.g., MyTFA or unit synthesis) and process (e.g., ANT) cmaps can readily be applied to a wide range of existing ESS courses and topics. Additionally, having students do concept map exercises in stages (e.g., by comparing a MyTFA map at the beginning and end of the semester, or by incrementally reducing the number of key actors in an ANT cmap) helps students better appreciate the tool. Finally, given the flexibility of the CmapTools application, ESS instructors could apply it to a wide range of desired learning outcomes, as we have by using actor-network theory to inform a more specific representation of environmental connections.

In our experience, certain principles have worked better than others. We have found that committing fully to the approach has allowed us to integrate the exercises into our curriculum more authentically. By differentiating concept mapping into lesson-specific exercises, we avoided tacking concept mapping exercises on to pre-existing lessons, thereby diminishing their impact. Yet our efforts to encourage relatively simple, elegant cmaps have clashed with the desire among (mainly high-achieving) students to comprehensively map connections. This tension may be a good one, given the need in environmental studies to identify answers in a messy, interconnected world.

Ultimately, no matter how much effort is devoted to designing high-quality concept mapping exercises for students to discover and communicate environmental connections, more fundamental issues may hamper even the best efforts, as the effectiveness of concept mapping seems contingent on student motivation. While there is no simple recipe for increasing student engagement, awareness of the fundamental importance of student interest can assist instructors in designing appropriate classroom activities.

4.2 Challenges inherent in reframing environment

Our empirical results speak as well to a larger challenge found in and outside of the classroom. Approaching environment as connection requires new ways of thinking and analyzing in ESS, and some ESS scholars—including our students—will be more willing to do the novel work following from this approach than others. We found that concept mapping may serve, unintentionally, as a differentiator between more and less motivated students, between those who worked hard to appreciate, analyze, and communicate environmental connections via concept mapping and those who were less convinced of the purpose of concept mapping. For all the scholarly justification behind this approach, many students come to ESS looking for the more familiar approach of environment-as-nature. The importance of finding ways to motivate these students was suggested above, but the larger challenge may fall on the ESS community of scholars to offer compelling models to our students of appreciating, and analyzing, the heterogeneous web of connections that matter. We may best serve our students by taking to heart the insights revealed by approaches such as environment-as-connection and tools such as concept mapping, even if they lead our ESS field in new and uncharted directions.

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