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Embedding the Scientists: Civic Issues as Context for Teaching and Learning

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Abstract: *We teach science as a path to meaningful civic engagement in a participatory democracy and as a path that should be open to all; our concern lies in how the next generation of young citizens¹ address challenging civic issues both by applying science to other contexts—public and civic—as well as communicating science to others—peers and the public. To that end, our article seeks to explain an interdisciplinary capstone course for our general education program that we developed to promote and support science learning and science communication by teaching in the context of important civic issues.*

Science is not about big words. It's not about lab coats and safety goggles, and it's definitely not about trying to make yourself sound fancy. Science is not an end in and of itself, but a path. It's a method to help you discover the underlying order of the world around you and to use those discoveries to help you predict how things will behave in the future. (López-Alt 21)

For 16 years, Longwood University students have traveled to the world's first national park, Yellowstone, to participate in an immersion learning program focused on the stewardship of public lands. Stewardship, a concept applicable in contexts ranging from financial institutions to art museums, offers an approachable framing for students' engagement with complex environmental issues. In the realm of environmental conservation and management, stewardship is rooted in the land ethic of Aldo Leopold and his intellectual descendants, and it offers a "pathway for action" for today's students (Mathevet, et al.). Because Longwood's Yellowstone National Park course (hereafter LU@YNP) is focused on complex environmental stewardship issues such as management of reintroduced wolves, protected status of grizzly bears, and permissible uses of park lands by visitors, student learning—through explorations, observations, and conversations with peers and local stakeholders—is strongly infused with scientific questions, methods, and concepts.

However, participating students, faculty members, and stakeholders not only have very different disciplinary perspectives and experiences, but also diverse understandings of the physical landscape, commonly known as the Greater Yellowstone Ecosystem

1. In this chapter, we use the word "citizen" not to denote a person's legal status but rather to refer to residents of U.S. communities who are engaged in civic life. Our collaborators, students, and stakeholders represent diverse communities and come from richly varied backgrounds and experiences. We acknowledge the significant contributions of diverse community members in the Greater Yellowstone Ecosystem and throughout our country; their places of origin and documentation are not relevant.

(GYE), and its human communities. Thus, we embed science students in a learning community in which students from many majors collaboratively discover, digest, and disseminate information about unresolved, and often bitterly divisive, natural resource issues in and around Yellowstone National Park (YNP). This work is facilitated by an interdisciplinary faculty team from biology, geography, mathematics, sociology, art, rhetoric, and other fields, depending on the year. Students construct their learning in key spaces such as the open range, visitor centers, and museums and benefit greatly from the synergy between informal science education and science communication that exists within those spaces as well as from broader disciplinary convergences.

Student learning therefore emerges through real participation in a community of practice that helps students to develop a sense of identity as contributing members of the community, which in turn cultivates in the participants belonging and commitment (Handley et al.). Our goal is for them to transfer the practiced skills to other contexts and communities in their civic lives. In this chapter, we explore the experiences of students steeped in this complex and complicated milieu and make inferences as to the contributions of immersive experiences to students' learning of science communication.

Situated Teaching and Learning: Scholarly Context

In acknowledgment of the pervasiveness of science in modern life and the need for all persons to be able to engage science issues, many countries around the world have invested in efforts to develop "scientific literacy" for all students (Feinstein et al.; Blanco-López et al.). In the United States, the Next Generation Science Standards (NGSS) were developed to address this ongoing and persistent need through K-12 science education reform because "too few U.S. workers have strong backgrounds in these fields, and many lack even fundamental knowledge of them" (National Research Council 1). The goal of the NGSS is that, by the end of secondary schooling,

All students will have some appreciation for the beauty and wonder of science; possess sufficient knowledge of science and engineering to engage in public discussion on related issues; are careful consumers of scientific and technological information related to their everyday lives; are able to continue to learn about science outside of school; and have the skills to enter careers of their choice, [including science, engineering, and technology fields]. (NRC 1)

Complementary efforts in U.S. higher education have sought to engage students in learning science through the study of "humanity's most pressing current and future challenges" (NRC 1). One articulation of this goal in studying and teaching science, the Science Education for New Civic Engagements and Responsibilities program begun in early 2001, has spawned efforts at hundreds of campuses, all seeking to engage students in connecting "science and civic engagement by teaching 'through' complex and unsolved public issues" (SENCER para. 1). The LU@YNP program exists at this important intersection: post-secondary education, science communication, and civic issues.

To mimic the situational context of a civic body, we placed students in an interdisciplinary course with instructors from multiple disciplines and embedded them in the field to exercise the skills of listening, questioning, dialoguing and researching. This

setup subverts the classroom dynamic of sitting and hearing information to be used later. We are not so much filling students with information as we are immersing them in the work of inquiry, research, and understanding. We have brought down the walls between learning environments and invited students to be careful participants of this new place and its issues.

This classroom draws on classic work of John Dewey and Paulo Freire. Freire criticizes the “banking” approach to education in which an expert gifts knowledge to learners with no understanding (*Pedagogy* 72). Freire instead argues for construction through communication: “Knowledge is built up in the relations between human beings and the world, relations of transformation, and perfects itself in the critical problematization of these relations” (*Education* 96). Constructivist Dewey, noting that most students will not become scientists, argued for an approach that connects students “with problems selected from material of ordinary acquaintance” so that “they will be sure and intelligent as far as they do go” (*Democracy* 235). Our approach intentionally avoids the “banking concept” and instead positions students to be the drivers of their inquiry. Thus, we implement these emancipatory pedagogies and strive for a democratization of education that makes learning environments more horizontal and the role of experts less privileged.

In the last several decades, science communication in professional contexts mirrors this shift from the deficit model (i.e., information is transmitted to consumers who are thought to be unaware of it) to an engagement model in which diverse stakeholders participate in dialogue (Bubela et al.). In parallel, many science educators have moved from a focus on content delivery to pedagogical approaches that position students as co-constructors of learning (Davis and Russ).

Another key to learners’ active engagement is their affective disposition. Science education scholar Mark Newton considered the emotive reasoning of a cohort of LU@ YNP students and found that they described much more empathetic dissonance (e.g., compassion, guilt, anger, and righteous indignation) for other citizens and for the natural systems after completing the program (Herman et al., “Students”). Newton and his collaborators also describe a realization by students that many ways of knowing should be considered in complex stewardship issues. Through their interactions with diverse stakeholders, students were challenged to consider in concert diverse cultural views, moral and ethical questions, scientific evidence, indigenous knowledge, and more (Herman et al., “Socioscientific”). “Rich” learning environments like this support students’ preparation to work to resolve challenging socio-scientific issues (Newton and Zeidler), and, we contend, also help motivate students to do so.

With students primed for action, we ask them to sit and listen just a bit more. For this work, we look to invitational rhetoric (Foss and Foss), which assists speakers with encountering difference, whether it is ideological, educational, or rooted in community history. Invitational rhetoric rests on a set of assumptions, one of which is that a speaker should operate from a position of “power-with rather than power-over” (13). This process suggests that instead of privileging loud or vigorous debate as an active classroom, we make room for careful listening to another’s perspective with the goal of understanding rather than waiting to speak. This “rhetorical listening” is a pedagogical strategy designed to make space for the intellectual work of hearing what the speaker is saying

within their context and situating the communication within the listener's understanding and interpretive work (Glenn and Ratcliffe). To take up a food metaphor, "There is no production of wine without a gathering and safekeeping of the vintage, just as there is no genuine dialogue without dwelling in another's ideas" (Stenberg 252). The promise of this practice is that the speaker and participants walk away with a richer understanding of multiple perspectives on fraught issues and recognizing the complexity of multiple needs.

To be successful in transferring their knowledge and skills from the ephemeral LU@YNP community of practice to other civic and professional contexts, though, students must be practiced in communication. Our braided approach to pedagogy supports that development.

The Pedagogy of Braiding

A rope is a useful metaphor to explain our pedagogical approach to promote improved communication of science to various publics and across the majors. Most ropes have three twisted fiber strands, each of which has value independent of the rope. If braided, the strands create an object that is far stronger and of greater value than a loose bundle of the same threads.

The LU@YNP program replicates the rope analogy in a number of ways. One strand is the multidisciplinary faculty team working in collaboration as co-facilitators of the course. The second strand represents students of different majors and minors. The third strand is an interdisciplinary pedagogy enacted onsite in the GYE. The braiding of these strands supports students' exploration and understanding of complex stewardship issues of public lands. Ultimately, each strand is crafted to help students enhance communication of complex issues.

Faculty Strand

Our faculty team is composed of humanists, mathematicians, artists, and natural and social scientists, which parallels the diversity of the legendary Hayden Expedition that, in its mission to explore and document the western territory that would become YNP, employed biologists, earth scientists, a statistician, and artists. In our course, single disciplinary perspectives from faculty members are not emphasized. Formal lectures in the field are minimal. Instead, the interdisciplinary pedagogy goes beyond separate disciplines to form a holistic approach, one in which we are focused on our scholarly expertise in asking questions, making observations, evaluating information, and synthesizing observational research with data. We are not there as experts in wildlife biology, human geography, art, or rhetoric, but rather as intellectual mentors for apprentice investigators who are asking questions, making observations, and communicating their findings.

The GYE with all that it contains, both natural and anthropogenic, serves as the classroom, and we engage a range of local co-teachers—state wildlife biologists, visitor center staff, museum curators, and a host of other stakeholders—to provide instruction

and local expertise. In some years, students conducted oral history interviews with citizens whom we consider co-teachers in this endeavor.

Student Strand

The student strand consists of a cohort of many majors. And yet this strand might be considered a three-thread strand within the larger braiding. Each student embodies three identity spaces within the course and is asked to activate those identities extemporaneously as the situation calls for.

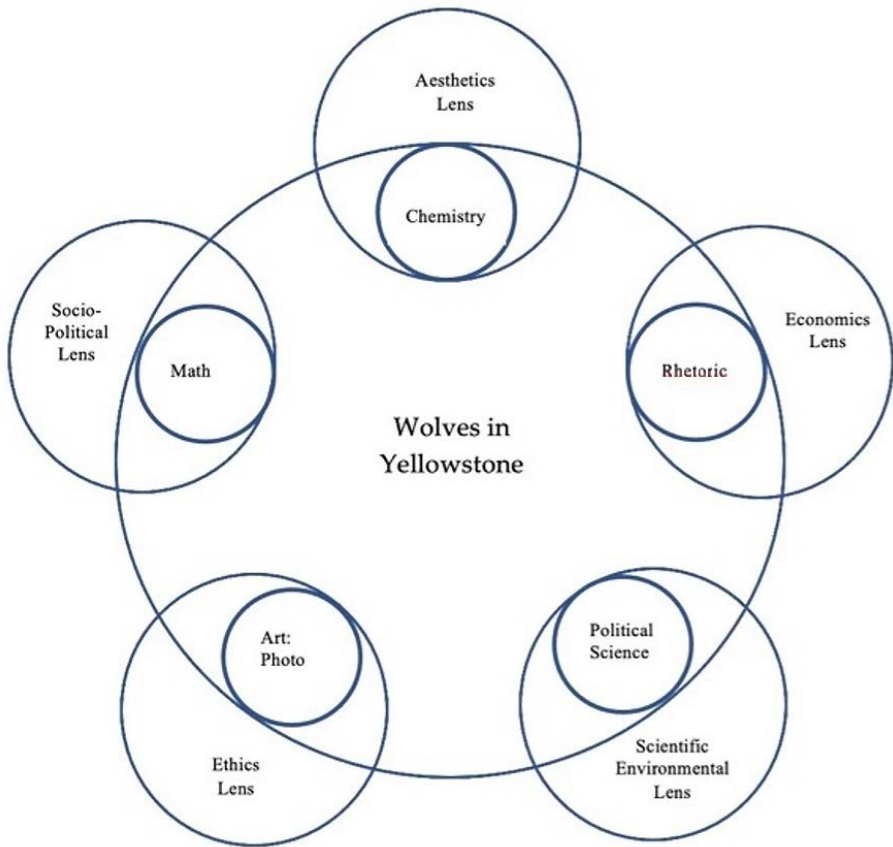


Figure 1: Students' Work Through Lens and Major on Wolves in Yellowstone

First, students are assigned to work with two or three peers in an "Issue" team. That Issue team focuses on one important stewardship issue, such as bison management, invasive species, fire management, water resources, or technology access. This grouping allows students to develop a cache of background knowledge pertinent to topical events affecting the park with regard to that issue. Second, students are asked to bring forward

disciplinary knowledge and skills of their majors. We invite students to be intentional in their explorations. How does their discipline interrogate a problem? What evidence do they find useful and where do they look for it? What count as credible conclusions in their field? Each should use the expertise learned in their major to unpack observations, research, and stakeholders' commentary. Finally, we consciously challenge students to think beyond their chosen field by placing them in a "Lens" team. Students are to view issues from their assigned lens: scientific and environmental, aesthetic, economic, ethical.

This three-part combination (see Figure 1) provides students with opportunities to deploy multiple perspectives to address their chosen stewardship issue across multiple audiences, genres, and situations. Using invitational rhetoric to open themselves to diverse perspectives and rhetorical listening to digest what is presented, students mobilize these three strands in order to understand not only their peers' perspectives but the stakeholders' as well.

This process of perspective-taking and listening is practiced daily in debriefing sessions during which students contribute insights on the day's learning activities by alternatively focusing on their lens and their issue. For example, while discussing a wild-life-watching outing, a chemistry major would be expected to introduce the effect of tourism-related air pollution while also considering the aesthetic disruptions of hordes of buses and vans to the wild-ness of the landscape. For discussion of civic issues, students must practice an intentional weaving of multiple perspectives, often extemporaneously, when we deliberate contentious issues in the field and in conversation with local citizens, a practice that ultimately serves them when they publish a document in service of the civic issue. For example, as the number of wolves increase in the Yellowstone ecosystem, the number of domesticated animals harmed or killed by wolves increases. Should hunting be allowed during a longer season or in larger numbers of kills? The art major would be expected to explain the economic benefit from ecotourism while also considering the perspectives of ranchers who have lost valuable livestock. Many of the other students in the art major's lens group may have seen the rhetoric of public communication in anti-wolf bumper stickers on local cars and trucks.

Pedagogy Strand

A fitting pedagogy for this mobile learning community of faculty and co-teachers working with a diverse student cohort is, in a word, flexible. The course unfolds over a six-week period during which students prepare for their immersion in the knowledge base and the communities they are about to enter, develop a portfolio of targeted research, meet stakeholders in the field, and design written, oral, or artistic performances to reflect their understanding and agency based on newfound knowledge and experiences. A critical factor throughout these stages is the act of faculty modeling: model, model, and model again.

For this complex endeavor, we have developed the *Field Immersion Framework*, a four-stage pedagogical scaffolding that guides faculty and students (see Pederson et al.). The first stage, Foregrounding, takes place before the group departs for the field. In this pre-travel period, we actively recognize the diverse perspectives represented in the fac-

ulty and intentionally lead teaching sessions with multiple faculty. We are modelling the integration of disciplinary perspectives when the geographer annotates a video clip of the landscape of the Yellowstone ecosystem and an art professor illustrates the use of painting as a tool to persuade Congress to preserve this area as a national park.

Central to student learning during Foregrounding is to have students practice hearing diverse perspectives and synthesizing those views in preparation for field work during the Immersion stage. One such activity is to gather stakeholders representing government interests, private interests, business interests, and university interests to discuss a selected issue with our students at various tables. Over the years, we have used a proposed natural gas pipeline, student housing expansion into the community, and water quality. During a shared meal with community members, students ask thoughtful and respectful questions while also taking notes. After the meal, faculty facilitate a debriefing not only on what they learned but how they learned what they have come to understand. Within these pre-departure days, we also set aside time to coach student research skills both with static sources online and in print as well as meeting invited stakeholders who preview the civic issues involved in the Immersion stage, the physical environment, and various community perspectives.

The second stage, Immersion, takes place in the field. Students are instructed (and faculty continue to model ways) to observe, record, reflect, analyze, focus, and inquire, again, at a moment's notice and in constantly changing environments. Reflection, the third stage, is an iterative metacognitive process initiated in Foregrounding and continuing to the end of the course. Reflective activities reify the actions of interrogating and transforming past knowledge, absorbing and challenging present knowledge during the Immersion stage, and then preparing to put that knowledge to use in the final stage, Agency. In completing the course during the Agency stage, students are challenged to create public documents on their stewardship issues. Students must think about how to use learned interdisciplinary skills to address an issue and to craft documents to elicit a change in thinking and/or behavior for a target audience.

Discussion: Science Communication, Science Education, and Civic Agency

To better prepare undergraduate students of all majors to engage as civic agents, we developed a braided approach that embeds students and faculty members as newcomers and masters in a community of practice (Lave and Wenger) focused on learning skills in context. By co-locating scientists, students of science, and others who use science in their lives as engaged citizens, we created an environment in which science can be talked about, deliberated, and applied in meaningful communicative ways by all involved. The context in which that community of practice functions is key: this all plays out in real

time in real communities with real people who are impacted by real issues. It is authentic. It is genuine. It is accessible.

Honoring Diverse Ways of Knowing

Our course situates Virginia students as “outsiders” in the GYE human communities so that students experience a shift in perspective. The insider/outsider context is never more apparent than when they meet Mr. Scott Frazier, a member of the Crow Nation and a Montana resident. As a co-teacher with the LU@YNP program, he shares his community’s indigenous ways of knowing and addresses contentious stewardship issues that our students study. Immediately, students gravitate to his literal and figurative narrative. He piques their curiosity as he describes the thousands of years of living his ancestors represent and their indigenous science knowledge—their ways of knowing the land, sky, weather, flora, and fauna.

After meeting with Mr. Frazier and listening to his storytelling about the significance of bison to his people, one of our students, Emily, an elementary education major, describes an integration of his ways with her ways of knowing culture, history, and biology. This integration is evidenced in part by her using the term ‘buffalo’—his term—instead of bison as we have used in the course:

My father is a hunter, who has actually killed a buffalo [with] a regulated, licensed ranch outfitter in Montana. I’ve eaten the lean, beef-like meat, and the buffalo head is mounted in his barn trophy room. Nonetheless, the Native American tradition and sacred reverence of the buffalo is recognized by my family, but it particularly stands out to me. In studying history, which I hope one day to teach, every part of the buffalo was used, every part. It provided, literally, food, clothing, and shelter for the Lakota Sioux, as well as other tribes. The annihilation, near extinction, [by white hunters] of this species is a stain in American history.

This assignment requires her to choose among the contentious issues of bison preservation, hunting, and societal uses in Yellowstone and to take a side. Emily’s reflection evidences her ability to synthesize her family’s heritage of hunting animals as trophies, Mr. Frazier’s narrative of buffalo as life-giving resources, and U.S. history of slaughter for her own ethical decisions about what should be done with bison and how she will teach in the future. We see her intention to use multiple and conflicting perspectives, rather than choose a single hegemonic perspective in addressing her audiences, as central to science communication. As a future teacher, this ability to listen and invite difference might promise a more integrative teaching approach for the sciences and communicating with other partners, who might be public, non-experts in her sphere.

Situating Science and Communication in Community

Rhetorical listening works well for students as they recognize the importance of a community’s history in understanding and synthesizing current issues. Calli, a chemistry major, recognizes that there must be understanding of how a community has come to be and to know the issues before one can consider how to address matters of public con-

cern. She explains that “These ranchers and wildlife biologists interact with their community and the surrounding community in ways that we could only understand by asking questions and listening, not assuming that we knew their way of life.” In these ways, Calli sees the ranchers and biologists as masters in a community-of-practice, and this opportunity is her apprenticeship in understanding in order to communicate effectively.

Diane, a biology major, extends that acknowledgement of expertise to many diverse community members:

The biggest aspect of the class and trip in my opinion was communication. I spoke with many different people...locals in shops, shop owners, or even the bartender. A lot of topics [we are studying]...are sensitive topics to the people who live there. The skills I've learned through practice in my general education curriculum prepared me to acknowledge the person's position so I could have a healthy conversation with them.

Acknowledging the person in conversation, a form of “power-with rather than power-over” (Foss and Foss 13), is the first step so urgently needed in public discourse about civic issues, and, by extension, a necessary social practice for young scientists speaking in community. The complexity of stewardship issues requires all voices be present at the collective table and, as demonstrated by Calli, the asking of complex questions through invitational rhetoric.

Transfer of Learning

As educators who work to promote strategies for transfer, our hope is for students to carry the lessons with them—when they return to family, coworkers, and peers—in their communications with myriad public, non-expert audiences. In the following reflection, Shawn, an integrated environmental sciences major, demonstrates his learned research and communication skills with family members. He is a translator of research, synthesizing complex concepts and terminology, then explaining for understanding rather than preparing for a debate.

When my parents or siblings have a question related to science..., I can sift through the dense language of scientific articles, but my family members may struggle comprehending the same information.... Since it would not be effective to relay the information to them verbatim, I have to acquire, organize, and present the information clearly and precisely so that they can understand too.

Thus for Shawn, science communication is not a summary of scientific principles or findings but a connection of his audience's concerns to his re-organization and explanation of research that encourages a dialogue, where his family members may continue to have questions. This process mimics one of our pedagogical moves to place students and stakeholders in tandem as they grapple with complex issues in the field. Our intention is

that students understand learning to be a dialogic process combined with active listening skills to understand who is speaking and from what frame of reference.

Recommendations for Transfer and Adaptation

We see science as a path forward to broader and more inclusive dialogues about the many complex issues that affect our local communities and that unfold on the global stage. Climate change, pandemic response, biodiversity loss, legacy chemicals: citizens need more than scientific literacy to be engaged with these challenges. They also need to be practiced in communicating about them with fellow citizens who are different in culture, education, and socio-historical signifiers.

We contend that braiding science communication and science education in the context of key civic issues is an effective approach to preparing the next generation of citizen leaders. In form and function, the LU@YNP program engages students in learning science by practicing key competencies of science and science communication. They do so in a mobile community of practice that immerses faculty members and undergraduate students in our own consilience (à la Wilson) to draw on diverse disciplines and interrogate ideas, evidence, arguments, and proposals. In this disciplinary milieu, students are consumers and producers of science communications through a “bottom-up” process of dialogue (Blanco-López, et al.) in the community of practice and in the human communities they explore. Through conversations with local citizens, students’ own written reflections, formal discussion with peers, faculty, and staff members, and formal written assignments, students build proficiency in science competencies through communication and in a context that calls on them to practice civic agency.

Even without substantial institutional or departmental support, the model of trans-disciplinarity can be started with a pairing of two courses scheduled at the same time. Perhaps it is a summer course or, during the traditional semester, the course can be co-constructed to share assignments or simply have students communicate at choice times for an interdisciplinary conversation. Regardless of the level of braiding, the following recommendations for teaching science communication are made with an interdisciplinary population of instructors and students in mind.

Teach the Conflict

We believe that introducing students to the heart of the problem early on will whet their appetite for course learning. This introduction should be facilitated by competing and complementary disciplinary voices to share in the development of information. Our course is led by a number of instructors from different fields, and we also include expert and non-expert stakeholders involved in the issue. In addition, we suggest transparency of expectations early and often: students need to know that they will co-construct their learning, which relies on their initiative, rather than waiting for material to be delivered. To that end, instructors must model good questions and make time for said questions and reflection. For instance, LU@YNP’s Foregrounding stage, which occurs three days before the course moves out West, focuses on engaging students with local civic issues and facilitating the explorations of conflicts. By embedding the students in sample conflicts in our campus town, we can coach students through the identification and research

of a civic issue, processes they will need as soon as they hit the ground in Montana. We find there is a lot less passivity on the part of the students using the conflict as a catalyst.

Use Organic Writing Genres

Rather than creating assignments based on “mutt” genres, which work to deliver information for teacher review and to transmit what the learner has learned (Wardle), we select assignment genres based on the rhetorical situation of student work. Typically, mutt assignments only function in the classroom and bear little-to-no resemblance to the writing found in professional or even personal spaces. While mutt genres can be useful for information delivery or checking student comprehension, those genres do not work well for engaging students in the real work of science communication or public work. For example, it is unlikely that a letter with citations or a five-paragraph essay would be an effective means to communicate with a stakeholder.

We believe what is best for the learner, especially operating in the civic, public sphere, is to use genres used in workspaces organic to the challenge of the complex issue in question. For example, if the goal is for students to record their observations or collect data, a field notebook might be a good choice. We might show them examples of how scientists or other operators in the field—anthropologists, archeologists, social workers—take notes on their work. The name “field notebook” signals to the student where the genre is used (the field), where the content is collected (the field), and the level of formality required (it is a notebook, a rough draft, a ledger, but it needs to be legible for later use or the review of outsiders). Adopting and adapting genres from outside the classroom allow students to work with types of writing that function with a sense of agency beyond the classroom; furthermore, they are practicing the very adaptivity they will need when approaching public audiences to communicate complex and contentious issues.

Maximize Reflection

Reflection has had a long history as a strategy for learning (Dewey, *How We Think*; Freire, *Pedagogy*), a record of change in thinking (Schön; Kolb), and a tool for assessment (White; Yancey). Our use takes up all three approaches.

In engaging students in this practice, the first goal is to have them use reflection as a tool of science. Notetaking in the field notebook channels both Darwin and Dewey. Mimicking Darwin, students take notes in certain physical and intellectual spaces in Yellowstone. We encourage their use of visual, linguistic, and spatial skills for these notebooks. Students might create a graphic display of information, draw the animal in its environment and label its parts, or sketch the new cultural geography before them. Dewey’s influence in the field notebook is encouraging learning from experience with the process of reflection. Thus, we ask students to place their reflections in proximity to these visuals so a record of learning and thinking is integrated.

These notebooks also are used as a point of learning during and after an activity. Donald Schön has proposed that learners reflect during and after an activity as a way to solve complex problems in the workplace. Given that we have embedded apprentices in the environment of local stakeholders sharing their expertise, we are intentional about

the tools that allow the apprentice to get up to speed. The field notebook is part organizational tool for cognition and part debrief as they navigate the messy boundaries of complex civic issues.

This process of learning and reflecting is a crucial fiber in our pedagogy strand of the braid. We continue the practice of reflection as students examine different ways in which scientific information is discussed in diverse settings. Listening and recording what they hear, see, and think facilitates looking deeper, and students distill the frames, terms, and perspectives that build understanding and cause increased conflict. For instance, because students have read during our pre-departure the seminal publications of Truman Everts' 1923 narrative "Thirty-Seven Days of Peril" that galvanized the public's imagination as well as the 1916 *National Geographic* that spurred Congress to preserve Yellowstone, students have prior knowledge of how well science was communicated in that context to the public. That prior in Foregrounding reading allows us to repeatedly recall those models as one way to write to different audiences about complex contentious issues, incorporating science using diverse source material.

Finally, students' reflections in the field notebook along with submitted documents make visible the learning and application of science as well as the rhetorical flexibility they have exercised in developing communication skills to a wider set of audiences. This metacognitive transparency is a key aspect of our community of practice as it supports critical dialogue among students and faculty members and also contributes to our real-time adaptive management of pedagogical activities. We assess student learning in this dynamic context through formal and informal reflection to evidence the often-invisible process of learning and to help students recall, organize, and name their learning (Adler-Kassner and O'Neill; Beaufort; Yancey). Reflection that requires students to reference their experiences or written work encourages them to document rather than invent the evidence of their learning (VanKooten; White; Yancey). We ask students to reflect on what they have seen, heard, read, applied, and learned. The resulting student work used herein was taken from two sources: field notebooks and a final reflective analysis (students are identified by pseudonym and major). This reflective material reveals some useful insights for our evolving pedagogical approaches as students document strengths and challenges to their learning.

Though an adventure in the wilds of the West is not feasible for all students, every community faces key civic issues that involve science—in the root causes, in the dialogues, and in the paths forward. Undergraduate students of all majors can be immersed in these challenging issues and therein apply their science knowledge and practice communicating it. Science is a path to discovery and to a view of the future, and undergraduates—all undergraduates—are a vital link to a future that includes richer dialogue about science in our lives.

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