

Establishing the Office of Phosphorus: Introducing wicked problems in collaborative governance through an active learning exercise

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Abstract: Collaborative, team-based research can provide unique educational opportunities for students while supporting faculty research goals. Increasingly, universities are developing programs to allow undergraduates to participate in team-based research on sustainability topics. In this paper, we outline a case study of a collaborative active learning exercise that supported an interdisciplinary project on governance and nutrient management. Students were asked to conduct research on behalf of a fictional “Office of Phosphorus,” which helped illustrate the real challenges that public administrators face when they must collaborate across levels of government or agencies to address sustainability challenges. The exercise also functioned as a diagnostic tool for faculty to identify where students needed more guidance, training, or support. By closely mimicking the experience of open-ended research, the exercise helped calibrate student expectations. Finally, we offer suggestions for how this type of exercise could be used to encourage collaborative research on other, related topics in sustainability.

Keywords: phosphorus, collaborative governance, nutrient management, active learning, collaborative research, undergraduate education, team-based research, open-ended research

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1. Introduction

Collaborative, team-based research can provide unique educational opportunities for students while supporting faculty research goals at the same time (Gade & Wallace, 2023; Jensen et al., 2023). Traditionally, students receive research training through research papers in classes or seminars using scaffolding techniques that break down a bigger project into smaller components (e.g. thesis statement, outline, etc.) (Knoll, 2016). Students may also be introduced to the methods and theories of the field through introductory methods seminars (Jeram, 2024) or “labs” (Sullivan & Bruin, 2023). Increasingly, students are encouraged to participate in team-based research projects, which may involve “vertically integrated” teams that include undergraduates, graduate students, and faculty (Balleisen et al., 2024). Many of these initiatives are responses to recommendations by the Boyer Commission (1998) that called for universities to increase undergraduate participation in research.

In this paper, we outline a case study in which researchers used a low-stakes, collaborative, active learning exercise to help introduce student researchers to some of the central research challenges at the intersection of sustainability and governance. Students were asked to conduct research on behalf of a fictional “Office of Phosphorus,” which helped illustrate the challenges that public administrators face when they collaborate across domains or agencies. The exercise also functioned as a diagnostic tool for faculty to learn what students already knew, and where they needed more guidance, training, or support. By closely mimicking the experience of doing open-ended research, the exercise helped calibrate student expectations about what their research experience would be like. Lowering the stakes of research activities created a space for students to experiment and ask questions, which carried over into how students communicated with faculty (and each other) for the rest of the project.

In the next sections, we contextualize our experience with an interactive exercise within the literature on active learning and collaborative research, describe how it fits into the goals and learning objectives of the broader research experience, and then outline the project itself in more detail. We quote excerpts from student reflections as preliminary evidence of the short- and long-term benefits of the activity. Lastly, we suggest how this approach could be applied to a wide variety of subjects and sustainability topics.

2. Review of literature on active learning

Collaborative research projects inherently involve active learning, which refers generally to methods that encourage students to participate in the construction of knowledge (Prince, 2004; Rickabaugh & Siegel, 2025). Active learning gives students an important voice in the research process and offers new perspectives from a younger generation that is more diverse and educated (Freire, 2012; Robinson, 2018). Active learning can include approaches such as the “flipped” classroom, in which students complete readings in advance and apply their knowledge through in-class collaborative activities (Buckman et al., 2019). Freire (2012) posited that dialogue surrounding the learning process allowed for new epistemological perspectives and an accountability to different cultures and systems. Being part of the process and collaborating with both teachers and peers helps students to better grasp concepts and develop relevant skill sets that benefit students beyond the classroom that also facilitate community engagement (Toomey et al., 2023). Lastly, research has shown that

applied learning, helps to “improve the mastery of challenging concepts” for students within the social sciences (Sarmiento et al., 2024, p. 4).

Faculty seeking to include undergraduates in research must strike a balance between providing students with an educational opportunity to grow and learn, while also ensuring that they have the skills to complete the work. As a result, it is common practice to recruit from upper-level undergraduates to ensure they come in with baseline knowledge, or to establish prerequisites for participation, such as taking an introductory research methods course before participating in research projects. However, Livny (2023) argues for broadening recruitment to involve more students, and to use participation in research as an opportunity to train students and develop skills. Other faculty mentors have responded to this challenge by designing projects in which students work on one narrow aspect of the project, so that they can gain mastery over that aspect, such as data collection or data analysis. (Gade & Wallace, 2023). For projects that span multiple semesters or years, it is especially important to clarify how the student will fit into this larger project, how their work will be passed on to others, and how their work might be used in future outputs that are developed after they leave. (Coyoli & Dosh, 2023).

Primarily Undergraduate Institutions (PUIs) may be an optimal place to do collaborative research projects with undergraduates precisely because there is often less infrastructure in place (i.e. fewer graduate students) to support faculty research. While faculty members accustomed to the stratified research environment of an R1 might initially write off undergraduates as potential collaborators, our experience is that the subset of undergraduates who seek out research opportunities are also more likely to have the intrinsic motivation to take on challenging or complex research tasks. Participation in research at a PUI gives students a preview of what they can expect from graduate school in a more competitive R1 or R2 setting, while supporting rising faculty research demands at PUIs that may be striving to R1 or R2 status (Huerta, 2015). Undergraduates at Minority-Serving Institutions also benefit from participating in these projects for similar reasons (Velásquez et al., 2023).

3. Background on the project

The activity described in this paper was developed as part of a project on collaborative governance regimes for nutrient management that was supported through a multi-institutional Science and Technology Center funded by the National Science Foundation, the Science and Technology for Phosphorus Sustainability (STEPS) Center. The STEPS Center is focused on “convergence” research, or problem-driven, highly interdisciplinary research, to improve the sustainability of global phosphorus management (The Science and Technologies for Phosphorus Sustainability (STEPS) Center, 2023). The subaward from STEPS, entitled “Collaborative Governance for Phosphorus Sustainability,” involved a study of collaborative governance regimes (CGRs) (Ansell & Gash, 2008; Emerson et al., 2012) in North Carolina through semi-structured interviews with members of regional river basin associations, which included city and county elected officials and staff, as well as NGOs, trade associations, and individual affiliates. The project was led by two tenure-track faculty at Appalachian State University from Government & Justice Studies and Communication, and a postdoctoral researcher at North Carolina State University. Appalachian State is a regional public university and PUI, and NC State is a land-grant R1.

Students were recruited through multiple university channels, including academic departments with disciplinary overlap for the project, the Honors College, and faculty affiliated with the university's Research Institute for Environment, Energy, and Economics. Four students were selected for the project; their majors were criminal justice, political science, sustainable development, and public relations. The students were in their third or fourth year and had some research experience and disciplinary knowledge from their respective fields. However, they had limited knowledge of phosphorus sustainability or theories of collaborative governance. The students worked for spring and summer stipends as research assistants for ten hours/week during the academic year and 30 hours/week during the summer. Students were required to attend a three-day orientation before the semester started, which involved a suite of readings, discussions, and presentations designed to introduce them to the key theoretical concepts and the technical information related to phosphorus sustainability.

4. How a fictional Office of Phosphorus helps students learn about real challenges public administrators face

Political scientists and scholars of public administration have long been interested in how institutional fragmentation, or “too many governments,” (Ostrom et al., 1961) affects the prospects of collective action. Fragmentation may be vertical, across multiple tiers or levels, or horizontal, with multiple units within the same tier (Goodman, 2019). Functional collective action dilemmas occur when multiple units have authority over a single issue, such as water quality (Yi & Cui, 2019) or sustainability (Deslatte et al., 2022). Institutional collective action dilemmas occur when the incentives of individual units undermine effective outcomes (Kim et al., 2020). While consolidation may seem like an obvious solution, it is often more effective to promote coordination through “collaborative governance regimes” (Ansell & Gash, 2008; Emerson et al., 2012). Recent scholarship provides insights on how these collaborations form (Innes & Booher, 2018) and how to evaluate their impact (Emerson & Nabatchi, 2015), especially at regional and local levels (Rickabaugh, 2023).

Nevertheless, the literature on collaborative governance regimes is quite limited when describing the dynamics of “phosphorus management,” a concept that is understood by chemists and materials scientists as a unit of analysis but crosses many issue domains in public policy. Because phosphorus is both an essential nutrient for agriculture and a documented pollutant, and it has a finite supply on Earth (Cordell & White, 2014), it is considered a “wicked problem” (Rittel & Webber, 1973) in which a variety of stakeholders must coordinate to manage the problem effectively (Deviney et al., 2023; Koliba et al., 2017; Lubell, 2004).

By creating a fictional government agency to foster collaborations across these issue domains, the project leaders invited students to confront the challenges of collaborative governance head-on. In the process of identifying how diverse policy domains intersect with phosphorus management, students reflected on how difficult it would be to bring these different groups and stakeholders together to address the larger issue. By encouraging students to think creatively in how they would design the new agency, this activity also promoted “unthinking,” or the development of entirely new cognitive models to understand a complex problem (Fuentes et al., 2019). This new model views responsibility for phosphorus flows holistically rather than as a segmented problem addressed in isolation by agriculture, wastewater engineering, surface water quality, etc. In the process of developing the organizational chart, students were required to consider how different agencies might view their authorities, and identify potential overlaps, as well as gaps or loopholes. As they explained how they

would organize their new agency, project leaders highlighted notable parallels to other institutional forms, which led to discussions of concepts such as institutional isomorphism (DiMaggio & Powell, 1983). The activity challenged students to think through the logistics of how this agency would work, how negotiations would happen, which agencies or actors might opt in or out, and why. The activity also helped students predict how those dynamics might play out in a real-world collaborative environment, which provided a clear foundation for the task of interviewing public officials involved in collaborative governance regimes.

While this example is fictional, the process of forming such collaborations is common for sustainability or environmental challenges. State and local-level sustainability officers coordinate disparate functions in public works, planning, and other departments, to improve how municipalities and local governments manage natural resources (Deslatte et al., 2022).

5. Description of the Office of Phosphorus exercise

For this exercise, project leaders wanted students to gain hands-on experience with open-ended research on environmental sustainability, while also gaining familiarity with relevant databases and government sources. Faculty framed the activity as a request from a fictional director of a fictional agency and used ChatGPT to draft a fictional Executive Order establishing this new office, the “Office of Phosphorus.”¹ Students were asked to investigate how phosphorus is currently overseen and managed by state, local, and federal agencies, and then draft a proposed organizational chart of this new agency based on their findings (Merck 2024, Supplementary Information). The exercise took place during an orientation at the beginning of the project; prior to the completion of the exercise, project leaders spent a day offering scene-setting lectures and a research tutorial. Students knew the complexity of the problem and its broad contours, but had to “scavenger hunt” to find which agencies had which authorities and resources and how different levels of government interact. As an example, North Carolina has soil and water conservation districts that operate as special-purpose local governments but with strong ties to the state’s Department of Agriculture & Consumer Services.

The students were given roughly four hours to complete the exercise; after about three and a half hours, the students shared their findings and outlined their proposed agency to the project leaders. The students wrote follow-up reflections no more than three weeks after the exercise concluded.

It was important that the exercise gave students an accurate picture of the challenges of truly open-ended research, without overwhelming or discouraging them (Aguado, 2009). By establishing a hard time limit on the exercise, students were forced to make decisions about how to balance breadth and depth of research, given limited time and resources. Project leaders emphasized that they did not expect students to know everything about the topic, which led to a productive discussion about how to overcome feelings of overwhelm and discomfort around uncertainty in research (Jones et al., 2023). Lastly, it was essential that the task be relatively low stakes. By reducing the emphasis on the quality of the end product, project leaders helped students get in the mindset that none of what they did was an assignment for a grade – instead, they were contributing to a larger project.

¹ We made slight edits and added language from the 1970 Executive Order establishing the Environmental Protection Agency. We did not use ChatGPT and/or any other AI tools for any other purpose.

At the end of the scavenger hunt, project leaders asked the students to explain how they would organize these disparate agencies together. The organizational chart provided a critical opportunity for students to synthesize their ideas and come away from the exercise with a sense of accomplishment. By asking them to explain their chart, the project leaders obtained a helpful check on whether they understood how public sector collaboration works more generally, and the process of making one chart together gave them a real opportunity to work together as a team.

6. Insights from student reflections

The following section provides excerpts from student reflections to illustrate the short- and long-term benefits of this activity for this research project. Because there were only four student researchers, more quantitative measures were not appropriate. In written reflections, we asked students to respond to the following questions (all excerpts are shared with the students' approval):

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- How did the assigned readings inform your research for the Office of Phosphorus?
- How did the Office of Phosphorus exercise prepare you for subsequent research for this project?
- Was any part of the Office of Phosphorus assignment especially difficult or challenging? If so, were you able to overcome those challenges?

In general, students highlighted how this exercise compared favorably to previous research experiences. As one student noted, "it was clear to me that I had completed nothing like it in any of my other classes." Students noted how this exercise helped illustrate key concepts that might be harder to grasp through a lecture alone, such as institutional isomorphism: "I thought that the most interesting and surprising element of this assignment was that the bureaucratic structure we came up with for the Office of Phosphorus mirrored that of the National Security Council." Another student noted: "I felt like I was able to apply what I read to something physical. [the reading] went over my head as someone who doesn't have a strong background in policy or government."

In written and oral reflections, students repeatedly emphasized how the open-ended and exploratory nature of the task of gathering information felt uncomfortable or challenging: "I find that I can get stuck in the details of information, or doubt the worth of the information I find, thus making that part of the activity more difficult for me." Another student explained, "I found the most difficult part of this activity to be discerning if I had found an accurate and broad coverage of all of the governing bodies that were engaged with phosphorus." However, the same student emphasized that the collaborative nature of the assignment helped students "compare our answers [which] allowed us to see possible areas of shortcomings in each of our research."

Students often framed their learning in terms of the positive benefits of collaboration. The timing of the exercise meant that it also served as an effective team-building exercise. As one student explained, "The activity not only allowed us to apply our background knowledge on bureaucratic systems, but also allowed [us] to collaborate on a project as a team for the first time. I found this activity important to our team dynamics due to the need for open communication between all of us." Another student concurred with this assessment, noting "It

was great to hear everyone’s ideas and opinions, but it was even better that we were able to combine our shared knowledge.”

Project leaders gave students no more than three weeks to write their reflections approximately completing the Office of Phosphorus assignment (as this was during spring semester), and as a result were able to consider how that experience translated to subsequent research for the project. Students noted that they “felt more prepared” for future research as a result of the Office of Phosphorus activity: “This activity familiarized me with the language commonly used to refer to phosphorus in a governmental context, which made it easier ... to navigate to relevant files within government websites.”

This group had a positive team dynamic and good rapport from the very beginning, and in their reflections, the students agreed:

What surprised me about this assignment was how well our team worked together. We immediately got to work and used what we learned to create the diagram. The collaboration was very strong and we all showed our strengths and weaknesses, which allowed us to discuss potential issues or questions we had with the model and answer them together.

7. Discussion and reflections from project leaders for future use

As the Office of Phosphorus activity was partially meant to prepare students to lead semi-structured interviews with stakeholders across an array of different policy areas, we solicited feedback to measure success in that regard. Contacting our interviewees for this kind of feedback afterwards fell outside of our IRB documentation, but we did contact our colleague in STEPS who served as a practice respondent for our students. He is a professor in civil, construction, and environmental engineering who has worked extensively with one of the collaborative governance regimes we identified for interviews. When we asked him his impression of the student interviews, he wrote: “The student interviewers were well-prepared, thoughtful, and professional. Their questions made me think, and led to bidirectional sharing of perspectives and insights (D. Obenour, personal communication, 2025).

In early 2025, two project leaders (Chernin and Rickabaugh) led a second iteration of the Office of Phosphorus activity with new students. This second activity generated somewhat more mixed results as a result, primarily due to instability in federal agencies under a new American presidential administration. This instability was fresh, highly salient news at the time—leading to uncertainty among students about what federal information was current. However, state and local governments had not experienced the same disruptions at the time and were not significantly impacted.

The second group of students had far less academic experience with the structure and functions of government that resulted in requiring some additional time and guidance. This group of students was recruited to create science communication strategies for the collaborative governance regimes interviewed in the first year, so the skill set of the students present reflects an evolution of the project. Understanding collaborative governance is still necessary for the success of the research, but its bureaucratic components are no longer the focus.

8. Conclusions and broader applications

In this paper, we have illustrated how faculty can use low-stakes active learning exercises to encourage synthesis of new ideas and hands-on application of skills and methods in collaborative research on sustainability topics. We outlined a specific case, “The Office of Phosphorus,” which involved exploratory research related to nutrient management and governance. Key elements of this exercise included (1) providing scaffolding and context for the theory and content to be explored in the activity, (2) conducting the activity early in a project to maximize the benefits of team building, (3) replicating the core features of academic research without creating frustration or overwhelm, and (4) allowing time for unseasoned researchers to synthesize their ideas, even if it means less time for exploratory research.

The approach outlined here could be readily applied to other wicked problems that require collaborative governance to prepare students for myriad civic, research, and career responsibilities. For example, one could just as easily imagine an “Office of Food Deserts” or “Office of Microplastics.” In addition to its utility for collaborative teams, this exercise could be modified as an in-class activity for classes in sustainable development, international relations, public administration, as well as public interest communication. More broadly, the “scavenger hunt” approach can be readily adapted to introduce a wide range of research methods in the interpretive social sciences, such as archival research.

Regardless of how instructors modify the content or form of the exercise, it is important for faculty to create spaces for metacognition and reflection on best practices in research. It can be especially helpful for faculty to invite initial responses and discussions immediately after the exercise, as well as a more formal written reflection after the fact. By encouraging students to share not just their findings, but their reactions to the process, faculty can create an opportunity for an honest, open discussion about the shared challenges (and joys) of research.

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