AN INTERDISCIPLINARY APPROACH TO UNDERGRADUATE CLIMATE CHANGE COURSE DEVELOPMENT

CAROLINE HACKEROTT, North Dakota State University
caroline.hackerott@nsdu.edu

ABSTRACT

Climate change presents multiple "wicked" problems requiring expertise from multiple disciplines. No one discipline could consider all aspects of the challenge before the global society. With this in mind, contributions from various disciplines must be synthesized and applied holistically. This paper reviews the development and delivery of an interdisciplinary, problem-based undergraduate course focused on climate change and details the broad institutional support received. The integration of substantial service-learning projects is also discussed. This paper includes a brief overview of the required administrative infrastructure, the students involved, an outline of the course content, a description of the pedagogies employed, and the observed learning outcomes.

Keywords: climate change, service learning, risk, wicked problems

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Climate change impacts all aspects of human society, and awareness of the phenomena is not new. Popular books and films began issuing warnings and calls to action decades ago (Friedman, 2008, 2016). Unfortunately, such statements are often met with more palatable counter-information and misinformation. The public's acknowledgment of the risk climate change poses may be increasing due to its visible, immediate, and profound adverse effects. Multiple scholars examine climate change causes, potential intervention, and impacts from widely different perspectives. Therefore, it is critical to consider the interdisciplinary intersections and articulations for proper adaptation and mitigation to occur (Center for Research on the Epidemiology of Disasters and United Nations Office for Disaster Reduction, 2015). From the disciplinary perspective of emergency management, the synthesis of others' contributions informs both practice and research. Understanding human behavior and its impact on the manmade and natural environment is critical to effective disaster management throughout the entire cycle. Aspects of this understanding include, but are not limited to, disaster risk reduction, social and physical adaptation, social and physical mitigation, risk perception, and risk communication. Informed consideration of these emergency management concerns requires input from multiple perspectives, including environmental sciences, political science, governance, public health, international relations, business, economics, education, engineering, agriculture, meteorology, biology, and climatology.

It is possible to meet this challenge through an undergraduate course that involves upper-level students from multiple disciplines using a problem-based, collaborative pedagogy. A community-based service-learning component was key to students' learning experience. This combination of pedagogies provides students the opportunity to examine a significant, complex

issue from multiple perspectives. By incorporating service learning as an instructional strategy, the course also allowed students to work collaboratively with community members, community organizations, members of the private sector, and elected officials.

INSTITUTIONAL SUPPORT AND CONTEXT

The host university for this original course was a four-year, comprehensive teaching university in the southern United States. This university celebrates its designation within the state system as a leader in progressive pedagogy and innovative instruction. Multiple departments across campus adopt service learning as a fundamental instructional approach. The support for this community-connected learning environment is evident as the university supports a Center for Service Learning (CSL) within the College of Arts and Humanities. Partnering with the university's Center for Excellence in Teaching and Learning (CETL), the CSL faculty director actively supports others in incorporating meaningful service-learning projects and activities in their courses. Service learning, intended to provide benefit to community partners while delivering experiential learning to students, is frequently adopted in some disciplines, including emergency management (Kapucu & Knox, 2013), public affairs (Bryer, 2011), and sociology (Blouin & Perry, 2009; Fritz, 2002). Increased experience with service-learning pedagogy may better prepare faculty to develop and deliver service-learning instruction than faculty from other disciplines. Faculty preparation, support, and development are critical to a successful problem-based interdisciplinary course (Warr & West, 2020). The host university's CSL and CETL offered multiple opportunities for faculty development to support these active pedagogies in an interdisciplinary classroom.

The combination of the commitment to progressive instructional strategies and service learning provides ample space for pedagogical creativity at the institutional level. The development of this course reflected that creativity.

Funding and Administrative Accommodations

An active university supporter and alumnus contacted the CSL director to offer financial support to develop a course designed to enhance critical thinking and benefit the greater community. This individual indicated a desire to gather students from across campus to "solve" a different complex problem each year. They insisted the course include community outreach and identified climate change as the first complex topical problem. With this external funding, students recruited expert speakers to present to a town hall that was open to the entire community, covered the speaker's travel expenses, and offered a substantial speaker honorarium. The external funding also allowed the class to sponsor on-campus receptions, which included catered refreshments. Because no specific budgetary entity "owned" the course, external funding simplified the process and relieved the students from any fundraising burden. Had external funding not been available, the expert speakers would have likely been drawn from the university's faculty instead of recruiting nationally recognized climate-change experts and authors. The service-learning project would have also included the task of soliciting donations if

catered receptions were desired. It is also possible that a course-sponsoring department or college would have provided a small budget for such activities.

A committee including the external funder, the CSL director, the deans of two of the university's colleges, and several faculty members already involved with the CSL created an actionable plan including expectations and a general outline of the problem. The committee created a new call code Interdisciplinary Problem-Based Learning (IPBL), with administrative support and IPBL 4893. The three-credit course fulfilled an upper-level elective requirement for any program except those related to K-12 education. Education majors followed a tightly articulated plan of study, which did not easily accommodate an upper-division elective. The committee marketed the course across campus to students and recruited the course instructor. The instructor received a release from one departmental teaching assignment. The committee negotiated student contact hours and faculty coverage costs through the central administration to ensure no negative financial impact to the instructor's home department and college.

Student Recruitment

Marketing the opportunity started in spring 2016 for a spring 2017 offering. The committee sent information to all faculty who served as academic advisors. Committee members attended multiple upper administrative council meetings involving key administrators. Faculty enthusiasm for the course was high, and many contacted upper-level students directly. Final enrollment totaled 28 students representing the following majors/programs: emergency management, nursing, sociology, psychology, political science/pre-law, hospitality, journalism, wildlife and fisheries, biology, engineering, physics, chemistry, and business. All held a minimum of third-year standing and reported being individually recruited by their academic advisor. Every student said that the impact of climate change on their focus of study motivated them to enroll. Only two students indicated experience with service learning. None reported taking a problem-based course before IPBL 4893. Because this was the initial attempt at creating an interdisciplinary capstone course, targeted recruitment was adopted. However, once the concept was introduced to the campus, no targeted recruitment occurred, and any student who met capstone course criteria could self-enroll.

PEDAGOGICAL APPROACH AND COURSE CONTENT

Problem-Based Learning

The interdisciplinarity of the students and the course topic lent itself to a unique approach to course instruction. Problem-based learning (PBL) is an instructional approach first developed in medical education in the 1960s. Generally, PBL exhibits the following four characteristics: (1) the problem is a complex, real-world problem that does not have a single solution; (2) it is collaborative and students work in groups; (3) students engage in self-directed learning to gather new information; and (4) the instructor functions as a facilitator (Thorndahl & Stentoft, 2020). The initial goal of PBL was to enhance students' ability to apply critical thinking to a situation reflecting actual practice. Those developing experiential learning activities and simulations often use PBL as a foundation. In an interdisciplinary classroom, PBL design provides an opportunity

for students to learn from one another as they approach the problem from their perspective (Warr & West, 2020). Interdisciplinary conversations encourage enhanced problem solving with broader impacts that mimic the contemporary workplace (Battelle for Kids, 2014).

Global climate change provides a wicked problem requiring multiple perspectives (Jordan, Kleinsasser & Roe, 2014). As a problem, climate change also present students with a poorly structured problem requiring them to explore unfamiliar aspects and self-organize their approach. By working collaboratively, students refined the problem through reflection and feedback and resources facilitated by the instructor.

Service-Learning Integration

As stated previously, this course purposefully included a service-learning project intended to benefit the greater local and statewide community. While each team of seven students (four groups) developed a unique community-based outreach project, the entire class worked collaboratively to plan and present a town hall meeting to all community members featuring nationally known speakers. Students designed and delivered the whole event. Their early exploration of the problem identified key experts focused on issues impacting the local and state community. Funding from the external sponsor provided the ability to offer speaker travel stipends and honorariums. Sponsor funding also allowed the students to provide open receptions for campus and broader community members to interact with the speakers. Students attended multiple student organizations and other campus meetings to encourage attendance. They spoke at local community organizations and initiated a broad media campaign to encourage the wider community to attend. Finally, they also recruited other campus and local community members to assist in marketing the town hall. As a result, the town hall was well attended, with students receiving overwhelmingly positive feedback from attendees.

Because the class identified increasing awareness of the issue and its local impacts as key to addressing climate change, all four unique projects also involved community outreach and education. Teams developed media and social media awareness campaigns, conducted outreach to local elementary and middle schools, created a “Climate Climb” that involved hiking a nearby state park trail with climate information provided at key “resting points,” and created general climate information materials distributed through community organizations. In addition to partnering with schools and the local state park organization, students worked with a hunter and wildlife conservation group, local agricultural extension organizations, and several private-sector partners involved in climate change-related projects, including recycling and green energy.

Collaborative Learning

This course used a modified Team-Based Learning (TBL) approach. Students worked within their assigned teams throughout the semester with multiple opportunities for cooperative and collaborative work with other groups. Unlike true TBL, as presented by Michaelsen et al. (2004), there were no individual readiness tests and the tangible project products were evaluated and scored. Students completed peer evaluations at critical points throughout the semester. Peer evaluations determined what percentage of the team’s earned points a student earned at progress

checkpoints. Every member of a team could reach 100% or 0% of the team's earned points. Peer evaluations revealed collaboration was a positive experience, and all students felt it enhanced their learning.

Combination of Pedagogies and Course Outcomes

Combining these three pedagogies: PBL, service-learning, and TBL provided a robust, inclusive learning environment as demonstrated by the post-course assessment (Kricsfalusy et al., 2018). The outlined course requirements and intended learning outcomes required concurrent application of these three pedagogical techniques. Specifics regarding assessment are addressed later in this paper.

Course Content

Course organization over 16 weeks involved splitting weekly class sessions among guest speakers, guided readings and activities, and working on collaborative projects. Each week involved one dedicated team activity session and one session presenting crucial information through readings, videos, and guest speakers. Guest presenters included representatives from the National Oceanic and Atmospheric Administration (NOAA), the state Environmental Education Coalition, the state Wildlife and Hunting Conservation Organization, the external funder, the U.S. Secretary of Energy's office, the 100 Resilient Cities project, state and local private sector organizations, and multiple faculty members from across campus. The enthusiasm for this course was exceptional across campus, the region, and the state, and it was more challenging to limit the number of speakers than to recruit them. To assist in defining the problem from their disciplinary perspective, students conducted interviews with a faculty member from their home department regarding climate change.. In support of the course's research demands, students also received personal instruction on library research methods and support services.

The course included five major topical sections in addition to the introduction to the problem. These sections broadly considered climate change a scientific endeavor, an economic construct, a political construct, and a social construct. The final section focused on science-based solutions. Throughout the course, students identified how climate change currently impacted local and regional issues. (The original course schedule is available by contacting the author.) The course structure included individual reflections, peer evaluations, and multiple aspects of research, outreach, and project development.

Student teams identified four different projects to address the unique challenges of climate change. Projects included problem identification; a synopsis of the current state of empirical knowledge regarding the problem, including the identification of gaps in this body of knowledge; identification of points of intervention, adaptation, and mitigation; and creation of a project to address the problem. Teams then had to "defend" why they developed to project in the manner selected and reflect on their success regarding implementation and acceptance to their intended audience. While project development changes each semester, the initial projects included engineering solar- and wind-powered water pumps for regional agriculture, the development of a campus-wide reduce/recycle/reuse program, an elementary-level climate change science module

in conjunction with a regional science museum, and the development of an educational hike event through a nearby state park (in collaboration with the state park leadership), which included information and guided experiences regarding climate change impacts on both the wildlife and flora within that state park. Course assessment and student reflection indicated these projects improved the depth of learning regarding not only the selected aspect of climate change selected but also in the process of research and the determination of reliable and valid information.

LEARNING OUTCOMES AND ASSESSMENT

The assignments and activities associated with each stated learning objective provided quantitative support for the stated learning outcomes. Students met or exceeded stated performance goals 100% of the time. Performance goals were set before enrollment and were not adjusted to "fit" the students. Because this success level is highly unusual, the instructor requested a colleague evaluate student performance against the stated learning outcomes in a blind format. The results were the same.

Qualitative learning outcomes evaluation using weekly student reflections, a final reflection paper, and formal assessment conducted by the university provided valuable insight. The university assessment office waived the standard end-of-the-semester course evaluations and conducted a guided reflective review without the instructor present. The assessment focused not only on the stated course learning objectives (Table 1) but also on the learning processes involved.

The assessment rubrics for interdisciplinary problem-solving and collaborative skills reflected the four outcome levels suggested by Repko (2008). Repko's problem-solving outcome levels ranged included (1) the application of perspective-taking abilities, (2) the development of interdisciplinary structural knowledge relating to the complex problem, (3) the integration of conflicting cross-disciplinary approaches to create a comprehensive understanding, and (4) the production of cognitive advancement or interdisciplinary understanding of the problem. Repko also developed an interdisciplinary collaborative skills assessment rubric with three criteria: (1) establishment of group process, (2) relationship with team members, and (3) participation in team tasks. Professional assessment staff conducted evaluations through student interviews to determine their success relative to Repko's interdisciplinary problem-solving rubric. Assessment of success regarding collaborative skills included a review of peer evaluations, self-assessments of individual contribution to the collaborative projects, and interviews regarding the collaborative processes used in class.

Table 1. IPBL 4893 course-level learning objectives and assessment product

Learning Objective	**Assessment Product***
Identify the underlying root causes and risks to natural, built, and human systems associated with global climate change.	Individual Activity Collaborative Activity
Evaluate and apply multiple theories from many disciplines to the problems associated with climate change to predict the potential scope of consequences.	Individual Written Assignment
Collaborate to create empirically supported potential solutions to meet the demands of the predicted consequences.	Collaborative Activity
Evaluate the feasibility of proposed solutions and balance the full costs against the costs associated with alternative solutions or inaction.	Collaborative Activity
Strengthen skills in writing and applying APA 6 writing style to all written work.	Individual Written Assignment

*Assessment products may be an independent assignment or a component of the final service-learning product

From this process, the university's assessment team identified several themes (Table 2). Students voiced great support for the problem-based approach and believed the service-learning projects greatly enhanced their overall learning. The majority of students felt that the information they produced through their projects was valuable to the greater community. Students reported collaboration broadened their appreciation of the problem and provided them an opportunity to expand their knowledge base. They indicated the course's rigor and the workload was what they expected of a capstone course and suggested it was what they would expect of a graduate course. No student indicated that they felt overwhelmed by the class, and all believed they exceeded their expectations.

Reflections revealed a great deal of perspective expansion and sharing among students. Peer evaluations confirmed the unique contributions each student brought to their team. Many students indicated having someone on the team who could "translate" research articles or that guest speakers from their disciplines was precious. Students also reported establishing relationships outside of their field, and the opportunity to exchange ideas with students who had taken different classes and instructors was highly valued. Interacting with multiple guest speakers was a positive experience during which students felt safe to ask challenging questions. Students reported in their weekly and summary reflections and the guided assessment that their active role in their information acquisition contributed to their most significant learning. Students stated that not only were they required to conduct their search for information but needing to verify its accuracy was challenging but worthwhile. They also valued the learning as they were required to apply it through their service projects. Translating the research they gathered into public outreach materials was identified as the most likely skill to carry into their future careers. Even though very few believed they would be preparing public education materials in the future, students stated that the ability to explain concepts to those with different disciplinary

backgrounds was essential. All reported at least two incidents of having their pre-existing belief systems, or mental scaffold, challenged and modified by the research involved in creating their service project. All of the students reported they believed this was the most interactive and unique course they had ever taken. They also indicated a desire to take another course with similar pedagogy. Finally, students universally assessed a willingness to split the class into two semesters, with the first dedicated to problem-based knowledge acquisition and the second devoted to developing the service projects.

Table 2. General Problem-Solving and Collaborative Skills Assessment Themes as Reported by IPBL 4893 Students

Students reported personal, academic, and professional benefits, working with people from different perspectives, advocating for a cause, and contributing to making a difference.
Students felt that all students will always have things to contribute regardless of major, there is strength in diversity (discipline, personality), collaborative work provides an opportunity for everyone to contribute meaningfully.
Making connections and networking with different people across the community was greatly valued.
Students were universally proactive and ambitious; each contributed to groups based on skill, discipline, convenience, and interest.
Students felt they had made significant accomplishments: Learning a lot about the problem, leading within the group, improving community and personal awareness about the problem, creating practical and locally needed solutions.
The assessment resulted in minor mismatches between scored rubrics and student's self-report.
Students identified the following as potential improvements for the course: balance between learning and doing, projects could build on what has already been done (recycling, Earth Day), more time for big/ambitious goals, have more pre-set tasks and extend to a second semester.

CONCLUSION

The IPBL oversight committee reviewed both the quantitative and qualitative assessments and determined the course model a success. The IPBL course continues to be offered once a year and involves private financial support from alumni and the private sector. The course topics included artificial intelligence, homelessness, and communication strategies for a multi-location, international business. The original course will likely be offered again soon due to the increased awareness and impact experience involving climate change.

It is unique to have outside funding and institutional support for an interdisciplinary course as experienced at the host university. The course did not depend on external funding for its core value. Instead, external funding served as a conduit for community-wide outreach without taxing students with fundraising requirements. It is possible to create a community-outreach event involving campus- or community-based experts who require no level of financial support. The catered receptions could be eliminated or sponsored by a host department or college.

The level of external assessment was extraordinarily high due to the novelty of the idea and the involvement of a critical university donor. The problem selected also carried substantial political

overtones within the host state, and the university felt assessment data could provide essential support if the effort was questioned. While assessment is critical for every course, the level of assessment could be reduced to internal student self-assessment and the standardized university assessment strategy simplifying the assessment process significantly. However, the initial intense scrutiny and evaluation support the continuation of such a course. The value of combining problem-based and service-learning pedagogies in an interdisciplinary classroom is undeniable. This course may provide a model for developing similar courses among a more limited number of partner departments or general education courses. The discipline of emergency management creates its own body of knowledge while participating in interdisciplinary synthesis. In recognizing the value of such synthesis, emergency management is uniquely positioned to provide leadership in developing interdisciplinary classes attempting to solve complex problems.

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