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The Common Problems Project: An Interdisciplinary, Community-Engaged, Problem-Based Pedagogy

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Abstract: The Common Problems Project (CP2) is an interdisciplinary, problem-based pedagogy that was launched in 2015 by four partner colleges in the State University of New York (SUNY) system (Cortland, Oneonta, Oswego, and Plattsburgh). Since its inception, 100 faculty have participated in CP2 and integrated the pedagogy into 134 courses to implement 47 collaborative projects. CP2 is based on a simple but innovative approach in which instructors from different disciplines identify a real-world problem they have in common. They pair their relevant existing classes so that students can work in interdisciplinary teams to propose solutions to the problem. This paper describes CP2 and its theoretical underpinnings, provides the results of a three-pronged approach to assessment, and outlines recommendations for faculty and institutions who may be interested in replicating CP2 on their campuses. CP2 model holds promise for a future of collaborative problem solving as a pedagogical approach, and, as such, this article will be of interest to a wide range of scholars, practitioners, educators, and administrators.

Keywords: pedagogy, problem-based learning, higher education, interdisciplinary education

Background

Calls for interdisciplinarity are increasingly common as a means to solve the world's most pressing issues (Ledford, 2015), and as a means for delivering impactful education (Newell, 2010). Institutions of higher education are responding to these calls (Jacobs, 2015) and, as faculty and institutions experiment with ways to foster interdisciplinarity in undergraduate education, pedagogical case studies have proliferated (e.g. Klaassen, 2018; Coleman et al., 2017; Coleman and Danks, 2016). While such cases studies are critical for advancing the field, for creating a foundation for future meta-analysis, and for providing examples of pedagogical approaches, they often present information from single classrooms or institutions. Thus, more work is needed to explore interdisciplinary pedagogical practices that are implementable across a range of courses and campuses. The goal of this paper is to help address that need by presenting The Common Problems Project (CP2), an interdisciplinary, problem-based pedagogy developed in 2015 by four partner colleges in the State University of New York (SUNY) system (Cortland, Oneonta, Oswego, and Plattsburgh). Since its inception, 100 faculty have participated in CP2 and integrated the pedagogy into 134 courses to implement 47 collaborative projects. We describe CP2, outline its theoretical underpinnings, present case studies from each of the four campuses, present assessment results and faculty reflections, and explore the relevance of CP2 for other campuses. This information will be useful to any faculty and institutions interested in interdisciplinary and problem-based teaching.

CP2 and Problem-based Learning

CP2 is based on a simple but innovative pedagogy in which instructors from different disciplines identify a shared real-world problem. They pair their relevant existing classes so that students can work in interdisciplinary teams to propose solutions to the problem. The goal of the CP2 is to enhance the problem-based pedagogy model by introducing an interdisciplinary approach to education while incorporating high-impact practices and learning outcomes associated with problem-based pedagogy. Under this goal, specific objectives of CP2 are that students:

1. Become adept at working in teams
2. Benefit from the expertise of peers in different disciplines
3. Improve in their ability to identify and describe a complex, ill-structured problem
4. Be better able to take an organized approach to tackling the problem described
5. Understand the nuances of the problem and the possibility that there might be multiple possible solutions to it
6. Increase their awareness of their own strengths and weaknesses as problem solvers.

An additional goal is that faculty will benefit from leaving their academic silos to work with colleagues in different disciplines.

The common problem pedagogy incorporates a number of what Kuh (2008) refers to as high-impact practices, including learning how to work in teams, managing projects and holding leadership roles, oral and written communication, self-directed learning, experiential learning, applied learning, civic engagement, interdisciplinary work and, of course, problem-solving. Such practices provide a range of student benefits, and help to narrow the achievement gap for underrepresented students in the STEM fields (Theobald et al., 2020).

Given that CP2 centers around problem-solving, educators can think of it as a variant of problem-based learning. Problem-based learning was first developed in the 1950s in medical schools in response to unsatisfactory results of clinical training of medical students (Barrows and Tamblyn, 1980). Problem-based learning has been shown to be effective in regard to a number of outcomes, including self-directed learning habits, problem-solving skills and deeper disciplinary knowledge, particularly as contrasted with lecture-only classes (Nilson, 2010; Yew and Schmidt, 2009; Pourshanazari et al., 2013; Loyens et al., 2015).

Scholars of problem-based learning have identified best practices for both selecting problems for students to address and for guiding students through the problem-solving stages. Barrows and Kelson (1995) suggest that the problems should be complex in nature, should be ill structured, where the solution is not clear. These are often referred to as wicked problems (Ritchey, 2011). Barrows and Kelson also suggest that the problems should be something that resonate with the students' experiences, or the subject matter of the course. Once an appropriate problem is selected, good problem-based learning follows a specific problem-solving process (Klein, 1998; Bransford and Stein 1984). First, there is an analysis of the problem, during which the following questions should be asked: Why is it a problem? What are the outcomes of the situation that make it problematic? What could be some of the causes of those negative outcomes? What is the goal or outcome to be attained in a solution? Since most researchers define a problem as an obstacle to a goal, it is important to identify that goal and how to remedy the obstacle (Agre, 1982; Frensch and Funke, 1995).

In the second stage of the problem-solving process, problem-solvers engage in discovery and ask the following questions: Has the problem been addressed before? What were their solutions? Did they work or not? Why did they work or not? Can these solutions be applied to this problem, or can it be adapted? Are there different solutions that might work better?

In the third stage, problem-solvers formulate a solution, usually a practical hypothesis, understood as an intervention which, if implemented, is thought to ameliorate the problem as defined. There are several heuristics that can be employed throughout the problem-solving process, such as the availability heuristic, reverse engineering, means-end, hill-climbing, and just old-fashioned trial-and-error. In the availability heuristic, students look to how similar problems were solved in the past (Kahneman, 2011). The means-end heuristic breaks down the problem into a number of sub-problems that may be easier to solve, then recombines them into the solution set (Newell and Simon, 1972). Hill-climbing is a strategy in which a solution is proposed and continually modified so that each modification improves the likelihood that the solution-goal will be achieved (Edelkamp, 2012). In reverse engineering, one works from the goal backwards to each preceding step that would be needed to achieve that goal.

Since solutions can be thought of as practical hypotheses then, like any hypothesis, they should be testable. The fourth and final stage of the problem-solving process is to determine whether the intervention has indeed ameliorated the problem. This last stage may be impractical for most one-semester classroom activity, since student solutions may not be implemented and, if implemented, may take considerable time before the results can be measured. However, in contexts such as presentations of the solution, audience members, community partners can test the solution by posing issues or raising questions.

In real-life, problem solving is often not linear, so that problem-solvers may bounce around through these different stages (Klein, 1998). For example, they may come up with a solution to a problem but test it imaginatively and reject it or modify it as a result of the thought experiment (Klein, 1998). After formulating an intervention, students may go back to the analysis to refine the outcomes or goals for a solution. Discovery may reveal nuances that modify the proposed solution as well (Klein, 1998).

The role of the instructor is to provide students with a framework for problem-solving, and make them aware of their cognitive processes as they attempt to solve the problem. Hmelo-Silver (2004) emphasizes that instructors should focus on the meta-cognitive skills of the students—how they formulate their solutions and explain the reasoning behind it. The instructor plays the role of an expert learner, rather than a content-expert. The goal is to have students take on more of the content-expert and learning-expert roles over time.

CP2 is similar to two common forms of problem-based learning, Process-Oriented, Guided Inquiry Learning (POGIL), a form of problem-based learning that has become popular in science, technology, engineering, and mathematics (STEM) fields (Farrell, Moog, and Spencer, 1999), and service-learning, a form of problem-based learning in which students work with community partners to equal benefit (Furco, 1996). However, CP2 differs from these approaches in notable ways. Although CP2 shares conceptual strategies with POGIL, the goal of CP2 is to help students address real-world problems, which tend to be ill-structured and complex, meaning that the constraints and routes to the solutions are not clearly defined or delineated (Jonassen, 2000; Newell and Simon, 1972). By contrast, most mathematical, logical, or science-based problems (i.e. those used in POGIL), although difficult, are well-structured, in that there are prescribed processes or algorithms for their solution (Klein, 1998). While CP2 shares goals of civic engagement with service-learning, it differs in that the goal of CP2 is not necessarily to provide a service to an organization or to do complete charitable work in the community, but rather to address complex problems. Finally, CP2 intentionally places emphasis on creating interdisciplinary teams of students, which is not a core tenant of either POGIL or service-learning. Thus, CP2 represents a unique approach to problem-based learning.

Case Studies

Across the four participating campuses, there was some variability in how faculty chose to coordinate linking their courses. We provide our own reflections on logistics later in the paper, in order to support replicability. To illustrate how the courses functioned, we outline one case study for each of the four partner campuses below. These show the variety of disciplines, project themes, and variations on the general design of the projects in the classroom. A summary of all the projects to date is provided in Appendix 1.

SUNY Cortland

SUNY Cortland's "Visual Storytelling of Scientific Data" was a collaboration between STEM and Arts fields. Faculty from physics and graphic design had their classes work together to translate scientific models into visual graphics accessible to non-scientists. The goal was to make infographics based on numerical models related to environmental topics chosen by students. Students in Principles of Physics III were responsible for developing numerical models representing an aspect of their groups' ill-defined problem and writing a technical report. Their colleagues in Graphic Design II were responsible for creating visualizations of the technical information in the form of infographics.

The instructors divided students into eight teams, with one physics student and two design students in each group. As the two classes did not meet simultaneously, the teams were responsible for making their own arrangements to work together outside of class, primarily through electronic media communication. The tools they used included text message, transfer of electronic data, and discussion boards created in the campus online learning system. Students recognized both the difficulty and the value of the interdisciplinary communications. For example, in their reflection one student stated, "The common problem project was a difficult but rewarding experience. It is difficult because it takes a lot of communication across a lot of people, as it would work in the work force as well."

The teams began their projects by brainstorming topics that represented significant social or environmental concerns. Faculty selected four topics from among the students' ideas based on their compatibility with mathematical modelling. The four resulting ill-defined problems were forest management, population growth, pollution and endangered species. The impact of seeing the value of their disciplines to the larger society was described in a student reflection: "It also opened my eyes to how politics and other recent social issues contributes to this field of work. We could look at almost any controversial issue and create an equation and a trend graph for it."

One successful pedagogical technique was the use of a real world business model, in which the Graphic Design students represented the members of a design firm team while the Physics students represented their clients. The students' reliance on electronic communication simulated the experience of design firms and scientists working together over a distance, without in-person meetings. The impact of this technique was evident in student reflections. For example, a physics student noted, "It was a fun and interesting process that gave me a peek into what real world jobs for scientists are like, working with numbers and translating them to designers to help convey a message to the public."

One of the tasks the design students needed to complete was the reading and understanding of the physics students' technical reports. To support this element of the course, both faculty members met with the design students to help them formulate meaningful questions for their physics peers. This improved the ability of the student teams to progress toward their final products.

Some examples of the resulting infographics were depictions of the correlation between income and population growth in representative countries, the effects of pesticides on raptors, and the impact of pollution on the possible extinction of shellfish. The graphics were both a solution to the problem of making scientific findings accessible to laypeople and a depiction of possible approaches to solving the underlying environmental and social problems.

The students' work was disseminated through a campus exhibit attended by local community members, campus administrators, faculty, and students. The posters were showcased in the form of an art exhibit while the physics students demonstrated the equipment used in their modelling and displayed their results. The exhibit was well attended and covered by local media. The pedagogical model was also disseminated by the participating faculty members at a professional conference (Edlund and Kadas, 2019), and published in *The SUNY Journal of the Scholarship of Engagement: JOSE* (Edlund and Kadas, 2020).

SUNY Plattsburgh

One interesting example of CP2 at SUNY Plattsburgh was between a sustainability class for seniors in the Plattsburgh's Center for Earth and Environmental Science, and a lower division one on urban cinema, run through the English Department. The assigned project for the student teams was to produce a short film addressing a sustainability issue in the city of Plattsburgh. Part of the goal of the project was to get students who were from different regions of New York State engaged with problems in the city of Plattsburgh, their college home.

The courses were scheduled at the same time, and the classes met together at key times during the semester. The instructors co-taught the combined classes, which provided orientation to the project, set up teams, set-up opportunities for students from both classes to get to know one another, and created a forum to discuss problems related to the projects. Student teams organized their own meeting schedules outside of class time, the division of labor, and work assignments related to the project.

Students began in stages, first being asked to participate in a "Secret Spaces" photography exhibit that was shown downtown in a local business. The goal was to think about how to make often unseen, unnoticeable spaces in the city visible. Students took pictures of abandoned civic spaces, scarred urban areas, such as trashed alleyways, but also murals and bike paths, and renovated locales. Students then progressed to the filmmaking, working in interdisciplinary teams, learning skills such as how to film interviews and make silent segments of the cityscape. They learned technical skills such as framing and editing. Most importantly, they learned from one another. The sustainability students learned to tell a story about sustainability problems, and the film students learned something about the science of sustainability.

Among the subjects of the films included *Ghost Bike,* documenting town planning efforts to alleviate dangerous conditions after a student's cycling death. Another was *A Day in the Life*, which showed two parallel days—one a typical day in the life of a college student and the other in the shoes of an individual experiencing homelessness – both living in the same city. A third film was *Power,* which focused also on the problem of homelessness and poverty in Plattsburgh. The narrative started with interviews of locals, who had certain stereotyped views about individuals experiencing homelessness. It transitioned to interviews with individuals experiencing homelessness themselves which, in many cases, controverted the popular biases. It turned to some of the projects in town that helped with poverty in the city, such as a community garden. The film subsequently moved to interviews with volunteers in the charitable organizations that support individuals experiencing homelessness around town, and officials in the government agencies tasked with such assistance.

One faculty member noted, "When authentic, student-generated questions proliferate, problem-solving follows." (Isaak et al., 2017). How to tell the story helped the students to formulate the problem for themselves. As such, they became engaged in understanding the problem, and thinking of solutions. One of the student directors of *Power* simply explained in a reflection paper: "I learned how hidden poverty can be." *Power* was later selected to be shown at the 2017 Lake Champlain International Film Festival and considered for the Lake Placid Film Festival. Based in part on their work on the common problem project, the faculty members authored a paper for the *Journal of Experiential Education* (Isaak, 2017) and gave a presentation, "Civic-minded filmmaking in the Common Problem Classroom," at a national meeting of the American Association of Colleges and Universities (Gervich and Devine, 2018). They used their common problem project to address the theme of the meeting: general education and democracy.

SUNY Oneonta

SUNY Oneonta began work with CP2 with a pilot project that incorporated four courses: a young adult literature course for English education majors, an education methods course, an astronomy course, and a political science course. These courses involved a range of undergraduate students from sophomore to senior.

The problem students were tasked with was sustainability programming in the Sidney School District, which also served as the community partner. Early in the semester, the three professors brought the participating students together for a meeting at the school district's elementary school. A faculty member, who also served as the Sustainability Coordinator for the district's elementary school, presented the challenges the school faced in their sustainability goals. Elementary school students who were part of a student group, Green Thumb Growers Guild, gave a tour of the property and current efforts.

Following this initial meeting, the college students were put into teams based on their available meeting times. Each team elected a team leader who would act as a liaison to the elementary school Sustainability Coordinator. Teams were responsible for designing their approach to solving the sustainability challenges the school faced.

Due to scheduling constraints, these classes were not able to meet at the same time, except at the initial meeting at the school, and at the showcase at the end of the semester, where they met again at the local school to present their ideas. Otherwise, teams met outside of class time to work on the problems.

The showcase audience included the participating elementary students, as well as administrators from the Sidney School District, and the Dean of Education and Human Ecology at SUNY Oneonta. The solutions presented by the students were wide-ranging, well-developed, and creative. The inclusion of the local school students enhanced the entire project. As this was the pilot project, the faculty were able to refine their practices for future courses using the common problem pedagogy. These changes were informed by the post assessment essays and through a collection of journals developed by the students that documented their personal challenges with the project.

The successes of the project included collaborating with the local school district, good logistics for team creation, and the showcase approach. One of the biggest challenges was the variability in student commitment to the project. In particular, the senior education students felt a great deal of pressure to perform well. As a result, many of their journals noted an increased level of stress, and pressure to take leadership roles in their teams in order to ensure success. Future CP2 projects prioritized pairing classes with students from similar years. Future pairings also prioritized crafting course grading structures that were consistent across the participating classes, so that the CP2 projects comprised a similar percentage of final grades regardless of course.

In conjunction with SUNY Oneonta's Faculty Center, this pilot project was used to generate interest among faculty in creating CP2 projects. The Director of the Center hosted informational sessions, and highlighted the process involved in the pilot. The successes and challenges were shared so that other faculty could build their courses with lessons learned. In this way, CP2 provided new development opportunities for faculty.

SUNY Oswego

The Smart Neighbors Project was a large-scale experiment with CP2. SUNY Oswego's Interdisciplinary Programs and Activities Center coordinated the effort. The city of Oswego faced economic challenges over recent decades, and the project was to focus on the problem of how to promote local independent businesses and not-for-profits. This project worked well with the College's commitment to the city. The effort included multiple courses across various disciplines, participating in a division of labor to address this ill-structured problem.

The major intended outcomes of the Smart Neighbors Project had to do with introducing and nurturing pedagogical best practices at SUNY Oswego. The project was conceived to pull as many faculty, students and diverse courses into CP2 as possible. It was set up so that it introduced the pedagogy without requiring major amounts of prep and class time. The faculty adopted the pedagogy for a single, major assignment within the course. In this way, the coordinators for the project were able to pull in multiple faculty and classrooms every year, increasing the number of students and the number of disciplines offering the civic engagement, interdisciplinary, and applied-learning aspects of this pedagogy. The fall 2019 project was typical and involved classes in filmmaking, marketing management, English composition, photography, graphic design, sociology and biology.

The initial project was so successful that it continued to build participation over time. In 2015, 59 students from four different courses participated in the project. In 2019, this had expanded to 118 students in eight different courses. In total, 641 students, 40 classrooms, and 22 different faculty participated in the Smart Neighbors Project in the six years since its inception.

Although each course had an assignment that involved course-specific skills and learning outcomes, all students were placed in multidisciplinary co-curricular small groups. Each small group had a student representative. They were tasked with weekly online interactions with other groups in which disciplinary information and skills were shared. For instance, the graphic designers in each small group often took on small design projects for others, the composition students often interviewed their small group members for audio clips for podcasts, and the marketing students often helped their student colleagues with task-based research.

Beyond the successes of the pedagogy, the Smart Neighbors project enhanced the relationship between SUNY Oswego and the city of Oswego over the six years. Participating students were more likely to go downtown for purchases and activities. There were lasting liaisons created between town and college faculty. Over time there has resulted in a considerable list of businesses and not-for-profits interested in being partnered with classrooms on the project. Furthermore, businesses and not-for-profits were increasingly likely to offer financial support to the project. As an example, the H. Lee White Marine Museum financed and arranged a meet-and-greet between students and townspeople using an art exhibition of student work related to the museum. The city of Oswego is purchasing banners to hang downtown, utilizing materials created by a collaboration of photography, design, creative writing and marketing students.

SUNY Oswego has an ongoing commitment to CP2 and the pedagogical legacy of Smart Neighbors. Our campus adopted the CP2 campus-wide in our Grand Challenges Project. The faculty and student bodies voted on the first three-year challenge (or common problem): Fresh Water for All. Because of the collaborative nature of the Grand Challenges Project inception and nature, stakeholders across campus have committed resources to the project. Academic Affairs set up faculty mini-grants for collaborative, multidisciplinary, civic engagement projects. Student Affairs invited multidisciplinary speakers and sponsored arts programming related to the Grand Challenge. Alumni and Development used the alumni magazine to promote the projects. The Office of Marketing and Promotion created a web site, Digital Oz, which displays the work of the students and faculty.

Assessment

Assessment of CP2 was done in three ways: assessment of student learning via pre-test and post-test evaluation, an outside assessment of the project by a third-party evaluator, and a survey to faculty. We describe each assessment component below.

Assessment of Student Learning

A cross-campus assessment of student learning was done through a pre-test and post-test design (Appendix 2). An initial test was designed collaboratively by the research team to assess aspects of students' problem-solving abilities. This test was then refined and improved with input from instructors who participated in CP2 pilot projects. An independent assessment consultant hired by the project also provided input. The final pre-test and post-test tool, as well as the scoring rubric, are available in Appendices 1 and 2. The pre-test was administered at the beginning of the semester. The post-test was given after the project for the course had been mostly completed. A common rubric was used to score pre-and-post test results.

All students were assigned arbitrary ID numbers so that the pre-test and post-test results would be anonymous. Both the pre-test and the post-test tools were administered by participating faculty and were voluntary (i.e. students were not graded on their responses). Due to the voluntary nature of the tests, as well as inconsistencies in administration, we were unable to obtain a complete census of every student enrolled in a CP2 course. Nevertheless, we were able to obtain data sufficient to provide useful insight regarding the outcomes of the pedagogy. We collected all available pre-test and post-test scores from faculty across all four campuses.

Prior to analysis, we evaluated the data for suitability on the class level and on the individual level. A class was only included in the final sample if the instructor 1) used the appropriate grading rubrics 2) administered the tests at the appropriate time during the semester and 3) administered both the pre-test and post-test. Individual test scores were only included if the student took both the pre-test and the post-test. After removing scores that did not fit this criteria, we were left with a sample of $N = 418$ (roughly 18% of the total population).

We ran a paired sample t-test to compare the mean of the pre-test sample with the mean of the post-test sample (see Table 1). Our results show that the mean score of the post-test was 8.8% higher than the pre-test, which was a statistically significant difference ($p = .001$). In short, after participating in the Common Problems projects, students scored almost a full nine percentage points higher on a test about problems and problem solving, than they did prior to the projects.

Table 1: Pair Sample t-tests of Pre-test and Post-test Scores.

	Mean	Std. Deviation	t	*df*	Sig. (2-tailed)
Post-test Pre-test	.088	.194	9.29	417	.001

Results of the 2018-19 Project Evaluation

In 2018-19, an outside assessment expert was hired to conduct an independent evaluation of CP2. The assessment expert conducted site visits for three of the four partner campuses, and phone interviews with the fourth. The expert interviewed at least one faculty and a number of students with each of the projects that were ongoing during that time. The expert also spoke with some campus administrators involved in the implementation.

In the report, the assessment expert concluded, "faculty perceptions of their Common Problem projects were generally positive." The benefits as the faculty saw it included teaching students to communicate across discipline, students playing the role of content experts in the teams, experiences that mirrored real-world employment, use of social media and electronic platforms, and the use of community partners who added gravity to the problems they were addressing. The faculty interviewed made several recommendations for improvement, including better training, more timely preparation for the projects, better explanation of the problem-solving process in the classroom, and assistance with managing student group work.

The assessment expert also concluded, "student perceptions of the Common Problem projects seemed generally positive." It was reported that the project work simulated what real-world work would be like. The expert appreciated the hands-on nature of the project, and thought it helped with understanding the course material. Evidence indicated that students were learning valuable practical skills in carrying out the projects. Students also acquired useful knowledge of electronic platforms for communication in working with their teams. The assessment expert noted that students seemed to enjoy working with others from a different disciplinary perspective. The assessment expert's report pointed out that students wanted more help in facilitating team meetings, and help with negative team dynamics. Some students suggested making the project the centerpiece of the course, rather than an assignment among others.

The assessment expert also met with several community partners associated with the project. The report concluded that "community partners seemed generally satisfied with their experiences as part of the Common Problem project, and all said that they would be willing to be involved in another project," although some voiced some conditions for that involvement. Their suggestions included making the involvement with students more meaningful for the community partners, by extending the partnership through follow-up projects (i.e. multiple semesters of projects) and with internships with the community partners. They also suggested that a greater emphasis be placed on students learning the importance of professionalism.

The assessment expert observed institutionalization of the project was made through a bottom-up spread of the pedagogy from faculty member to faculty member. In his view, this had "the advantage of building campus change from the grassroots level rather than by edict from administrators." It had "the disadvantage of being dependent upon the interest of a relatively small group of faculty members." The assessment expert suggested more integration of the project into other aspects of the campus and community, and made a number of recommendations related to applied-learning efforts on campus and curriculum.

Finally, the assessment expert also evaluated the pre-test and post-test assessment tool. A recommendation was made to improve the consistency between the pre-test and-post-test. As a result, the campus partners worked to revamp the assessment tests.

Faculty Survey

In February of 2020, a survey was developed using Qualtrics and shared with CP2 faculty at all four campus sites. The survey collected basic data about the type of course, and asked a series of questions about satisfaction with the pedagogy, the likelihood of utilizing the pedagogy in the future, and the likelihood of using the pedagogy to produce scholarship. These were formatted on a Likert scale. Open-ended questions asked about the likelihood of teaching with this method in the future and about the benefits and drawbacks of the method. These questions were qualitatively coded for positive attributes of the pedagogy and for challenges to teaching with the pedagogy.

Of the 100 faculty who have taught CP2 courses, thirty-six (36) faculty responded to the survey (36% of the total population). Of those respondents, 19 (roughly 53% of respondents) were from SUNY Cortland, 7 (roughly 19%) were from SUNY Plattsburgh, 6 (roughly 17%) were from SUNY Oneonta, and four (roughly 11%) were from SUNY Oswego. There was a wide range of department participation across the different campus sites, representing both the humanities and the STEM fields.

Likert scale questions revealed interesting trends (see Table 2). When asked, "How would you rate this approach as a means of meeting learning outcomes for your course?" 95% of faculty selected "excellent" or "good". When asked, "How would you rate this approach as a means of engaging students in course content?", again, 95% of faculty responded "excellent" or "good". However, when asked, "How would you rate this approach as a means of involving students in the local community?" only 69% responded "excellent" or "good."

The open-ended responses revealed several trends. First, faculty frequently highlighted the benefits of working with the community in their responses. As one participant noted it was, "an excellent way to connect students with stakeholders" and another noted the "deeper engagement with the community." Respondents also highlighted both student engagement and collaboration; these were the most frequently cited benefit of the pedagogy. Other benefits cited by respondents included more purposeful learning, development of critical thinking skills, developing community connections, and application of real world situations. As one faculty participant stated, "students were inspired by dealing with an actual problem and working with fellow students in another discipline…a deeper engagement with the community."

The open-ended responses also revealed trends in challenges associated with CP2. Faculty consistently noted that poor communication with both the community partner and with the partner courses prevented success of the projects. Faculty also consistently noted that the time commitment required to plan for CP2 presented a challenge. Respondents discussed the extra time commitment they had to put in to ensure a successful completion of the project and the challenge of finding time to work with the partner course faculty. A few respondents noted that the time devoted to the project took away class time when they would have normally covered additional content. Finally, faculty noted that students' responses to the project presented challenges, when students perceived uncertainty or demonstrated resistance to the pedagogy. Several faculty caveated their discussions of challenges by stating that, despite these challenges, the pedagogy was, "well worth the extra effort."

Table 2: Faculty Rating of CP2.

Survey Questions	Excellent	Good	Average	Poor
How would you rate this approach as a means of meeting learning outcomes for your course?	9 (26%)	24 (69%)	2 (5%)	0 (0%)
How would you rate this approach as a means of engaging students in course content?	23 (66%)	10 (29%)	2 (5%)	0 (0%)
How would you rate this approach as a means of involving students in the local community?	11 (32%)	13 (37%)	7 (20%)	4 (11%)

Lessons Learned about Logistics

As is evident through the case studies above, CP2 projects can vary greatly. However, the implementation of CP2 across four campuses revealed common effective logistical strategies. We report on those insights below.

Recruitment of Faculty

Participating campuses have used several strategies to recruit faculty participants. One common approach is to hold informational sessions to describe key elements of the methodology, with particular emphasis on the student-centered approach that is central to problem-based learning. At these sessions, it is helpful to include sufficient networking time so that faculty from different departments have time to discuss common interests and explore potential partnerships. Campuses have also distributed short surveys to collect information from interested faculty who were unable to attend information sessions. It is critical that the information shared in these sessions is clear and consistent; in once instance, faculty participants shared that the description of CP2 during the initial information sessions was different from what was emphasized in a faculty development webinar offered a few months later. The campus administration, including deans and department chairs, must also send clear and consistent message that faculty participation in this project is both encouraged and valued. It is important to ensure that faculty fully understand the goals and methodology from the outset.

Selection of Courses

The selection of appropriate courses is just as important as the recruitment of faculty. The goal of CP2 is that faculty would integrate this new pedagogy into existing courses, and ideally into courses that are required in a major, rather than creating new courses just for this project. New courses are less likely to attract enrollment and are not easy to sustain. Course level is also a significant consideration. On our four campuses, we have successfully run projects involving courses at all levels, from freshman-level introductory classes to senior-level seminars. Based on our experience, we can recommend several best practices here:

1. Make the team projects a significant component of all participating courses, as the intent is for much of the student learning to occur through their engagement with a difficult problem, and with one another.
2. Both (all) courses in a given project should be at the same level, so that all students feel they can contribute equally.
3. Classes should be of similar size so that teams are balanced across disciplines.
4. In general, upper-division classes might be better suited for this pedagogy. We want students to see themselves as the experts in their disciplines within their teams. They need to have enough experience in their majors to feel comfortable in that role.
5. While having three or more classes involved in a project may initially sound attractive from an academic point of view, such arrangements add a significant amount of complexity for each of the logistical areas discussed below.

Scheduling

Planning for a CP2 offering should ideally occur at least two semesters before the courses are to be offered. On most campuses, fall class schedules are typically built at the beginning of the previous spring semester, so any discussion and approvals regarding fall semester projects need to have concluded in the prior fall semester. A similar timeline would be needed for spring offerings. This also allows sufficient time to organize training workshops and other faculty development activities.

Early in the planning process, faculty need to decide how many classes will be involved in a given project. Having more than two disciplines involved in a project certainly provides for a greater diversity of viewpoints and creates opportunities for students to have more enriching and productive discussions. However, faculty who have participated in projects involving three or four classes have reported that coordinating schedules and managing student teams was much more complex than it was for projects only involving a pairing of two courses.

Participating faculty also need to decide how and when the collaborative work across their classes will occur. A common model has been for students to work on a collaborative project during the second half of the term, after each of the individual classes has had time to master significant content. One common scheduling model is for both of the participating classes to meet on the same days and times. Each class would have its own classroom, but combined class meetings would be easy to hold, provided of course that at least one of the rooms is large enough to accommodate both groups.

A second model is for the participating classes to schedule an additional weekly common meeting time (similar to a lab or recitation section) for which all students in the participating sections would register. This provides flexibility in scheduling the individual classes while still ensuring that collaborative time is built into the students' schedules. This model might have workload implications for faculty who might be entitled to overload pay, depending on the policies of the particular campus. If the additional meeting time is credit bearing, there might also be implications for student credit hour limits and tuition costs, although this has not been an issue for our projects.

In a third model, teams of students are responsible for making their own arrangements to work together outside of class, primarily through electronic communication including text messaging, email and discussion boards created in the campus online learning platform.

A fourth model was implemented at SUNY Cortland in both the 2018 and 2019 summer terms. The projects began with the individual classes meeting fully online for two weeks, followed by a weeklong residency at the college's facility in the Adirondacks where the bulk of the collaborative work occurred. Although this fourth model is not logistically possible for all campuses to implement, it illustrates that many creative ideas can be considered to facilitate collaborative work.

Team Formation and Monitoring

The ways in which teams are organized and monitored depends heavily on the scheduling model chosen. Some faculty choose to be very deliberate about team member selection, making sure that there is gender balance, proportionate mixture of students from both classes, and a good mix of strengths and abilities. Organization and monitoring are both straightforward if the collaborative work occurs during class meetings that are facilitated by faculty. With any scheduling model, student teams can submit journals or progress reports on a periodic basis. In any class that involves group projects, it is a good idea to build in accountability measures, such as providing mechanisms for students to report issues related to non-participation.

Grading and Types of Assignments

Assignments and grading varied widely by courses and campus. However, the project should make up a significant component of the course grade. Examples of graded assignments include:

- Formulation of an initial problem or proposal
- Weekly student journals that include progress reports
- Periodic update reports from student teams
- Final reports and/or presentations
- Reflection papers

Regardless of the assignment format, faculty should work together to create common rubrics for shared assignments, otherwise students may perceive a level of unfairness if one course is graded more critically than the other is.

Discussion and Conclusion

The goals of the CP2 were (1) to enhance the problem-based pedagogy model by introducing an interdisciplinary approach to education while incorporating high-impact practices and learning outcomes associated with problem-based pedagogy, and (2) to encourage faculty to go outside of their academic silos to work with colleagues in different disciplines. The assessment results described above show that the CP2 is a promising pedagogical approach for achieving these goals. Results from the pre-test and post-test show a statistically significant improvement in students' problem descriptions, organization, awareness of complexity, and self-evaluation. Statements from student interviews demonstrate an appreciation for the contributions of their peers from other disciplines to individuals' own learning. They show an appreciation for the value of working with others on generating both problem descriptions and solutions.

One unexpected finding was that students believed that CP2 classes were excellent preparation for their future careers. They found that working with peers in another discipline and community groups simulated a work environment in which they would have clients, meet with people whose talents and interests differed from their own and work with others using online platforms. Students enjoyed this real world aspect of their CP2 courses and it kept them engaged in both the class and the CP2 project.

The CP2 model also benefitted faculty members who found working with colleagues in other disciplines to be a welcome change from their routine. They appreciated the comradery and intellectual stimulation that resulted. Both students and faculty found the project to be challenging, as well as enjoyable. Students had to figure out how to meet with their group members in other classes. They had to take on a more complex project than they would usually expect in an undergraduate class. Faculty members needed to spend more time than usual on their CP2 courses in order to coordinate their classes with colleagues, arrange meetings with community partners and assist students with complex projects. However, for both students and faculty, the overall experience was positive and the majority of the faculty would be interested in teaching using the CP2 model in the future.

Results of our assessment activities echo existing literature about similar pedagogical approaches. First, our results support earlier claims that problem-based learning is effective for fostering self-directed learning habits, problem-solving skills, and deep disciplinary knowledge (Nilson, 2010; Yew and Schmidt, 2009; Pourshanazari et al., 2013; Loyens et al., 2015). Second, our findings add to this list by illustrating that problem-based learning has the potential to support the development of teamwork skills. Third, the CP2 model validates increasing calls for interdisciplinary education (Newell, 2010; Jacobs, 2015); students learned the differences between their own discipline's approach to a specific problem and that of another discipline. Finally, the CP2 experience demonstrated that in order to bring the benefits of their disciplines with them to the project, students in the third and fourth years of college were a better fit for the model than first- and second-year students. This aligns with recommendations about student development and problem-based learning (Howe et al., 2014).

Based on these findings, the CP2 model holds promise for a future of collaborative problem solving as a pedagogical approach. Since it does not involve semester-long team-teaching, nor specially developed classes, it is relatively easy to implement into existing curriculum, and usually has no additional cost. In a time of disciplinary silos and struggles of the humanities and arts in the academy (Schmidt, 2018), an added benefit of the pedagogy is that faculty from different disciplines work with one another, step outside of their silos, and see the worth of disciplines other than their own.

These results, however, come with several important caveats. First, the focus of the pre-test and post-test assessment was limited to one instrument, which focused on whether students' problem-solving skills were improved through their CP2 experiment. There are many other student attributes that faculty may wish to assess, which our instrument did not attempt to measure, including civic engagement, teamwork, oral communication, and integrative learning. Some individual faculty have conducted assessment to measure these and other student learning outcomes, but we are unable to comment on the outcomes in a synthetic way, because we did not conduct a comprehensive assessment in these areas. Second, the assessment of CP2 did not attempt to evaluate the quality of the final student projects, and thus we cannot comment about students' abilities to solve the project problems. Faculty who replicate CP2 may wish to conduct such evaluations. However, we caution that many large, ill-structured problems, which are well suited for problem-based learning (Barrows and Kelson, 1995), are unlikely to be solved in a semester or less. Since the goal is to promote student learning, we recommend that future evaluations of CP2 examine the learning process in addition to the final product. Questions along this vein may include:

1. Were solutions grounded in sound methodology?
2. Did student teams consider relevant information?
3. Did they study previous failed attempts to address the problem?
4. Did the community partner provide feedback on the quality of their solutions, or about the overall experience?

One way to explore these questions systematically is through qualitative analysis of students' reflective essays, which is a method well suited to documenting student learning (Ash et al., 2005). Our assessment activities did not include a comprehensive collection and analysis of reflective work. We suggest that faculty and institutions interested in replicating CP2 should consider assigning students a universal reflection assignment. We provide an example of such a prompt in Appendix 3. Such reflection assignments can then be collected by faculty and qualitatively analyzed to explore the questions above. Broader adaptation of the CP2 model and subsequent assessment work will help to refine and expand the model.

Finally, our work examined student outcomes in aggregate and did not measure differences between demographic groups. Similar high impact practices have been shown to be especially effective for narrowing the achievement gap for Black, Indigenous, and People of Color (BIPOC) (Kuh, 2008), particularly within the STEM fields (Theobald et al., 2020). Thus, CP2 may have potential as a pedagogical approach to closing the achievement gap. Given the social inequity associated with low

STEM participation and achievement among BIPOC students (Holdren et al., 2013), future research should investigate how different demographic groups experience CP2.

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Appendices

Appendix 1: Complete Census of CP2 Courses from fall 2015 through spring 2020.

Semester	Campus	Course Titles	Project Title	Enrollment
Fall 2015	Oswego	Advanced Digital Photography	Smart Neighbors Project: Promoting Local Businesses	59
		Literary Citizenship		
		Cinematography		
		Marketing Management		
Spring 2016	Plattsburgh	Cities in International Film	Sustainability Issues in the City of Plattsburgh	44
		Sustainability		
Fall 2016	Oswego	Marketing Management	Smart Neighbors Project Promoting Local Business	133
		Experimental Filmmaking		
		Intermediate Photo		
		Literary Citizenship		
		Race, Ethnicity, Gender, Class		
		Advanced Poetry		
		Design Concepts		
Fall 2016	Plattsburgh	Moral Problems	Animal Ethics Issues	61
		U.S. History 1877-Present		
Fall 2016	Plattsburgh	Atmospheric Processes	Climate Change Skepticism	38
		U.S. Environmental History		
Fall 2016	Cortland	Social and Academic	Migrations in the Cortland	52

		Curriculum Current Issues in Public Policy Migration and Impacts	Community: Toward Better Understanding	
Fall 2016	Cortland	Tree Biology Writing Studies World Environmental History Environmental Ethics	Local Sustainability: Green Walking and Biking Trails	62
Fall 2016	Cortland	Introduction to Environmental Studies Video Production I Political Economy and Social Thought Historical Methods	Sustainable Development in Cortland County	54
Spring 2017	Plattsburgh	Cities in International Film Sustainability	Sustainability Issues in the City of Plattsburgh	27
Fall 2017	Oneonta	Statistics and Research Methods for Counselors Math Theory Combinatorial Computing	Work with Queens High School for Language Studies and Josiah Quincy School in Boston	21
Fall 2017	Oneonta	Senior Seminar Sociology and Communications and Media	Farm Sanctuary	15
Fall 2017	Oneonta	Apparel Design – Flat Pattern Textile Science	Assisting Second-hand Stores in Otsego County	33
Fall 2017	Oswego	Directing Photography Literary Citizenship Advanced Poetry Experimental Filmmaking Advanced Screenwriting History Methods Marketing	Smart Neighbors Project: Promoting Local Businesses in the Oswego Community	178

		Management Typography Ceramics Graphic Design and Typography		
Fall 2017	Plattsburgh	Shine on Practicum Psychology of Women	Image Issues of Young Girls	32
Spring 2018	Cortland	Multimedia Production Research Experience in History	Creating a Digital Timeline for the SUNY Cortland Sesquicentennial Celebration	24
Spring 2018	Plattsburgh	Nutrition Education and Counseling Teaching Methods II	Food Choices Available to School Students: Nutrition Issues in Schools	45
Spring 2018	Plattsburgh	Seminar in Dietetics Teaching Methods II	Food Choices Available to School Students: Nutrition Issues in Schools	46
Spring 2018	Plattsburgh	Environmental Ethics Evolution	Antibiotic use in Animals	65
Spring 2018	Oneonta	Issues and Advocacy in Early Childhood Advanced Composition	Sustainability in Elementary School	71
Spring 2018	Oneonta	Differentiated Instruction Science and Technology in Elementary Education Issues in Education	Sustainability in schools Worcester Elementary	61
Spring 2018	Oneonta	Nutritional Assessment Intro to Computer Science	Partnership with Sodexo	50
Spring 2018	Oneonta	Galaxies Live Electronic Music Performance Audio Arts	Partnership A.J. Read Science Discovery Center	28

Spring 2018	Oneonta	Race, Crime and Justice Black and Latino Experience	Oneonta NAACP	62
Summer 2018	Cortland	Political Economy of the Adirondacks Tourism and Economic Development in the Adirondacks	Development of Ecotourism in the Adirondacks	6
Fall 2018	Oswego	Advanced Filmmaking Cinematography Intermediate Screenwriting Graphic Design Photography Marketing Intro to Creative Nonfiction Composition	Water Tourism	143
Fall 2018	Plattsburgh	Public Relations Campaign Planning and Development Brain and Behavior Junior Seminar Psychology	Stigma of Addiction and the Opioid Crisis	49
Fall 2018	Oneonta	Family Communication and Collaboration Teaching Technology: Elementary School Curriculum	Otsego County Division for Children with Special Needs	17
Spring 2019	Plattsburgh	Archaeology Expeditionary Studies	Issues Related to Archaeological Sites, Tourism and Cultural Heritage	26
Spring 2019	Plattsburgh	Mapping Culture Crime and Intelligence analysis	Keeping Cities Safe: Crime Mapping in the Region	47
Spring 2019	Plattsburgh	Environmental Ethics Environmental Science	Environmental Planning Issues	36
Spring 2019	Oswego	Communicating Science in Media	Communicating Science in Media	17

Spring 2019	Oswego	Globalization and Poverty Earth Resources Hypermedia Cultural History of Iroquois Information Storage and Retrieval	Mapping Oswego: Using Hypermedia to Create a Digital Map of the History and Culture of a Small Town	196
Spring 2019	Oswego	History Methods Modern Languages: Spanish Global Engagement: Communication Studies	Decoloniality: Narratives of Knowledge In and Beyond Academia	4
Spring 2019	Cortland	Principles of Physics III Graphic Design II	Increasing Public Awareness of Issues Related to Population Growth	25
Spring 2019	Cortland	Economic Development Historical Methods	Providing Access to Healthy, Locally-grown Food	41
Summer 2019	Cortland	Political Economy of the Adirondacks Environmental Geography of the Adirondacks	Sustainable Tourism Development in the Adirondacks	7
Fall 2019	Oswego	Marketing Cinematography Children’s Film Intermediate Writing for Film Graphic Design Photography Intermediate Poetry Composition	Smart Neighbors Project: Promoting Local business	118
Fall 2019	Plattsburgh	Archaeology of Latin America and the Caribbean Global Gender Issues	Problems of Gender Issues in Ancient and Modern Latin America	41
Fall 2019	Plattsburgh	Atmospheric Processes Global Dynamics	Equity in the Carbon Budget	25

Fall 2019	Plattsburgh	Environmental Criminology Intro to Geographic Information Systems	Using GIS and Criminology Methods to Identify Specific Crime Problems in the Region	40
Fall 2019	Cortland	Tree Biology Remote Environmental Sensing	The Homer Tree Survey project	36
Fall 2019	Cortland	Technical Writing Advanced Laboratory	Public Messaging on Issues Related to Water Analysis	33
Spring 2020	Plattsburgh	Advanced Personal Training Intro to Biopsychology	Improving Athletic Performance through Connections Between Exercise and Cognitive Performance	69
Spring 2020	Plattsburgh	Environmental Ethics Recreation and Tourism Geography	Land-use Planning and Zoning Issues in the Adirondack Park and the City of Plattsburgh	33
Spring 2020	Plattsburgh	New Product Development Fundamentals of Engineering Design	Addressing Socio-environmental Problems through Technically Feasible Project Designs	49
Spring 2020	Plattsburgh	Crime and Intelligence Analysis Geographic Information Systems	Using GIS to Analyze Repeat Victimization for a Specific Type of Crime	33
Total	4	134	47	2352

Appendix 2. Pre-test and Post-test Prompts.
Students were asked to write short-answer style responses to the following questions:

1. Pre-test Question
   Give an example of a problem, describe its characteristics and parameters, discuss the steps you would take to solve this problem, and how you would decide on the best possible solution.
2. Post-test Question
   At the beginning of the semester, you were asked to describe your approach to solving problems. Using the problem project for this class, describe its characteristics and

parameters, discuss the steps you and your group took to solve this problem and how you decided on the best possible solution.

Appendix 3. Rubric for Scoring Pre-test and Post-test.

Dimension	Standard to Earn 4 Points	Standard to Earn 3 Points	Standard to Earn 2 Points	Standard to Earn 1 Point	Standard to Earn 0 Points	Points Awarded
Complexity of the problem described	Complex, multi-layered, ill-structured	Some complexity and ill-structure	Fairly straight Forward, little complexity	Simple, relatively obvious solution	No attempt	
Organization of approach	Clear step by step organization, with planned opportunities for review and analysis	Discernible organization and planning	Some elements of structure and planning analysis but overall weak organization	Disorganized, no structured process.	No attempt	
Depth of reflection on outcome	Shows consideration of nuances and the possibility of multiple solutions, ethical weight	Consideration of some important issues at stake in problem solving	Very little recognition of complexity and other factors	No depth of reflection or consideration of complexities	No attempt	
Degree of self-evaluation	Very self-aware and critical of one's strengths and weaknesses in the process of problem solving	Acceptable degree of self-awareness and interest in growth	Some self-awareness but lacking sufficient ability to be critical of one's strengths and weaknesses	Little to no self-awareness	No attempt	
Total						

Appendix 4. Reflection Paper Prompt.

The Reflection Paper is an opportunity for you to think about how the problem-based project affected you personally. The 3-5 page paper should address the following questions:

1. Problem-Solving:
   - **a.** What were some of the problem-solving skills you used in working on this project? Did they improve in the process?
   - **b.** Did you achieve a better understanding of the problem through your research and discovery than when you started?
2. Was working with a group on the problem a help or a hinder? In which way? How did you handle differing perspectives and points of view?
3. How did working with others outside of your major help or hinder the project? What did you learn from other disciplines that was helpful in analyzing the problem or proposing a

solution?
4. Did working on the project deepen your understanding of the problem and make you more aware of the issues involved, particularly how it affects the community?
5. Did the community partner(s) perspective change your approach and understanding of the problem? How otherwise did the community partner affect the project?
6. Were you able to incorporate concepts and theories taught in the class? If so, which were most helpful? Do you think your field of study is helpful to understanding and solving the problem?

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