

Co-teaching Two Interdisciplinary Courses in Higher Education

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Academics are challenged to shift from traditional lecture models to accommodate rising student expectations, digital delivery platforms, and inclusive evidence-based classroom practices. As a solution, co-teaching can add value to undergraduate students' and faculty's learning and problem-solving skills. We investigated effective co-teaching practices in higher education and its impact on students' learning outcomes. We analyzed co-teachers', teaching assistants', and students' interview and focus group data and an external evaluator's assessment of co-teaching classroom dynamics using thematic analysis; surveys on what co-teachers learned from teaching together; and students' self-reported learning assessments with co-teaching using descriptive analysis in two undergraduate Introduction to Public Health and Health Policy courses. Co-teachers learned from one another in teaching styles, troubleshooting, collegiality, and shared goals to improve students' learning outcomes. Given our limited student sample, students appreciated different co-teacher's perspectives, more resources and instructor help, despite not always receiving a balanced biomedical perspective.

Co-teaching is primarily practiced in K-12 settings (Beninghof, 2012; Heck & Bacharach, 2016), with the exceptions in higher education generally focused on teacher preparation in special education (York-Barr et al., 2004). Co-teaching occurs when two educators collaboratively create a learning community with shared planning, instruction, and assessment for students (Beninghof, 2012; Chanmugam & Gerlach, 2013; Villa et al., 2013). A number of co-teaching models exist (Villa et al., 2013), including: *supportive teaching*, with one teacher doing primary instruction and the other doing classroom observations or providing individual student assistance; *team teaching*, where lessons flow between both instructors during a class; *parallel teaching*, where each teacher instructs the same material to half of the students; and *complementary teaching*, where one teacher's efforts enhance the other teacher's instruction, for example, paraphrasing the other teacher's statements, providing examples, or note-taking during lectures. But, the literature varies on what is not co-teaching. One researcher suggests co-teaching *does not* mean: 1) teaching teams with unequal degree credentials, who may have different expectations or contributions in their instructional efforts; 2) both instructors are merely present in a classroom at the same time; 3) one instructor consistently plans and delivers all lectures while the other circulates; or 4) teaching teams who consistently plan together but group and instruct students in separate classrooms (Batur 2012). However, other researchers include student teachers training with an experienced instructor or two instructors planning a course together but alternating teaching classes or modules (Murphy & Scantlebury 2010; Scantlebury & Murphy 2010). Minnett-Smith & Davis (2020) identify this latter model as sequential team-teaching, which was the most common team-teaching example in their research. Our co-teaching falls across supportive, team, and complementary models.

The relative absence of co-teaching in North American higher education is attributed to the institutional expense of two instructors and a professional culture and student experience emphasizing individual-level disciplinary expertise with control over course content. Additional challenges in traditional univer-

sity settings include: teachers meeting rising student expectations as consumers; increasing costs (Bunce & Bennett, 2019); incorporating digital delivery platforms (Crawford & Jenkins, 2017); and adopting inclusive, evidence-based classroom practices to improve student engagement (Gladstone-Brown, 2018; Sharma & Cobb, 2018). Collaborative teaching models could address these concerns and improve teaching quality, as literature on co-teaching in higher education shows it is positively transformative for students and instructors (Dugan & Letterman, 2008; Ferguson & Wilson, 2011).

Co-teaching benefits students working in interdisciplinary settings, gaining perspectives from different disciplinary knowledge, and receiving more help with course content and problem-solving (Bryant et al., 2014; Crow & Smith, 2005; Renshaw & Valiquette, 2017), while openly discussing with students the contrasting perspectives of co-teaching related to diverse backgrounds, power, and inequality (Harris & Harvey, 2000; Lock et al., 2016). Instructors benefit from conversations about their teaching strengths and weaknesses, while enhancing their interdisciplinary content knowledge and teaching skills and modeling effective collaboration for students (Bryant et al., 2014; Chanmugam & Gerlach, 2013; Jarvis & Kariuki, 2017a). But, challenges do exist to implementing co-teaching, such as additional planning time, personality differences, managing difficulties with power or workload imbalances between instructors, or students playing one instructor against the other (Ginther et al., 2007; Jarvis & Kariuki, 2017b; Montebancho, 2021; Rytivaara et al., 2019). Thus, proactive communication, planning, and assessment must be at the core of good co-teaching, particularly with interdisciplinary teams and student learning (Bryant et al., 2014; Bucci & Trantham, 2014; Jarvis & Kariuki, 2017b; Lock et al., 2016).

As instructors, we hoped co-teaching would support our undergraduate public health program's learning outcomes, based on the Association of American Colleges and Universities' Liberal Education and America's Promise (LEAP) essential learning outcomes (AACU, 2009). Our co-teaching model included collaboration between co-instructors on all aspects of a course,

from development of content and assessments, through classroom instruction and advising, to evaluating student outcomes. As much as possible we created teams of instructors equally committed to undergraduate education, working together over several semesters. Interactions between faculty as they debate an issue or disagree with an approach fosters an active learning environment, critical thinking, and problem solving, carried over into student interactions in lectures. Co-teaching enhances high impact practices of learning communities, collaborative assignments and projects, common intellectual experiences and service and community-based learning (Jarvis & Kariuki, 2017a; Kuh, 2008). Students hear about two sets of professional experiences and observe rapport between faculty members as role models for collaborative learning (Bryant et al., 2014; Lock et al., 2018). Students' professional development is enhanced by having more exposure to professors and their networks, with increased opportunities for internships and research.

The two faculty co-authors, each of whom have co-taught two required public health courses over multiple semesters, designed a preliminary evaluation of the benefits and challenges of co-teaching in the undergraduate program in public health at the University of Colorado Denver. We evaluated two core courses, combining the practical knowledge of public health with the theoretical and analytical strengths of the social sciences, to break down disciplinary silos, model interdisciplinary dialog and teamwork for students, and achieve essential learning outcomes. Our arguments on the benefits of combining a liberal arts education (e.g., the social and behavioral sciences, humanities, and sciences) with public health have been discussed previously (Albertine, 2008; Rodgers et al., 2016; Stewart, 2020). Stewart (2020) successfully experimented with this type of co-teaching to facilitate faculty and student interdisciplinary conversations, reflect on student motivations for studying public health, and prompt critiques of public health practices.

We collected co-teachers', teaching assistants' (TAs), and students' perspectives on the benefits and challenges of co-teaching, and external evaluations of co-teaching classroom practices. Because our program focuses on social justice, health disparities, and social determinants, we assessed students' understanding of these concepts and how they applied them to improve population-level health (Muntaner et al., 2000). We assessed co-teachers' and TAs' use of best practices through engaged learning and multicultural education principles (Grant & Sleeter, 2009). Finally, we assessed co-teaching as reflective practice, understanding if and how co-teaching led instructors to have "reflective conversations," enhancing their teaching practice and possibly providing a model for similar conversations with and among students (Crow & Smith, 2005; Lock et al., 2018). Our evaluation addressed the following research questions:

1. **How do co-teachers, TAs, and students perceive the benefits and challenges of co-taught, undergraduate public health courses compared with their experiences in independently taught public health courses?**
2. **How do our co-taught, undergraduate public health courses facilitate student learning outcomes?**

METHODS

Setting the Context

Although expensive in faculty expenditure per pupil, co-teaching promises significant added value to undergraduate public health programs. In our program co-teaching meant both instructors, where one from our department in the College of Liberal Arts and Sciences (CLAS) and one from the Colorado School of Public Health (CSPH), would be present at all class sessions (with limited exceptions) and would design and teach the course and evaluate students, sharing the workload equally.

Recognizing the need for a larger public health workforce in Colorado and a survey indicating strong interest in public health among undergraduate students, the Department of Health and Behavioral Sciences at the University of Colorado Denver proposed an undergraduate program offering Bachelor of Arts and Bachelor of Science degrees and minors in public health (Gebbie et al., 2002; Rosenstock et al., 2008). Faculty agreed to promote health equity through an understanding of the social determinants of health as central to our program. Although social determinants were discussed in public health literature, analysis and interventions often focused on individual-level lifestyle choices, deflecting attention from "materialist structural inequalities (e.g., class, gender, and race)" in social life, and thus, did not always provide a platform for effective population-level interventions (Muntaner et al., 2000). Our faculty wanted our students to have a rigorous theoretical foundation in the social sciences as a basis for public health practice. Therefore, we housed the undergraduate program in CLAS and implemented the interdisciplinary co-teaching model.

Undergraduate programs in public health were then uncommon (13 programs nationally in 2005; Gebo et al., 2008). The CSPH offered a Master of Public Health degree in the five main areas of public health (e.g., biostatistics, social and behavioral health, environmental and occupational health, epidemiology, and health systems, management, and policy) and an expanding faculty of public health practitioners. To increase integration between CSPH, housed on the University of Colorado Anschutz Medical campus, and CLAS, housed on the undergraduate campus, and ensure a social sciences focus, we incorporated co-teaching into our six required core courses for the major: Introduction to Public Health, Introduction to Epidemiology, Introduction to Environmental Health, Health Policy, Social Determinants of Health, and Perspectives in Global Health. Each topical course would be co-taught by a faculty member from CLAS and the CSPH, while our required senior capstone course would be independently taught.

Courses

We selected two co-taught core courses, pre-COVID-19 and in-person, for our preliminary evaluation using a cross-sectional study design: Introduction to Public Health, with two co-instructors and two graduate student TAs, and Health Policy, with two co-instructors and one TA. Although different sections of a core course cover similar content, each co-teaching team determines how they teach the material, resulting in varied evaluation criteria and grading scales. In the online survey, we asked students to compare their experiences with independently taught courses in other subject areas to their experiences with co-taught public health courses.

Introduction to Public Health is a lower division course introducing the core curriculum and discipline for students considering the major or minor in public health. This course surveys the history and practice of public health, its population perspective, and its emphasis on prevention illustrated through contemporary public health case studies. It is offered every fall and spring semester, with class sizes averaging 90 students per semester. The course includes a three-credit lecture section, meeting twice a week, and a one-credit recitation section (i.e., with smaller class sizes, more interactive learning, and more individualized teacher-student time), meeting once a week, taught by one of two graduate student TAs.

Health Policy is an upper division course required for the major, but optional for the minor, in public health. This course focuses on accessibility, cost, and quality of health care; individual vs. public health rights; private and public health insurance; and ethics, while providing frameworks for understanding the social, political, and economic dimensions of health policy and law. The course consists of a three-credit lecture and small group application sessions, meeting twice a week, assisted by a graduate student TA. It is offered every fall and spring semester, with enrollment averaging 54 students in the spring semester.

Sample

Our sample included four faculty, two from CLAS and two from CSPH, and two TAs, one from each course (we could not arrange a convenient time for the third TA to participate in our study), and 50 undergraduate students. Co-teachers were ranked as Clinical Assistant Professor, Clinical Associate Professor, and two tenured Associate Professors at the time of data collection. TAs were first year doctoral students, in their second semesters of teaching undergraduate students. The faculty and TAs in Introduction to Public Health were an experienced co-teaching team, having taught together several semesters (with the TA twice). Faculty co-teaching in Health Policy were a new co-teaching team, with a new TA. Students were volunteer participants from the two courses and dual enrollees may have participated in both course evaluations. Our survey response rates were (22%, $n=21/95$) and (33%, $n=21/63$) for Introduction to Public Health and Health Policy, respectively. Two students from the Health Policy course started but did not complete the survey, although we included their partial data. Focus group participants ($n=8/158$) may also overlap with our survey participants. We provided \$25 gift cards to co-teachers and TAs, snacks during class time for student survey participants, and a meal for student focus group participants as incentives.

Evaluation Team

The evaluation team comprised two co-teaching faculty and two undergraduate research assistants (RAs), both public health majors nearing graduation at the time of data collection. The instructor on the team with expertise in qualitative research trained the RAs in interview techniques and leading focus groups. We discussed power differences between instructors, TAs, and undergraduate students and decided that having student RAs conduct the interviews posed fewer problems than having peers, from a small department who might teach together in the future, complete the interviews. Neither RA was currently enrolled in courses with the co-instructors or TAs and both felt comfortable conducting these interviews. Our RAs have now completed their public health degrees and are co-authors on this research.

The Colorado Multiple Institutional Review Board approved this study as exempt research.

DATA COLLECTION AND ANALYSIS

We relied on a variety of data sources and analytic methods to ensure a rigorous evaluation. To assess co-instructor experiences with co-teaching in each course, the student RAs interviewed co-teachers and administered quantitative, self-assessment surveys to elicit their perceptions of the challenges, benefits, and satisfaction with co-teaching and student learning. We adapted the survey from Villa, Thousand, and Nevin (2013) for K-12 educators. Identical survey versions were administered online via Qualtrics® and in paper for faculty convenience. We based our co-teacher interview questions on our literature readings discussing how to assess co-teaching in K-12 and higher education, particularly in public health, medicine, and other health professions, and our experiences with students (Beninghof, 2012; Dugan & Letterman, 2008; Harris & Harvey, 2000; York-Barr et al., 2004). We contracted an evaluator from the university's Center for Faculty Development and Advancement to observe classroom dynamics during one class session in each course. The evaluator assessed co-teaching best practices, levels of student engagement, and students' reports on the co-teaching model. We analyzed co-teacher surveys using descriptive statistics, while we used thematic analysis for co-teacher interviews and evaluator observation notes.

Table 1. Data Sources and Type of Analysis for Co-teachers, Teaching Assistants, and Undergraduate Students

Data Collected From	Type of Data Collected	Analysis
4 Co-teachers	<ol style="list-style-type: none"> 1. Structured Interviews 2. Self-Assessment of Co-Teaching Survey 3. Observation of Classroom Teaching (one session) 	<ol style="list-style-type: none"> 1. Thematic Analysis 2. Descriptive Statistics 3. Evaluation Report with Key Findings
2 Teaching Assistants, one from Introduction to Public Health and one from Health Policy	<ol style="list-style-type: none"> 1. Focus Group 	<ol style="list-style-type: none"> 1. Thematic Analysis
50 Undergraduate Students in Introduction to Public Health and Health Policy	<ol style="list-style-type: none"> 1. 2 Focus Groups with students in Introduction to Public Health ($n=4$) and Health Policy ($n=4$) 2. Online Survey: Students in Introduction to Public Health ($n=21$) and Health Policy ($n=21$) 	<ol style="list-style-type: none"> 1. Thematic Analysis 2. Descriptive Statistics

To assess TAs' perceptions of the benefits and challenges of co-teaching and student learning, our RAs conducted a TA focus group using similar co-teacher interview questions. We analyzed data using thematic analysis.

We worked with consultants from the Evaluation Center at the University of Colorado Denver to assess student experiences and satisfaction with co-teaching, including their evaluation of faculty's and TAs' instruction, grading, and interactions. We developed an online, student self-reported learning assessment survey in Qualtrics® tailored to each course. We pilot tested our survey in the semester prior to launching our project, in Introduction to Public Health and Perspectives in Global Health, and revised it based on students' feedback. We provided an anonymous survey link to students in Canvas during the last month of classes. We

conducted two student focus groups, one for each course, after student surveys were administered. We analyzed student surveys using descriptive statistics and focus groups using thematic analysis, with the same coding scheme used for co-teacher interviews.

RESULTS

Co-teachers' Surveys

Co-teachers responded to identical written or on-line surveys with 34 yes or no questions asking about best practices used in their co-teaching (Villa et al., 2013). Co-teachers agreed on 23 items (68%), in three areas, including: co-teachers' course preparation, working with students, and working with others. Course preparation meant sharing curriculum ideas and resources; contributing disciplinary ideas to teaching; using a variety of co-teaching models and having fun together; on-going communication, flexibility, and collaboration; and dependence on each other to follow through with our tasks and responsibilities. Working with students meant jointly assessing student learning and modeling teamwork for students. Working with others meant seeking external expertise when needed to help faculty and students, like guest speakers or peer teaching reviewers.

However, co-teachers disagreed on 11 items (32%), focused on details about the co-teaching process involving instructors, students, and others. Co-teachers' disagreement included having regularly scheduled meetings to discuss co-teaching; being able to effectively co-teach even when no planning occurred; awareness of what the other co-teacher is doing in the classroom even when not directly seen; using team teaching; having a process to resolve co-teacher disagreements; celebrating co-teacher outcomes and successes; and seeking additional training to improve co-teaching. Different perspectives about others included being mentors to those who want to co-teach and communicating our need for logistical support and resources to administrators.

Co-teachers' Interviews

We asked our four co-teachers to speak to four aspects of co-teaching: organization, communication, learning outcomes, and effectiveness.

Organization

All four co-teachers spoke at length about the importance of equal workloads: "Work is evenly split; [we] alternate grading (Co-teacher 2)." Both co-teaching teams divided responsibility for class sessions, alternated in leading classes, and decided who would speak on a given topic based on their disciplinary and professional expertise whenever possible. "In some ways we're a good match. There are things that I know about and work on that she doesn't necessarily do then there is a lot of stuff that she knows that I don't have a lot of background on (Co-teacher 1)." One team said, "We [make] a list of tasks and who is responsible for each of them (Co-teacher 1)." Aside from preparing lectures, which was completed individually, all other course activities and documents were prepared collaboratively. However, none of the co-teachers mentioned jointly grading assignments. In Introduction to Public Health, TAs were included in planning content and activities. In both courses, TAs collaborated on creating grading rubrics and participated in grading students' work to ensure fairness and consistency.

Co-teachers also noted planning time had to be built into co-teaching more deliberately than in independently taught courses.

Every set of grading guidelines, assignment instructions, exams, and exam questions, every single thing we do goes back and forth between us. There is a ton of coordination that goes along with that that you wouldn't do if you just wrote the exam and then gave it to your students. There's a ton of coordination that goes into it and takes a lot of time (Co-teacher 2).

The Introduction to Public Health team scheduled a planning session in the summer with the teaching team, while prior planning was precluded for the Health Policy team, as one instructor was assigned immediately before the semester started to fill a grant buyout vacancy.

Instructors differed on whether co-teaching decreased their workload. "Not necessarily less work, but a different experience. [Co-teaching] may increase workload in terms of communicating with the co-teacher. . . In a lot of ways, it does represent more work. . . because you have to confirm constantly (Co-teacher 3)." And, "After I continued to be paired with the same co-teachers. . . besides the drop in time invested because I'm not lecturing every week, there was a drop in time after I got used to my co-teacher (Co-teacher 2)." Last minute changes in co-teachers and frequent reorganization of teaching teams created obstacles to advanced planning and efficient organization of work between co-teachers. "[I] came late to the course, so not much room for negotiation over days and times of the course or who would do what. May have reduced conflict (Co-teacher 1)."

Communication

None of the teams mentioned communication as a problem. All co-teachers discussed the importance of regular communication among team members. "We do a little debrief of what transpires which is really helpful (Co-teacher 1)." And,

We have some in person stuff that happens prior to a semester. Then we see each other in classes, and we meet with each other then. We do a lot of emailing to each other as well. On occasion if something comes up and we need some sort of response quickly, usually we'll call each other on our cells (Co-teacher 3).

Both teams instituted policies requiring students to include all team members (both co-teachers and TAs) in their email messages. "We, multiple times, told students when you are sending correspondence to us make sure you are emailing all three of us, so that we know what you are asking of all of us so decisions can be made jointly (Co-teacher 1)." This ensured that all co-teaching team members were aware of issues with individual students or the class, email messages were answered promptly, and students did not instigate conflict between instructors.

Learning Outcomes

Both teams worked collaboratively to set course objectives, align the objectives with class assignments, and select readings and other course materials. Co-teachers create grading rubrics and grade exams and papers as important measures of learning outcomes for their courses. Both sets of co-teachers said it was important to be equally committed to student learning, which meant constant assessment of learning outcomes and revising assignments, classroom activities, and teaching techniques.

Effectiveness

Co-teachers discussed two aspects of effectiveness: student engagement and co-teaching's contribution to teaching practice and student learning. In addition to assessing learning outcomes through graded assignments, all co-teachers spoke about observing student behavior in the classroom to assess engagement. For example, were students speaking up in class, coming to class on time, appearing confused or inattentive?

I think so, in terms of expecting us to sort of go in and figure out how to better facilitate our lectures, making it interactive, post questions to them to keep the discussion going, bring up potential exam questions, how they would address that from the lecture... So we both try to do that I think. Trying to facilitate learning in different ways, keep people paying attention... So it's hard to gauge if this is exactly facilitating learning (Co-teacher 2).

With respect to co-teaching as enhancing effectiveness, co-teachers stressed the value of two different sets of experiences and expertise, though not necessarily different perspectives on public health, increasing the breadth of student learning.

So maybe you get a better lecture on health behavior theory because someone who does health behavior theory all the time is doing that lecture. Or like a person who is teaching communicable disease who knows a lot about that. I think maybe there's just better learning and better content because you get a wider range of skills in the teaching. I mean I don't know if there is a way to measure that (Co-teacher 4).

Co-teachers also noted students might feel more comfortable working with one instructor more than another.

Finally, co-teachers spoke at length about the benefits of co-teaching to their teaching practice. "Yeah, there was something in the first week of class that she did and I thought 'Ok, that's a good strategy; I have to remember that now' (Co-teacher 2)." And,

Scholarship can be a very lonely pursuit but teaching too. The way our work is structured we don't have a lot of time to come together. That is hard to do, it is hard to make that time. And compared to everything else we do, it's relatively low priority. When you're co-teaching it is built in. It is part of the structure. In that way it is a great advantage (Co-teacher 4).

Evaluation of Co-teachers' Practices

The external evaluator focused on co-teaching practice and did not specifically discuss how well the co-teachers represented distinct approaches or viewpoints on public health. The evaluator observed how organized team teaching in Introduction to Public Health was, with clear planning for the class small group activity. In Health Policy, as the co-teachers debriefed from a prior guest speaker, then lectured and conducted a small group activity, the evaluator suggested we remind students in lectures about our different training areas, sharing different examples on a lecture topic to benefit students' understanding of concepts. Our evaluator assessed the teaching teams in both classes as demonstrating effective co-teaching strategies and displaying exemplars of evidence-based co-teaching models most relevant to university-level instruction (Villa et al., 2013) including: supportive and complementary model variations such as *one teaches, one scribes* (i.e., one provides information or leads a discussion while the other instructor takes notes for the class on a screen or white

board); *one teaches, one observes* (i.e., one provides information or leads a discussion while the other observes student responses); and *one teaches, one assists* (i.e., with a class activity); parallel (i.e., each instructor delivers the same content to a different group of students enrolled in the same class); and team teaching (i.e., both instructors are present in the class and either divide the material, add content during the presentation, or discuss the same content from different perspectives).

Teaching Assistants' Perspectives

TAs observed students were very sensitive to the interaction between co-teachers. Students were more engaged with co-instructors interacting during the class and provided information or examples from different disciplines or areas of research. "I've heard students say two things; with [Instructor X] and [Instructor Y] they really like that connection and they appreciate the two different perspectives (TA 1)." Throughout their focus group the TAs repeated that from their perspective co-teaching was most effective when there were stable teams of co-teachers who worked together across semesters. This produced more dialogue and interaction between co-teachers in class sessions and more consistency in communication and organization. Co-teachers who emphasized mutual commitment to student learning and teaching effectiveness were most successful with co-teaching. "Yeah, but I think if they interact more with each other in class it would help students more (TA 2)."

It's hard to do but I think having the pair be the same is very beneficial, because they can play off of each other and students notice that. If people are in and out each semester it doesn't work because you are too busy trying to learn each other and what works (TA 1).

Students' Surveys

The same number of students responded to the survey online (Introduction to Public Health, $n=21$; Health Policy, $n=21$) in each course, both with an average student age of 22 years, mostly women (76%, $n=16$ and 72%, $n=15$), and Hispanics/Latinos as the dominant racial/ethnic minority group vs. non-Hispanic Whites (40%, $n=8$ and 35%, $n=7$ in Introduction to Public Health; 16%, $n=3$ and 58%, $n=11$ in Health Policy). Introduction to Public Health was more diverse than Health Policy. The majority were public health majors (67%, $n=14$) in Introduction to Public Health and (76%, $n=16$) Health Policy, which reflects Introduction to Public Health as a prerequisite for Health Policy and more majors likely enrolling in the latter course. Similarly, most students in Introduction to Public Health were lower division class status (57%, $n=12$), whereas in Health Policy the majority were upper division (57%, $n=12$).

We asked questions designed to assess whether students perceived they met key learning objectives based on their self-reports. Most students in Introduction to Public Health (95%, $n=20$) and Health Policy (81%, $n=17$) agreed with the statement that they could apply the public health approach to a health issue, and they could communicate the public health approach to another person (95%, $n=20$ and 81%, $n=17$ respectively). More students in Introduction to Public Health than in Health Policy reported familiarity with the concepts of health equity (100%, $n=21$ and 80%, $n=17$) and social justice (100%, $n=21$ and 67%, $n=14$), but both groups reported similar familiarity with social determinants

Table 2. Comparison of Undergraduate Student Survey Results for Introduction to Public Health and Health Policy		
Questions	Intro to Public Health (n=21)	Health Policy (n=21)
Public Health Major?		
Yes	67% (14)	76% (16)
No	24% (5)	10% (2)
No response	9% (2)	14% (3)
Class Status		
Lower division	57% (12)	29% (6)
Upper division	19% (4)	57% (12)
Other	14% (3)	0% (0)
No response	10% (2)	14% (3)
Gender		
Female	76% (16)	72% (15)
Male	14% (3)	14% (3)
No response	10% (2)	14% (3)
Ethnicity (select all that apply)		
American Indian or Alaska Native	0% (0)	5% (1)
Asian	10% (2)	5% (1)
Black or African American, not of Hispanic origin	15% (3)	16% (3)
Hispanic or Latino	40% (8)	16% (3)
Native Hawaiian or other Pacific Islander	0% (0)	0% (0)
White, not of Hispanic origin	35% (7)	58% (11)
Other	0% (0)	0% (0)
No response	5% (1)	10% (2)
We asked the students to think about how true the following statements were:		
: I can communicate the Public Health approach to another person		
1 (not true at all)	0% (0)	0% (0)
2	0% (0)	0% (0)
3	5% (1)	10% (2)
4	14% (3)	38% (8)
5 (very true)	81% (17)	43% (9)
No response	0% (0)	10% (2)
: I can apply the Public Health approach to a health issue		
1 (not true at all)	0% (0)	0% (0)
2	0% (0)	0% (0)
3	5% (1)	10% (2)
4	10% (2)	24% (5)
5 (very true)	86% (18)	57% (12)
No response	0% (0)	10% (2)
: the two co-teachers exhibited a balanced relationship when it comes to teaching		
1 (not true at all)	0% (0)	0% (0)
2	0% (0)	10% (2)
3	10% (2)	4% (1)
4	33% (7)	14% (3)
5 (very true)	57% (12)	62% (13)
No response	0% (0)	10% (2)
: the two co-teachers exhibited a balanced relationship when it comes to interacting with the students		
1 (not true at all)	0% (0)	0% (0)
2	0% (0)	4.5% (1)
3	24% (5)	10% (2)
4	28% (6)	4.5% (1)
5 (very true)	48% (10)	71% (15)
No response	0% (0)	10% (2)
: In addition to the two co-teachers, the TA contributed to my understanding of the content.		
1 (not true at all)	0% (0)	42% (9)
2	5% (1)	23% (5)
3	0% (0)	5% (1)
4	33% (7)	10% (2)
5 (very true)	62% (13)	10% (2)
No response	0% (0)	10% (2)
How well did a co-taught class prepare you for:		
: a job/internship in the field of public health		
1 (not at all prepared)	0% (0)	5% (1)
2	14% (3)	5% (1)
3	24% (5)	19% (4)
4	38% (8)	23% (5)
5 (very well prepared)	24% (5)	38% (8)
No response	0% (0)	10% (2)
: a volunteer position within the field of public health		
1 (not at all prepared)	0% (0)	5% (1)
2	0% (0)	5% (1)
3	19% (4)	0% (0)
4	38% (8)	43% (9)
5 (very well prepared)	43% (9)	33% (7)
No response	0% (0)	14% (3)

Questions	Intro to Public Health (n=21)	Health Policy (n=21)
When thinking about your co-taught classes compared to your singularly taught classes, how true are the following statements:		
: there is more clarity regarding what is expected of me in class		
1 (not true at all)	5% (1)	5% (1)
2	10% (2)	14% (3)
3	33% (7)	19% (4)
4	19% (4)	19% (4)
5 (very true)	33% (7)	33% (7)
No response	0% (0)	10% (2)
: the class provides more resources to enhance my learning		
1 (not true at all)	0% (0)	0% (0)
2	5% (1)	5% (1)
3	14% (3)	14% (3)
4	24% (5)	38% (8)
5 (very true)	52% (11)	33% (7)
No response	5% (1)	10% (2)
: I have more opportunities for one-on-one help with a professor than I normally would.		
1 (not true at all)	5% (1)	5% (1)
2	0% (0)	10% (2)
3	19% (4)	14% (3)
4	24% (5)	14% (3)
5 (very true)	47% (10)	47% (10)
No response	5% (1)	10% (2)
How familiar are you with the following public health concepts:		
: health disparities/health equity?		
1 (not familiar at all)	0% (0)	0% (0)
2	0% (0)	0% (0)
3	0% (0)	10% (2)
4	29% (6)	14% (3)
5 (very familiar)	71% (15)	66% (14)
No response	0% (0)	10% (2)
: social determinants?		
1 (not familiar at all)	0% (0)	0% (0)
2	0% (0)	0% (0)
3	9% (2)	0% (0)
4	29% (6)	24% (5)
5 (very familiar)	62% (13)	66% (14)
No response	0% (0)	10% (2)
: socioeconomic status (SES)?		
1 (not familiar at all)	0% (0)	0% (0)
2	0% (0)	0% (0)
3	0% (0)	0% (0)
4	29% (6)	14% (3)
5 (very familiar)	71% (15)	76% (16)
No response	0% (0)	10% (2)
: social justice?		
1 (not familiar at all)	0% (0)	0% (0)
2	0% (0)	0% (0)
3	0% (0)	19% (4)
4	43% (9)	29% (6)
5 (very familiar)	57% (12)	38% (8)
No response	0% (0)	14% (3)
Do you interact equally with both professors?		
Yes	71% (15)	62% (13)
No	29% (6)	28% (6)
No response	0% (0)	10% (2)
What is/are the main reason(s) for interacting with one professor over the other? (check all that apply)		
More convenient office hours	10% (2)	0% (0)
Prefer their teaching style	10% (2)	36% (4)
Had the professor before	0% (0)	0% (0)
Prefer the way they communicate	10% (2)	36% (4)
Responds more quickly	5% (1)	9% (1)
Know the professor better	0% (0)	0% (0)
One professor seems more in charge	0% (0)	18% (2)
I don't interact with either	5% (1)	0% (0)
No response	62% (13)	48% (10)
Do you prefer one or two instructors?		
One	0% (0)	19% (4)
Two	52% (11)	29% (6)
No preference	38% (8)	38% (8)
No response	10% (2)	14% (3)
Source: Undergraduate on-line survey.		
Notes: The columns for ethnicity don't add up to n=21, given the option to select more than one group. We did not add a "no response" option on the question asking students about the main reason for their interaction with one faculty over another. Students were only directed to this question if they answered "No" to the prior question about interacting equally with both professors. We then allowed these students to pick multiple answers.		

(90%, $n=19$ in both courses) and socioeconomic status (SES; 100%, $n=21$ and 90%, $n=19$).

When asked about their public health career preparation, most students in both courses perceived these co-taught courses prepared them for an internship (62%, $n=13$ and 62%, $n=13$, respectively), with a greater proportion feeling prepared for a volunteer position (81%, $n=17$ and 76%, $n=16$). And 68% ($n=14$) of students in Health Policy agreed that their co-taught course prepared them for post-graduate education. We did not ask this question of students in Introduction to Public Health, as it is a lower division course.

Differences were more pronounced in students' assessments of co-teaching. A higher percentage of students in Introduction to Public Health reported co-teachers exhibiting a balanced relationship in teaching (90%, $n=19$) compared to students in Health Policy (76%, $n=16$). Students in both courses reported co-teachers exhibiting a balanced relationship in interactions with students (76%, $n=16$). In both courses most students stated they interacted equally with both professors (71%, $n=15$ and 62%, $n=13$, respectively). However, more than half of students in Introduction to Public Health preferred two instructors to one instructor (52%, $n=11$ vs. 0%), while 38% ($n=8$) reported no preference. In Health Policy 29% ($n=6$) vs. 19% ($n=4$) preferred two instructors to one, with 38% ($n=8$) reporting no preference. When asked about reasons for interacting with one professor over the other, the most frequent reasons were preferences for styles of teaching (10%, $n=2$ and 19%, $n=4$, respectively) and communication (10%, $n=2$ and 36%, $n=4$, respectively). When students compared their co-taught to independently taught courses, a slight majority (52%, $n=11$ in both courses) reported more clarity around course expectations. Additionally, 71% ($n=15$) and 62% ($n=13$), respectively reported having more opportunities for one-on-one contact with a professor, with students reporting having more resources for learning in Introduction to Public Health (76%, $n=16$) than Health Policy (71%, $n=15$).

Student Focus Groups

Student responses to the online survey corresponded closely to focus groups responses, with some differences between students in Introduction to Public Health and Health Policy. The main differences in focus group responses were students mentioning Health Policy's greater number of guest speakers than Introduction to Public Health; weaker preference for co-teaching among students in the Health Policy focus group; and less contribution from and contact with the TA in Health Policy.

Organization

Students observed co-teachers dividing class sessions evenly between them and given the level of organization, there must be work "behind the scenes" that students don't directly observe. "I think part of it is yeah they are dividing the labor up behind the scenes, so it's possible they are doing that and looking how the class responds to the professor and how well it gauges students (Student 3)." Students were positive about one instructor being available to answer questions or look up supplementary material while the other was lecturing.

I think this is important for all the participants in the class, if something is less clear and professor I does not have the information two things happen: 1) the other professor can

immediately respond or 2) the other one can look it up. So that keeps class flowing properly (Student 2).

One student found this format to be very effective in organizing and structuring the class, wishing co-teaching was offered in other classes. "I agree. If there were two teachers in every class like math for example, where you can get two ways to get to an answer, it is helpful. I like learning different ways to do the same things (Student 3)."

A recurrent theme voiced from students was that co-teachers would not be aware of assignments, lectures, and/or deadlines that the other instructor had shown. While some students hoped for more continuity, other students commented that they felt co-teachers were working "very well" and "in conjunction" with each other. "They are on the same page as far as knowing what is going on (Student 1)," and

They may not always walk together in class but before class they will chat a bit. I've talked to them separately about different things but often times they will be together or walk together after class. It shows that the collaboration happens outside of class which is good (Student 2).

Communication

Students liked having more than one person to go to with questions or concerns about the course. For some, this meant feeling more comfortable speaking with one instructor or TA, and for others it meant having multiple people to ask and obtain answers to questions more quickly. "For questions, I tend to go to the person I feel more comfortable with (Student 5)" and "I'm like you, too. I will usually email someone first and then go to office hours. I usually just email the person I like more (Student 3)."

Not only were there various office hours to accommodate more schedules, but students could also see a topic through multiple perspectives. One student noted,

I think it gives me more opportunities for one on one time with a professor when I have questions or need to have a concept explained more in depth. Also, having two professors means being able to have more than one perspective being brought into the lecture which is important (Student 3).

At the same time, in the beginning of the semester having two instructors did create some confusion for students as they might be unsure about whom to reach out to with a question or concern.

Just that I guess it seems like sometimes they don't know, like one will be on one page and the other will be on the other page. They are trying to figure it out, and then for the students you get confused on what to focus on (Student 1).

Learning Outcomes

Key learning outcomes of the public health degree are that students can recognize and distinguish between social science and public health perspectives and be familiar with concepts such as health disparities, social determinants, SES, and social justice. Students observed differences in instructors' backgrounds and what they emphasized in lectures, but differences mentioned were not always social science or public health focused.

To me, it seems like one professor focuses on global health so things that are more pandemic also with the nursing background so you can think of things that take place in the

hospital setting...The other professor focuses in on certain demographics...I want to say the double perspective dimension...(Student 2).

Students liked having multiple perspectives and found it beneficial, "I like having that connection to that campus [The University of Colorado Anschutz Medical campus] and everything. I feel like it is a good resource for public health students who might want to get in more of the medical and biomedical aspect (Student 5)." Students also found co-taught courses more challenging, "I agree. With this class there is a lot of thinking involved, decision making, and judgement overall (Student 2)."

Effectiveness

Students valued the resources and professional connections that two instructors brought to the class. One student noted that "You may learn better with one teacher than the other which improves chances of success (Student 6)." Other students were more engaged than they might be in courses taught by a single instructor.

I think there is more participation than a singularly taught class. I know that in my other classes there is not much student participation. When two teachers are chiming in along with the TAs then you're like 'Oh I have a question about what she said or about what they said' versus them just saying the information and asking the questions. If they are bouncing ideas off of each other then you really have more to think about (Student 3).

DISCUSSION

Our program is one of the first in the nation to use a co-teaching model to emphasize the importance of collaboration between the social sciences and public health to reduce health disparities in the U.S. As a novel program where all core courses employ co-teaching, our program was recognized in the Institute of Medicine's Roundtable on Population Health Improvement (see Bachrach et al., 2015).

Co-teachers benefited from collaboration across public health and liberal arts schools to enrich their teaching beyond their research and professional practice areas. Co-teaching models facilitate the team-based, interdisciplinary character of most public health work and exposed students to different approaches of research and problem solving.

The perceived benefits of co-teaching from our sample of students in two courses included an appreciation for two instructors with different teaching styles for communicating and conveying information; presenting information from their research and professional practice; sharing information about different academic career paths in public health; and providing access to different professional networks and public health-related organizations for internships, research experiences, and employment opportunities. While students did not always identify co-teachers' social science or public health backgrounds, they appreciated instructors' different perspectives on course topics. Some students benefited from having additional interaction with TAs, particularly in Introduction to Public Health's recitation sections.

This evaluation identified several recommendations for co-teaching, although we do not want to over-generalize our results given our limited data collection at one institution. Planning before the course's start date and throughout the semester and collaboration, with a willingness to try different activities

and procedures, were essential to creating syllabi, assignments, and student assessments. We recommend regular team meetings, where prior planning and reflection are more likely to facilitate alternating co-teaching models during lectures (Bryant et al., 2014; Lock et al., 2016; Rytivaara et al., 2019). Clear communication among co-teachers and TAs facilitated teamwork and communication with students. Requiring students to include all team members in their electronic communication reinforced effective teamwork, reduced misunderstandings, increased response time to student questions and requests, and distributed work more evenly among team members. Finally, we recommend creating stable teams whenever possible (Minett-Smith & Davis, 2020). Instructors noted that over several semesters they developed a strong, positive working relationship and were able to focus on updating content or trying out new activities, readings, or assessments. Possible differences in student focus group and survey responses across our two courses could be attributed to Introduction to Public Health being taught by two instructors and TAs who had co-taught together for four consecutive semesters compared to Health Policy that had a team teaching together for the first time. Students were aware of how well co-teachers worked together and whether they were communicating clearly with each other.

Some co-teacher teams are consistent across multiple years, but this occurs more rarely over time in the undergraduate public health degree. What occurs more often is two new co-teachers and a new TA are paired and must learn each other's strengths and weaknesses as they work together. This change could be complicated further when one or both co-teachers have prior experience teaching this course with other co-teachers who teach the course using a different curriculum. This issue could lead to power differences and co-teacher conflict (Montebalanco, 2021). But, hopefully both instructors are equally willing to invest time to work together; discuss power and privilege differences in the classroom; be flexible in teaching different lectures with different co-teachers to create an engaging course; and discuss conflict resolution steps for disputes among themselves or with students. Sometimes we approached disagreement by "choosing one's battles," based on how important the issue was to overall pedagogy and student learning experiences. We also sought our department chair, Director of Undergraduate Studies, and the university's judicial board for conflict resolution help.

Similarly, in thinking about power differences, we acknowledge co-teacher rank, seniority in teaching experience, personality, and pedagogical differences could be an impediment to co-teaching. These differences may influence course preparation and assessment investments, where tenured or higher academically ranked faculty could invest less time on the course in lieu of their research; perceive greater autonomy to make course changes and be less willing to jointly modify courses with clinical teaching track or lower academically ranked faculty; or perceive co-teaching as an opportunity to mentor lower academically ranked faculty, with little bidirectional learning between co-teachers (Morelock et al., 2017). Our co-teachers had different disciplinary backgrounds, but our pedagogical approaches were generally aligned, such as agreement on using active learning assignments, student group discussions, co-teacher group interactions, and group debriefings to the larger class in co-creating knowledge and sharing our personal and professional stories to illustrate course concepts for students. While these difficulties did not occur in our research, where

we experienced more collaboration and joint teaching development, we recommend intentionally discussing power differences in faculty rank and pedagogical approaches, and their impact on co-teaching explicitly during course preparation (Montebalco, 2021). If co-teacher selection is possible, faculty should consider what kind of learning partnership best suits them – choosing tenured or higher academically ranked faculty as new instructors or those wanting mentorship or similarly ranked faculty for greater course design and autonomy in teaching development (Morelock et al., 2017).

Another complication may be that our co-teachers have similar training backgrounds, where there is little difference in co-teachers' perspectives to enhance students' learning. However, co-teachers typically bring varied research interests to integrate into co-taught courses and provide students with guest speakers, researcher and practitioner networks for professional guidance, and opportunities for internships and work.

Future research on co-teaching could explore how co-teaching can be used as a resource to better integrate and scaffold writing and research methods skills for students into our required courses, where these foundational skills are important to our program values for a high quality, interdisciplinary, undergraduate education and in preparation for the Public Health job market or graduate school (Resnick et al., 2018). Second, we could investigate what type(s), and how much, training could enhance co-teacher relationships, given frequent high turnover in teams and its noticeable impacts on team dynamics by students in the classroom, along with possible power differences among faculty. What incentives exist, or should be offered, for voluntary co-teacher training? Finally, we could examine faculty co-learning (a topic discussed by Lock et al. 2016; Morelock et al. 2017), focusing on if/how reflective practices are used to build pedagogy, and if these efforts lead to collaborative scholarship of teaching and learning research.

For those interested in co-teaching at their universities, it can be promoted as cross-college collaboration. This program works best when both schools and their faculty are equally committed to co-teaching and respectful of each other's contributions to the philosophy of the program. The schools need to provide supported time to instructors for planning and curriculum development. Co-teachers who have taught the same course together over several semesters may realize more complementary teaching, possibly addressing some earlier co-teacher survey disagreements. Moreover, they may experience some time savings and flexibility to miss one or two classes to attend professional conferences; however, co-teaching is not teaching half a course. Our program requires co-teachers to attend every class unless they have a pre-arranged professional conflict. Even then, it is frowned on by co-teachers and administration if one team member misses more than a few classes.

While this research was based on face-to-face teaching, we realize most co-teaching literature assumes teams are physically in the same location (Minett-Smith & Davis, 2020). However, during the COVID-19 pandemic, co-teachers were geographically remote, reliant on technology for online or hybrid teaching, and had to develop curriculum and possibly new co-teacher relationships for multi-modal teaching. Supportive and complementary co-teaching models in synchronous online teaching may benefit students and faculty, where the primary instructor lectures and the other instructor visits student break-out rooms to facilitate discus-

sion, manages questions and answers in the chat room, facilitates polling questions on lecture material, or monitors attendance and participation and takes notes. With hybrid co-teaching, the primary instructor may lecture or conduct group work in-person, while the other instructor records lectures, monitors online questions, or works with online students in break-out rooms.

Our study was a cross-sectional, pilot examination of co-teachers', TAs', and students' perspectives on co-teaching in two undergraduate Introduction to Public Health and Health Policy courses. We did not examine all co-taught courses in the undergraduate public health degree in this pilot study. Thus, we had a small sample size for faculty and TAs. We plan to apply this research to our other required courses, to provide feedback to our departments and Deans, who continue to fund and support our co-teaching model. We did not have a control group of required independently taught courses to compare to our co-taught courses. But, we used multiple sources of data collection to compensate for not having a control group. Future research could examine comparisons between co-taught and independently taught capstone and elective courses. However, a challenge is that elective courses are not directly comparable, often drawing non-majors in the courses. We did not follow-up with participants to examine possible changes in their perceptions of co-teaching. Future research might consider a follow-up with students prior to or post-graduation when students reflect on their public health learning in co-taught courses as they write job market applications.

We had a low survey response rate from students, despite multiple efforts, such as faculty promoting the survey in class; having a RA briefly speak to both courses' students about the survey; offering time and snacks for students to do the survey in class; providing a link to the survey through Canvas; and ensuring confidentiality of students' responses to improve our sample size. Future efforts to boost student survey sample size but maintain confidentiality could include providing extra credit to all students in a course if 85% of students complete the survey. To improve student focus group participation, we could provide gift cards to students, as we did with co-teachers and TAs for their participation.

Co-teaching is expensive for the institution. Salaries are doubled, there are two instructors to hire and two schedules to coordinate for every course, creating an additional administrative burden. In our case, course staffing is coordinated across separate schools at the university with different models of faculty compensation. As this was a preliminary evaluation, we did not undertake a cost-benefit analysis. But, benefits to the institution might include examining the role the co-teaching model played in students' decision to enroll in the program, ability to recruit and retain faculty, type and number of student internships, pre- and post-graduation employment and admission rates to graduate schools, and the institution's and program's overall reputation.

CONCLUSIONS

Our research examined if co-teachers, TAs, and students perceived challenges and benefits with co-taught, undergraduate public health courses compared to those perceived in their independently taught courses. We also examined if our co-taught courses facilitated student learning outcomes, based on students' self-reported learning assessments. Our co-teaching model addresses health problems from multiple perspectives, creating

student and faculty learning and problem-solving. We believe that this is how the real-world works, where people from different disciplines work together. But, despite the collaborative character of most public health work, co-teaching is unusual in public health programs. Our co-taught courses are unique in their ability to unite students and faculty across two university campuses and provide students with more faculty time and different disciplinary perspectives on course material. Faculty benefit from collaborative teaching and can discuss the best teaching approaches to convey material and enhance students' learning.

Declaration of Conflicting Interests

The authors declare that there is no conflict of interest.

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