

Coteaching in Higher Education: A Case Study of Instructor Learning

Hannah H. Scherer, Virginia Tech, hscherer@vt.edu

Megan O'Rourke, Virginia Tech

Rachel Seman-Varner, Virginia Tech

Peter Ziegler, Virginia Tech

Abstract. Tenure-track faculty at research intensive universities have competing responsibilities in their role as both researchers and teachers, leading to barriers to pedagogical change. This has been well-documented in the sciences. Coteaching models of collaborative planning and teaching with an explicit goal of facilitating educator growth have been successful in increasing the use of research-based pedagogy in higher education settings. We documented our experiences coteaching in an undergraduate ecological agriculture course and, drawing on sociocultural views of faculty work as learning, identified opportunities for learning that occurred. We found that the collaborative teaching team structure provided timely access to pedagogical knowledge, the collaborative planning process was a mechanism for faculty learning, and observing members of the team teach provided opportunities for new insights. Coteaching has had significant, lasting impacts for the instructors. We recommend that universities implement coteaching as a mechanism for supporting faculty use of student-centered pedagogy.

Keywords: coteaching, collaboration, faculty learning, higher education, pedagogical change

Tenure-track faculty at research intensive universities have competing responsibilities that are uniquely tied to their role as both researchers and teachers. Science faculty face barriers to pedagogical change such as accountability structures (e.g., promotion and tenure review processes) that do not reward improvements to teaching, limited time, and lack of support (Henderson et al., 2011). Confounding the issue, faculty hired into these positions may have minimal preparation for teaching in higher education. Brownell & Tanner (2012) further argue that scientists' training may have actually supported development of a professional identity that is antithetical to seeing themselves as a teacher. Simultaneously, the knowledge base demonstrating the effectiveness of student-centered teaching is steadily growing (National Research Council, 2012; Weimer, 2013), offering new opportunities for faculty to employ evidence-based strategies. Efforts to promote adoption of new pedagogy in undergraduate science, technology, engineering and math (STEM) teaching, however, need to be sustained over time and include feedback (Henderson et al., 2011).

We addressed these challenges by employing a coteaching model of collaborative planning and teaching in a higher education setting. We had an explicit goal of utilizing a student-centered approach that included a variety of student engagement techniques and formative assessment (Barkley, 2010). The specific coteaching model we used situates learning to teach alongside a more experienced teacher as a central purpose (Roth, 2001). Drawing on sociocultural views of faculty

work as learning (Lattuca, 2002; Lave, 1988; Lave & Wenger, 1991), we identified opportunities for learning that arose from coteaching. In this case study, we present an account of our experiences in order to illustrate the affordances of *coteaching as a learning opportunity* and allow others to explore potential applications of the model in their context.

Literature Review

Higher education faculty development efforts reported in the literature cluster around six areas of focus: skill development, mastery of teaching methods, reflection, institution-level plans, disciplinary understanding of pedagogy, and action research or inquiry (Amundsen & Wilson, 2012). These activities, however, rarely explicitly address the “academic and social context in which faculty work and in which new knowledge must be embedded, practiced, and refined” (Amundsen & Wilson, 2012, p. 110). In undergraduate STEM teaching, efforts external to the classroom, such as efforts to disseminate curricular materials to faculty, are not effective (Henderson et al., 2011).

Learning Through Collaborative Faculty Work

Unlike pre-college teachers, it is less common for new higher education faculty members to receive formal preparation for teaching prior to hiring; much of this learning occurs instead through interactions with colleagues. In one case study, faculty often learned about teaching from colleagues through unofficial channels such as informal mentors (Jawitz, 2007). Other interactions can be highly structured, such as in Faculty Learning Communities (FLCs) where groups of faculty learn together with the goal of strengthening their teaching and learning efforts; FLCs are highly effective in producing learning outcomes for participants (Cox, 2004). Additionally, faculty can learn from collaborations with education experts in efforts such as curriculum design teams (Burrell et al., 2015) and postsecondary STEM education improvement projects (Bouwma-Gearhart et al., 2014). Education experts can serve as “brokers of education research and theory” (Bouwma-Gearhart et al., 2014, p. 43) who hold both procedural and tacit knowledge of pedagogical research and theory. These “brokers” can facilitate STEM faculty learning about reformed teaching practices by translating ideas in a way that makes them accessible to STEM faculty with little training.

From the perspective of collaboration as a source of faculty learning (Lattuca, 2002), collaborative teaching (also called coteaching or team teaching) can also be viewed as a mode for learning. While often motivated by content expertise and student learning outcomes as the primary drivers (Wenger & Hornyak, 1999), some studies have documented benefits of collaborative teaching with respect to faculty learning. Learning from colleagues through the experience of collaborative planning has been found to be highly valued by faculty in teacher preparation programs (Bacharach et al., 2008; Graziano & Navarrete, 2012). Crow and Smith (2005) describe their experience of teaching together in a health and social studies program as a powerful mechanism for enhancing their own learning through promoting deeper shared reflection on teaching practice. Faculty within

collaborative teaching teams have reported learning from colleagues in the areas of disciplinary knowledge and pedagogical practice (Culhane et al., 2016; Ferguson & Wilson, 2011; Morelock et al., 2017). In one program, faculty also discussed the benefits of working with and learning from colleagues with more teaching experience (Helms, 2014). Benefits related to development of teaching skills and personal development as educators have also been reported for graduate students teaching as a team (Burns & Mintzberg, 2019; Chanmugam & Gerlach, 2013). These findings are consistent with outcomes reported for collaborative teaching as a mode of professional practice at the K-12 level (Cook & Friend, 1995).

Considerations for Entering Into Teaching Together

A growing body of case studies, evaluation of institutional programs, and qualitative research studies provides guidance for faculty considering entering into a collaborative teaching arrangement. In terms of team member interactions, developing a good working relationship and committing to “open communication and continual reflection” (p. 8) are essential (Holland et al., 2018). Setting goals for these interactions in addition to teaching-related goals can provide a solid foundation for the relationship (Holland et al., 2018; Orlander et al., 2000). Throughout the collaborative teaching experience, it is important to attend to the expertise that each faculty member contributes (Ferguson & Wilson, 2011; Looft & Myers, 2019), who holds structural power due to their position in the institution (Morelock et al., 2017), and how ownership of the course and responsibility for decision making are shared (Ferguson & Wilson, 2011; Morelock et al., 2017). Beyond the classroom, institutional policies and culture can either support or hinder collaborative teaching arrangements and how credit is assigned. At a large research university, faculty expressed concern that their collaborative teaching efforts were not recognized by administrators and that budgetary or resource concerns were prioritized (Bryant et al., 2014). In some instances, faculty report that coteaching with another person takes more than 50% (Morelock et al., 2017), which is an additional concern when negotiating credit assigned versus effort. Potential models for team teaching that work with traditional modes of assigning one instructor per course include having one team member receive full credit with the other donating their time, sharing major assignments between two courses taught by different instructors, and linking two courses through shared class time and assignments (Ford & Gray, 2011).

Coteaching: A Model for Purposeful Faculty Learning in Praxis

Coteaching has emerged in recent years as a promising practice for faculty development. This version of coteaching, as described in detail by Roth (2001), was originally developed for pre-service K-12 science teachers (e.g., Roth et al., 1999). In this model, the pairing consists of a novice and an experienced teacher. They share responsibility for all aspects of teaching, allowing for “teachers to experience the classroom at the elbows of another practitioner” (Roth, 2001, p. 15). The coteaching model addresses the theory-practice gap in science teacher preparation through “situating learning to teach science in the praxis of teaching science” (p. 12) and explicitly addresses the tacit dimensions inherent in teaching (Roth et al.,

1999). This model has successfully been employed in higher education settings (with various names) for graduate student training (Davis-Bundrage & Medvedev, 2016; Walters & Misra, 2013), mentoring less experienced instructors (Bryant et al., 2014) and faculty development to promote the use of evidence-based teaching practices in undergraduate science courses (Henderson et al., 2009; Holland et al., 2018). Coteaching allows new instructors the opportunity to observe and experiment with new teaching strategies while learning from a more experienced colleague (Bryant et al., 2014; Holland et al., 2018). The coteaching model differs from traditional collaborative teaching in higher education in that learning to teach is an explicit goal for the novice teacher and the experienced teacher is identified for their expertise in research-based pedagogy within the disciplinary context of the course.

Theoretical Framework

Sociocultural theories are a powerful way to understand collaborative faculty work as learning (Lattuca, 2002), which can be described as the “personal and shared construction of knowledge” (Lattuca & Creamer, 2005, p. 4). From this perspective learning is viewed as mediated by culture (Vygotsky, 1978) and constitutes an “integral part of generative social practice in the lived-in world” (Lave & Wenger, 1991, p. 35). This situated experience is foundational, not secondary to abstracted forms of knowledge (Lave, 1988). If learning occurs through social practice, however, what is possible to learn may be limited by a person’s ability to observe others (Hutchins, 1996). Furthermore, “knowledge always undergoes construction and transformation in use” (Lave, 1996, p. 8); in practice there are variations in how a particular activity unfolds in different situations, how knowledge is applied and constructed in practice, and what problems a person encounters in different settings (Lave, 1988). In order to gain insights into faculty learning in our study, we specifically draw on Lave’s theory of cognition in practice that calls for examination of the activities of persons-acting as they unfold in a particular setting (Lave, 1988) and Lattuca’s (2002) framing of interdisciplinary faculty work as learning.

Methods

We employed an ethnographic approach in the design of this study in order to document opportunities for learning that arose in practice. The lead researcher, Hannah, was a participant observer in the collaborative teaching team. Data sources for the study included:

- Hannah’s jottings from meetings and classes, fieldnotes constructed from those jottings, and memos composed throughout the planning (PF) and teaching (TF) process;
- individual reflections for each class period composed by members of the teaching team (R) following a standard set of questions, including “what did I learn today that will be useful to me as an instructor?”;

- semi-structured exit interviews conducted by Hannah with team members (EI) with questions designed to promote reflection on what they learned about teaching throughout the coteaching experience;
- and artifacts from the unit of interest (lesson plans, syllabus, handouts, etc.).

Hannah conducted the data analysis by first open coding ethnographic fieldnotes and developing initial categories following the constant comparative method (Lincoln & Guba, 1985). She then selected targeted categories that related to mechanisms for learning and developed focused codes within these categories following Emerson, Fretz, and Shaw (2011). Next, she conducted a second cycle of coding of fieldnotes, reflections, memos, and exit interview transcripts using these focused codes and developed themes, using artifacts for triangulation where relevant. She wrote integrative memos throughout analysis and conducted member checking through team debriefing sessions during and after analysis. Members of the teaching team agreed upon the final themes reported here for their significance both theoretically and practically.

Course Context and Teaching Team Members

Our course, Ecological Agriculture, is situated within an experiential, interdisciplinary, undergraduate minor (Civic Agriculture and Food Systems, CAFS) at a land-grant university in the United States. CAFS is administered at the college level, with faculty members from multiple departments teaching courses and serving on the task force that oversees the minor. CAFS is challenging resource allocation and models for collaborative teaching at our university and each course is led by a collaborative teaching team in which collaborative planning and team teaching are the norm (Clark et al., 2013). In some cases, faculty instructors each receive credit for teaching, however this was not the case in our course. The characteristics of the teaching team for our case study and specific affordances of our unique situation that enabled us to implement the coteaching model were:

- Megan was a new lead instructor for the course with significant disciplinary expertise but little higher education teaching experience. She was instructor of record and received full teaching credit for the course.
- Hannah was an agricultural education faculty member with a science background. She had relevant content expertise and a research interest in innovative models for STEM educator professional development. Involvement in the course aligned with the research component of her appointment and she did not receive teaching credit.
- The CAFS Minor graduate teaching assistant (GTA) (Rachel) was already assigned to the course. The GTA was primarily responsible for grading student work, but operated as an active member of the team in all planning activities.
- Pete had an appointment with the academic programs office that oversees the minor and he participated in that capacity. He brought extensive prior experience with the course and CAFS that ensured that the course remained aligned with the overall objectives for the minor.

Our course content focused on fundamental principles of ecology as applied to the context of sustainable agriculture. Learning experiences included: classroom and field experiences, service learning, debates, a farm design project, and critical reflections. The in-class portion of the course had been predominantly lecture-based in previous years and we aimed to significantly revise a portion of the course to be more student-centered. In our implementation of coteaching, subject matter expertise played a key role in who taught which topics. Throughout the process, Hannah was able to guide decisions related to the course in real-time before Megan had invested time into planning the course on her own.

Findings

Collaborative Teaching Team Structure Provided Access to Pedagogical Knowledge

Hannah has expertise in student-centered pedagogy developed from practice, facilitating professional development experiences, and training pre-service teachers and served as an “education broker” (Bouwma-Gearhart et al., 2014) for the team, someone who could help “brainstorm techniques to most effectively teach the content to students” (Rachel EI). She was able to offer ideas from the education research literature that were new to the team members. For example, Megan commented:

There's a term that I never even used or heard before, but you talk about scaffolding a lot. And I guess just that being conscious of what is going to be new or hard for them and how to make the steps of getting to a better product easier and more feasible.
(Megan EI)

Hannah’s procedural and tacit knowledge of student-centered teaching became a resource for the other team members throughout the planning process and in the classroom. Framing coteaching as a sociocultural learning process (Lattuca, 2002) allows us to view these experiences, resources, and tools that Hannah brought to the project as potential sources of knowledge to be transformed and applied in this new setting.

Collaborative Planning Was a Mechanism for Learning

A key element of the coteaching model (Roth, 2001) is collaborative planning that involves an experienced teacher and a novice, which allows for the complexities inherent in the planning process to be revealed. In our case, meetings with the entire team occurred (7 during summer, weekly during the semester) and group discussions during team meetings served as a major component of our planning process. Additionally, team members did individual work in preparation for team meetings and to finalize the lessons prior to teaching class.

During team meetings, the group discussion primarily centered on typical course planning topics, including the course schedule and flow of topics; lesson planning; course assignments and grading; and working with the learning management

system. Megan guided the planning process and team members contributed by providing input and resources related to their expertise and prior experience with the course and/or topic. Early in the planning process, Hannah “volunteered to research activities for each class and bring ideas to the meetings” stating that she has “a ‘bag of tricks’ that [she] can easily draw from, so it isn’t too much work” (PF). There were also multiple instances during planning conversations where a team member sought input related to pedagogy and acted on it, such as in this exchange from the first planning meeting from the perspective of Hannah, the “education broker”:

Megan asked me [Hannah]: so, “what’s the best way to teach this stuff?” I explained my process for starting from learning objectives by asking myself “what do I want the students to remember in 6 months?”, deciding how I want them to be able to use the material, and then developing activities from there...Megan then offered to take my suggestion of writing learning objectives for each topic and then we decided to look at them all together next week. (PF)

In this moment, Hannah introduces the concept of backwards design (Wiggins & McTighe, 2005) in real-time as it naturally arises in the context of the planning process. Megan’s question opens the door to this opportunity for Hannah to describe her planning process and Megan commits to following through on the suggestion.

Collaborative planning meetings also provided the opportunity to discuss pedagogy along with content when planning individual lessons and Hannah frequently made suggestions regarding instructional approach and student engagement techniques. For example, in planning a 50-minute class about nitrogen, phosphorus, and carbon cycling:

Megan said she would normally just split the class up into thirds and lecture for 15 minutes on each. She asked what I would do and I suggested starting with the big picture (multiple forms of matter, not all available) and then having a group for each one and have them answer some questions and then teach the class. She could then tie it all together at the end. (PF)

Here Megan acknowledges that she would have defaulted to didactic teaching and Hannah was able to provide a suggestion for a student-centered approach that was tailored to the particular content that needed to be covered. Megan followed through on this idea and developed and taught a version of this activity.

Planning meetings thus provided an opportunity for faculty members to have real-time guidance in making important decisions about the structure, content, and teaching strategies employed in the course. Team members followed up with actions outside of the meetings and were collegial and accountable to each other throughout the process, which is an element of successful coteaching in higher education (Henderson et al., 2009). Planning the lessons together went far beyond splitting up the semester topics and allowed for generative discussions about

pedagogy to occur in concert with the learning objectives, content, and overall flow of the topics from class to class. Through bringing together our collective expertise and making it accessible to other team members, we constructed new knowledge about how to teach this particular course. As Megan stated:

...now that we've gone forward I feel like I can go backwards. So, seeing more what were the most valuable big outcomes that we had, now how do I go back and build to them to a more successful product. And so I think...some of the ideas that we introduced in this class about simplifying the teaching, having a main take-home message, scaffolding so that [students] build the skills to complete the main project. Now I can go back and more consciously build those steps in to the farm project and the debates and those...bigger outcomes. (Megan EI)

The strategies described here and the intent to continue to improve on the course represents powerful learning outcomes for Megan. These take-aways, learned through the practice of planning and teaching her first college level course, have the potential to impact her for an entire career.

Observing members of the team teach provided opportunities for new insights

I would see you do something and then I would say "I want to try that" [because] just the content alone takes so much time that to do both the content and these new techniques that aren't at my fingertips and I've never thought about before, realistically I'm not going to do both at the same time. It was good, I just copied you! (Megan EI)

In our implementation of coteaching, there was typically just one instructor leading class on a given day. All members of the teaching team, however, were present in each class to observe and participate; this was highly beneficial in learning how to implement student-centered techniques. Team members were able to observe student engagement techniques enacted, including the following.

- stations (also called gallery walk): small groups of students respond to a prompt on a large sheet of paper hung around the room and then circulate to view and respond to what their classmates contributed to each prompt (Barkley, 2010)
- think-pair-share: in response to a question posed by the instructor, students first think on their own and then share with a partner before reporting out to the whole class (Barkley, 2010)
- jigsaws: small groups of students first develop expertise on a topic and then the groups are reconfigured so that the new groups have "experts" from each original group (Barkley, 2010)
- interactive lectures: lectures are punctuated by short student engagement techniques and opportunities for students to contribute their ideas (Macdonald & Teed, 2019)

Seeing the “nuances” (Pete EI), flow, and “managing the time” (Rachel EI) in practice were particularly valuable. Additionally, observation allowed for team members to see things not go well and this prompted reflection-in-action as the class unfolded. This was particularly important for Pete, who explained:

I could recognize things that I would say are attributable to last minute planning or...just things getting too busy, and [I thought], “Oh, OK, this is what it looks like from the other side” and it sort of gave me that point of reflection...[T]hat's just one aspect. The rest of it is, again, watching in action everybody else and thinking about it and being cognizant of what you're trying to do in the classroom...it really helps reflect on your own practice when you're sitting there thinking. (Pete EI)

Thus, being able to observe others enacting student-centered techniques provided opportunities to learn through modeling and personal reflection. Finally, observation of individual personalities led to new insights about what is possible in science teaching. Rachel in particular discussed the contrasts with past experiences in science, stating “I come from [a traditional]...lecture style background, that's what most of my coursework has been in...I get the professor...using powerpoint and [stating] ‘these are the facts’” (EI). Seeing alternatives to this approach allowed Rachel to build her confidence in not having to conform to this model, concluding “I can just be myself” (EI). Our implementation of coteaching disrupted the pattern of reproduction of teacher-centered approaches for team members through providing access to alternative modes.

In addition to the general benefits of observation, there were opportunities for learning that arose from the coteaching model. Times when Hannah intervened when someone else was teaching provided powerful learning opportunities:

there were...a couple times I noticed you [Hannah] jumped in and they...were perfect, I mean they were exactly what needed to be done to salvage whatever was going on and that was really valuable...To me, those were the biggest learning moments, I'm like “oh, alright, that's what it should have been.” (Pete EI)

In these instances, Hannah was able to draw on her expertise and recognize in the moment what needed to happen. The infrequency of these moments likely arose from the lack of clarity on expectations for team member participation in class and “out of respect for the instructor and not wanting to interrupt the flow” (TF). Further clarifying classroom roles and expectations for contributions in class could enhance opportunities for learning through coteaching.

Coteaching further allowed for iterative cycles of observation and practice. As Megan stated, “it was the observation and then the re-observation because there were iterative time points. You did it, I tried it, you did it, I tried it, you did it...that was really useful” (EI). Furthermore, because this happened in the context of the specific course that we were working with, it was particularly valuable:

it was different having you part of the teaching team compared to say if I just went and watched a random physics lecture using a technique because my head's not wrapped around...the nuances of the content and how difficult it is to present...seeing you simplify things that I know are complex...was really useful. (Megan EI)

Coteaching allowed for the subtleties in teaching to come through in an authentic setting. Learning in practice led to new insights that would not likely arise in a more abstract context (e.g., Henderson et al., 2011) as each instance of problem-solving in practice is unique and allows for existing knowledge to be transformed (Lave, 1988).

Conclusion and Recommendations

Our implementation of the coteaching model went beyond traditional team teaching in higher education by making the goal of learning to teach explicit, thus affording team members a heightened opportunity to learn from collaboration, observation, and reflection in practice. Similarly, it went beyond short-lived, decontextualized faculty development models by embedding learning to teach in an authentic context. From the perspective of practice theory, coteaching served as a vehicle for faculty learning that employed the lived experience of teaching together as a mechanism for learning a complex process. Our case study was unique to our context, but allows for some recommendations for practice that may be of use to others interested in coteaching.

Target the Course Development Phase and Include GTAs

For the lead instructor, coteaching in the first semester of the course was particularly impactful. Additionally, Rachel gained a new perspective on how she could operate in a future faculty role. Without training in student-centered pedagogy, the default strategies that Megan and Rachel described are consistent with examples of teaching that they had access to from previous experience, which is realistically all that an instructor can be expected to do (Hutchins, 1996). With so many barriers to faculty pedagogical change (Brownell & Tanner, 2012), it can be difficult for instructors to go out of their way to access anything different. Through this coteaching experience, we observed and participated in diverse teaching practices that elicited a high level of student engagement and enthusiasm that can serve as a benchmark for future iterations of the course and other courses. Consistent with Holland et al. (2018), we recommend targeting early career faculty, particularly as they take on new courses, for coteaching.

Be Intentional in Defining Coteaching Purpose and Role of the "Education Broker"

In our experience, a key element that led to meaningful learning outcomes for team members was Hannah's role as an "education broker," someone with enough familiarity with course content to be able to teach and enough expertise to model student-centered course planning and teaching techniques. Throughout the

experience, it was important for Hannah to be purposeful in making her thought process explicit when discussing planning, provide constructive feedback and suggestions in real time, and intentionally model a variety of classroom engagement strategies when she was teaching. The purpose of coteaching as an opportunity to learn to teach was forefront for Hannah, however, this could have been more explicit for other team members. We recommend more structure, such as a contract outlining respective roles and responsibilities, in forming new coteaching teams (see Holland et al., 2018).

Embrace Imperfection and Reflection as Learning Opportunities

Student-centered teaching is a complex, messy process and seeing mistakes and the nuances of teaching lead to new insights. The lived experience of working with someone with more experience can lead to learning how to teach, including learning how to navigate challenges that arise in real time. Engaging the coteaching team in reflective practice (both individually and as a team) allowed for a unique opportunity for deepening understanding and building capacity for employing student-centered teaching in the future. We recommend that coteaching teams actively work to build positive relationships amongst members so that the coteaching environment is one that supports experimentation and reflection.

Consider Allocation of Resources and Feasibility in Context

A major consideration moving this work forward is the allocation of university resources to support a coteaching model, which will vary widely depending on institutional context. The focus of our case study was confined to our coteaching experience, so we have limited recommendations for practice at an institutional scale. In our case, all members of the teaching team had a valuable professional learning experience. The lasting benefits for the specific course, however, could likely have been achieved with the involvement of just the lead instructor and education broker. We recommend careful consideration of the available expertise, potential collaborators from other departments, and the timing of the investment when developing a coteaching program. The inclusion of a GTA on the team allowed for the lead instructor to devote more of her time and attention to lesson planning, so we highly recommend this where feasible. Coteaching was an efficient use of Megan's time as a new faculty member because learning to teach was embedded in her teaching responsibilities, not an additional burden. It was a highly productive semester with lasting benefits that efficiently allowed for sharing of expertise in practice.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

References

- Amundsen, C., & Wilson, M. (2012). Are we asking the right questions?: A conceptual review of the educational development literature in higher education. *Review of Educational Research, 82*(1), 90–126. <https://doi.org/10.3102/0034654312438409>
- Bacharach, N., Heck, T. W., & Dahlberg, K. (2008). Co-teaching in higher education. *Journal of College Teaching & Learning, 5*(3), 9. <https://doi.org/10.19030/tlc.v5i3.1298>
- Barkley, E. F. (2010). *Student engagement techniques: A handbook for college faculty*. Jossey-Bass.
- Bouwma-Gearhart, J., Perry, K. H., & Presley, J. B. (2014). Improving postsecondary STEM education: strategies for successful interdisciplinary collaborations and brokering engagement with education research and theory. *Journal of College Science Teaching, 44*(1), 40–47. https://www.nsta.org/store/product_detail.aspx?id=10.2505/4/jcst14_044_01_40
- Brownell, S. E., & Tanner, K. D. (2012). Barriers to faculty pedagogical change: Lack of training, time, incentives, and tensions with professional identity? *CBE life sciences education, 11*(4), 339–346. <https://doi.org/10.1187/cbe.12-09-0163>
- Bryant, L. H., Niewolny, K., Clark, S., & Watson, C. E. (2014). Complicated spaces: Negotiating collaborative teaching and interdisciplinarity in higher education. *The Journal of Effective Teaching, 14*(2), 83–101. <https://files.eric.ed.gov/fulltext/EJ1060430.pdf>
- Burns, V. F., & Mintzberg, S. (2019). Co-teaching as teacher training: Experiential accounts of two doctoral students. *College Teaching, 67*(2), 94–99. <https://doi.org/10.1080/87567555.2018.1558169>
- Burrell, A. R., Cavanagh, M., Young, S., & Carter, H. (2015). Team-based curriculum design as an agent of change. *Teaching in Higher Education, 20*(8), 753–766. <https://doi.org/10.1080/13562517.2015.1085856>
- Chanmugam, A., & Gerlach, B. (2013). A co-teaching model for developing future educators' teaching effectiveness. *International Journal of Teaching & Learning in Higher Education, 25*(1), 110–117.
- Clark, S., C. Byker, K. Niewolny, and J Helms. (2013). Framing an undergraduate minor through the civic agriculture and food systems curriculum. *North American Colleges and Teachers of Agriculture, 57*(2), 56–67.
- Cook, L., & Friend, M. (1995). Co-teaching: Guidelines for creating effective practices. *Focus on Exceptional Children, 28*(3), 1–16.

- Cox, M. D. (2004). Introduction to faculty learning communities. *New Directions for Teaching & Learning*, 2004(97), 5–23. <https://doi.org/10.1002/tl.129>
- Crow, J., & Smith, L. (2005). Co-teaching in higher education: Reflective conversation on shared experience as continued professional development for lecturers and health and social care students. *Reflective Practice*, 6(4), 491–506. <https://doi.org/10.1080/14623940500300582>
- Culhane, J. H., Niewolny, K., Clark, S., McConnell, K., & Friedel, C. (2016). Learning through collaborative and interdisciplinary teaching: A case study of faculty work as learning in sustainable agriculture education. *NACTA Journal*, 60(2), 219–226.
- Davis-Bundrage, M., & Medvedev, K. (2016). Teacher training and student learning outcomes in family and consumer sciences: A mentoring and co-teaching case study. *Journal of Human Sciences and Extension*, 4(1), 34–50.
- Emerson, R. M., Fretz, R. I., & Shaw, L. L. (2011). *Writing ethnographic fieldnotes* (2nd ed.). University of Chicago Press.
- Ferguson, J., & Wilson, J. C. (2011). The co-teaching professorship: Power and expertise in the co-taught higher education classroom. *Scholar-Practitioner Quarterly*, 5(1), 52–68.
- Ford, J., & Gray, L. (2011). Team teaching on a shoestring budget. *Honors in Practice - Online Archive*, 7, 103–111.
- Graziano, K. J., & Navarrete, L. A. (2012). Co-teaching in a teacher education classroom: Collaboration, compromise, and creativity. *Issues in Teacher Education*, 21(1), 109.
- Helms, J. (2014). *Teaching and learning in sustainable agriculture curricula: A case study of faculty work as learning at a land grant university* (Doctoral dissertation). <https://vtechworks.lib.vt.edu/handle/10919/47354>
- Henderson, C., Beach, A., & Famiano, M. (2009). Promoting instructional change via co-teaching. *American Journal of Physics*, 77(3), 274–283. <https://doi.org/10.1119/1.3033744>
- Henderson, C., Beach, A., & Finkelstein, N. (2011). Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature. *Journal of Research in Science Teaching*, 48(8), 952–984. <https://doi.org/10.1002/tea.20439>
- Holland, T., Sherman, S. B., & Harris, S. (2018). Paired teaching: A professional development model for adopting evidence-based practices. *College Teaching*, 66(3), 148–157. <https://doi.org/10.1080/87567555.2018.1463505>
- Hutchins, E. (1996). Learning to navigate. In S. Chaiklin & J. Lave (Eds.), *Understanding practice: Perspectives on activity and context* (pp. 3–34). Cambridge University Press.

- Jawitz, J. (2007). New academics negotiating communities of practice: Learning to swim with the big fish. *Teaching in Higher Education, 12*(2), 185–197. <https://doi.org/10.1080/13562510701191943>
- Lattuca, L. R. (2002). Learning interdisciplinarity: Sociocultural perspectives on academic work. *The Journal of Higher Education, 73*(6), 711–739.
- Lattuca, L. R., & Creamer, E. G. (2005). Learning as professional practice. *New Directions for Teaching and Learning, 2005*(102), 3–11. <https://doi.org/10.1002/tl.192>
- Lave, J. (1988). *Cognition in practice: Mind, mathematics, and culture in everyday life*. Cambridge University Press.
- Lave, J. (1996). The practice of learning. In S. Chaiklin & J. Lave (Eds.), *Understanding practice: Perspectives on activity and context* (pp. 3–34). Cambridge University Press.
- Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press.
- Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Beverly Hills, Calif: Sage Publications.
- Looft, R., & Myers, M. J. (2019). Exploring faculty and student reflections on collaborative teaching in the honors seminar classroom. *Journal of Interdisciplinary Studies in Education, 8*(1), 140-157.
- Macdonald, H., & Teed, R. (2019). Interactive Lectures. *Starting point: Teaching entry level geoscience*. <https://serc.carleton.edu/introgeo/interactive/index.html>
- Morelock, J. R., Lester, M. M., Klopfer, M. D., Jardon, A. M., Mullins, R. D., Nicholas, E. L., & Alfaydi, A. S. (2017). Power, perceptions, and relationships: A model of co-teaching in higher education. *College Teaching, 65*(4), 182–191. <https://doi.org/10.1080/87567555.2017.1336610>
- National Research Council. (2012). *Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering*. Committee on the Status, Contributions, and Future Directions of Discipline-Based Education Research. Board on Science Education, Division of Behavioral and Social Sciences and Education. The National Academies Press.
- Orlander, J. D., Gupta, M., Fincke, B. G., Manning, M. E., & Hershman, W. (2000). Co-teaching: A faculty development strategy. *Medical Education, 34*(4), 257–265.
- Roth, W.-M. (2001). Becoming-in-the-classroom: Learning to teach in/as praxis. In D. R. Lavoie & W.-M. Roth (Eds.), *Models of science teacher preparation: theory into practice* (Vol. 13; 13., pp. 11–30). Dordrecht: Kluwer Academic Publishers.

- Roth, W.-M., Masciotra, D., & Boyd, N. (1999). Becoming-in-the-classroom: A case study of teacher development through coteaching. *Teaching and Teacher Education, 15*(7), 771–784. [https://doi.org/10.1016/S0742-051X\(99\)00027-X](https://doi.org/10.1016/S0742-051X(99)00027-X)
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.
- Walters, K., & Misra, J. (2013). Bringing collaborative teaching into doctoral programs: Faculty and graduate student co-teaching as experiential training. *The American Sociologist, 44*(3), 292–301.
- Weimer, M. (2013). *Learner-centered teaching: Five key changes to practice* (2nd ed.). Jossey-Bass.
- Wenger, M. S., & Hornyak, M. J. (1999). Team teaching for higher level learning: A framework of professional collaboration. *Journal of Management Education, 23*(3), 311-327. <https://doi.org/10.1177/105256299902300308>
- Wiggins, G. P., & McTighe, J. (2005). *Understanding by design*. Alexandria, VA: Association for Supervision and Curriculum Development.