Collaborative Co-Teaching of a Secondary Science Methods Course: A Self-Study of Three Science Teacher Educators

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Abstract

In this manuscript, we present findings from a self-study of three science teacher educators, the authors of this manuscript, who collaborated in the planning and teaching of a secondary science methods course. The three of us, all from unique backgrounds and experiences, met regularly, recorded those meetings, and reflected on both the meetings themselves and the co-teaching experience. We also revisited the course over three years later to undergo another round of self-reflection and co-analysis. Results of this self-study document the refinement of the curriculum based on disciplinary expertise, an increased emphasis on the overlap between content and practice, professional community building within science teacher education, and individual growth as educators. In addition to the perceived successes of the collaboration, challenges and recommendations for other science teacher educators who want to co-teach methods courses are discussed. We especially want to encourage the underutilized partnership of methods instructors and field supervisors in co-teaching models.

Introduction

The preparation of secondary science teachers is a complicated task, and one that is made even more so when considering the distinctions in teaching various scientific disciplines. While scientific disciplines (i.e., Biology, Chemistry, Physics) do share key features, there are elements of pedagogical content knowledge (PCK) that are distinct to each (e.g., Kind & Chan, 2019; Sengul, 2024; Van Driel et al., 1998; Zeidler, 2002). For example, students approach the learning of content in these disciplines with different assumptions and, therefore, unique alternate conceptions, which a science teacher must address through pedagogical strategies specific within them (e.g., Käpylä et al., 2009; Sperandeo-Mineo et al., 2006; Van Driel et.al., 1998). As a result, teaching pre-service secondary science teachers involves preparing these individuals to teach various topics that do not necessarily overlap.

In our experiences, however, due to relatively low enrollment numbers in secondary science teacher education programs (Luft et al., 2011), prospective science teachers enroll in the same science methods courses regardless of their content area of expertise. Because only

one secondary science faculty member typically teaches these courses, some preservice teachers may miss important perspectives related to very specific science topics. For example, if a former high school chemistry teacher is teaching a group of preservice teachers that includes future biology teachers, the ethics and practical aspects of performing dissections are likely to be a topic that is underexplored as a result of a lack of experience with biology laboratory exercises on the part of the instructor.

Another common and challenging issue in educating preservice teachers in larger institutions is that the science educator teaching methods courses might not necessarily be the supervisor of student field experiences in which the pre-service secondary science teacher could simultaneously participate. Student field experiences defined here include any practicum, student teaching, internship, or residency that a preservice teacher completes in K-12 classrooms prior to obtaining licensure. The potential disconnect between the messaging communicated by methods and field experience instructors, respectively, could cause confusion between course content and what is observed and experienced in the field. This theory-practice gap is one of the more cited critiques of preservice teacher education (e.g., Darling-Hammond, 2009; Korthagen, 2010; Huang, Lubin, & Ge, 2011) and one that we believe could be addressed through collaborative co-teaching methods courses in particular.

Our collaborative self-study (Butler & Bullock, 2022a) involved three instructors (the authors of this manuscript) co-teaching a science methods course that preservice secondary science teachers were required to take alongside their field experience during the final semester of their teacher preparation program. We consider this an innovative strategy because co-teaching among faculty members in higher education is notably absent outside of the general/special education domains (Bacharach & Heck, 2007). Moreover, this collaboration involved three (rather than a more traditional two) faculty members, all of whom came together to learn from one another and to share the responsibility for planning, teaching, and assessment of the preservice teachers. Research has demonstrated the benefits of collaborative planning in undergraduate science instruction (Capobianco et al., 2020). Other research indicates that co-teaching, in particular, is valuable to both the co-teaching instructors and the students in pre-service teacher education programs (Damiani & Drelick, 2024). Specifically, pre-service teachers are more likely to co-teach themselves, and the co-instructors were more likely to take risks as they implemented novel strategies learned from their peers (Damiani & Drelick, 2024). We wanted to take this further in that we would also be co-teaching and applying similar lessons to the preparation of secondary science teachers. In this article, we will share the lessons we learned and the challenges we faced as we reflected both in real-time while co-teaching and again looking back at the experience years later.

Context

Instructor Background

Leading up to the Spring 2021 semester, a science educator and former high school chemistry teacher (Author 1) was tasked with revising and teaching a new version of a course entitled *Secondary Science: Theory to Practice*, the second science methods course in a sequence of two science methods courses. A science education doctoral student who was currently an instructor in the biology department (Author 2) signed on to complete an independent study within the course as part of her doctoral work. As they both began to think about what an independent study would look like in the context of this methods course, collaborative self-study as a methodology (Guðjónsdóttir & Jónsdóttir, 2022) was discussed as a natural fit that would work even better if the doctoral student took on some co-teaching responsibility. Soon into these discussions, the decision was made to invite a third co-instructor (Author 3), a former high school science teacher who taught biology, physics, and chemistry for more than ten years and the current field supervisor of the preservice teachers who would be enrolled in the course to participate in both the self-study and the course itself. Due to simultaneously supervising the students in their field experience, she was able to provide a unique perspective on the connections between what was being discussed in the methods course and what was actually happening in the secondary science classrooms where these student teachers were conducting their field experience.

Course Structure and Participants

Preservice secondary science teachers at the institution where this self-study took place are part of either a four-year undergraduate program or a fifth-year graduate program, both requiring an undergraduate degree in the content area that the teacher candidate intends to teach. Both programs require two separate three-credit-hour methods courses that are taken in sequence and culminate in a semester-long field experience (e.g., student teaching, internship, residency, etc.) that is taken concurrently with the second methods course the semester before the teacher candidate graduates with their license to teach secondary biology, chemistry, or physics.

While the course was being planned, we decided to use a textbook, “Teaching Science in Diverse Classrooms: Real Science for Real Students” (Larkin, 2019), to organize the syllabus and to be a required textbook for the pre-service science teachers. The topics for the semester were divided into four main areas of focus: media in the science classroom, assessment in the science classroom, the laboratory in secondary science, and multidisciplinary science education within science instruction. We decided to devote approximately two weeks of instruction to each of these topics with additional class periods being used to supplement and support the things that were happening within the preservice teachers’ field placements in local schools. We planned to assess students through projects that they would implement in their field placements. Specifically, students would use mass

media to teach science content, develop a laboratory investigation that they would implement, and engage their students in a STEM activity. Preservice teachers would design, implement, and reflect on each of these.

Eight preservice secondary science teachers enrolled in the course. Among these were two future chemistry teachers, two future physics teachers, and four future biology teachers. The class met once a week for three hours in the evening.

Self-Study Defined

Self-study is a method for examining and improving the practice of teacher educators and is a well-documented research strategy (e.g., Butler & Bullock, 2022a, 2022b; Dinkelman, 2003; LaBoskey, 2004; Loughran, 2005, 2007). Specifically, self-study of teacher education is an endeavor intended to increase the quality of reflective teaching through a group of critical friends who provide feedback to those engaged in the practice (Schuck & Russell, 2005). We built our framework of collaborative self-study with the expectation that "professional and personal agency" (Guðjónsdóttir & Jónsdóttir, 2022, p. 117) would be fostered for each of the three self-study researchers involved. Our self-study was guided by a desire to make adjustments to our instructional practices, build collaborative relationships, and share what we've learned as a model for science methods courses for pre-service teachers as we each grew professionally (Simpson & Feyerabend, 2022).

Our Reflective Process

In our self-study, we held 11 semi-weekly meetings over the course of the semester. These meetings lasted, on average, for 45 minutes and took place online via video-conferencing software. Each of these meetings was video recorded. The purpose of these meetings included an opportunity to share individual reflections on the co-teaching experience thus far, to debrief from previous class sessions, and to plan for upcoming class sessions. We did not have an organized protocol to guide these discussions, but rather allowed for free-flowing organic conversations. At the conclusion of the semester, the three co-instructors reviewed the videos and reflected upon them. These typed reflections served as our primary data source. These reflections were analyzed using an inductive approach in which we organized our writings quickly into initial codes and then organized these codes into five main themes (disciplinary expertise refined the curriculum, connections between content and practice, professional community building, personal growth through reflection, and the challenges of existing hierarchies). After a lengthy amount of time (over three years later), the three of us revisited the aforementioned five main themes. We spent time writing a personal narrative reflection organized around these themes. We then used a qualitative data analysis software program to generate codes within each theme. We came together and discussed and

reached a consensus on a final list of 30 unique codes divided among the five themes. We applied constructivist grounded theory methods throughout the processes described above (Charmaz, 2017).

Lessons Learned

Benefits of Collaborative Teaching

We noted four primary benefits of working together as a collaborative team. These benefits included the disciplinary expertise that refined the curriculum, connections between content and practice, professional community building, and personal growth through reflection. We identified key excerpts from our reflections for each of the four benefits. We do wish to point out again that the purpose of this self-study was truly to study the impact of collaborative teaching on the three of us as science educators and not to investigate the impact of this course on the preservice teachers who were enrolled. That being said, the preservice teachers reported positively on course evaluations with high ratings on a 5-point scale at the end of the semester and turned in high-quality work throughout the semester. These evaluations are comparable to prior course evaluations for the same class, and the work was of the similar high quality typically received. This leads us to believe that co-teaching in no way diminished the students' perceptives regarding the course or the ability to meet and exceed course outcomes.

Disciplinary expertise refined the curriculum. One of the most obvious benefits was the different areas of disciplinary expertise that each one of us brought to the table in planning and implementing the methods course. Author 1 had a background of investigating and participating in media-based secondary science curriculum where students are introduced to science concepts through the use of mass media and therefore took a lead role on the weeks where that was the topic of focus (Klosterman et al., 2012). Author 2 took the lead on laboratory instruction, specifically in a lesson where preservice teachers discussed and participated in a frog dissection. Author 3 had experience teaching multiple science subjects and was uniquely positioned to lead the class periods focused on interdisciplinary instruction and the integration of various STEM disciplines. This allowed for a modeling of good interdisciplinary science teaching on our part (Czerniak & Johnson, 2014). We truly worked together and combined our various backgrounds and areas of expertise. The following reflection excerpts from the three of us demonstrate this point.

It was very helpful to bounce lesson ideas off of others. Higher education typically does not get to do that. We were able to brainstorm together various ideas. Knowing what we did and the options for what we could have done I want to run the lesson again and try other ideas we had for the lesson. (Author 1)

[I] thought the leadership structure was excellent: Lead professor/science teacher educator, science instructor/science teacher educator, practicum supervisor/science teacher educator. All of us were working toward a common goal, had differing perspectives, and yet a very common desire to be excellent science teacher educators and improve preservice teacher teaching and learning. (Author 2)

The value of having three different instructors with three very different roles/areas of expertise was quite evident. Specifically, we had two instructors with a background in biology, one of whom was the field supervisor, and one instructor with a background in chemistry. Having someone who knew exactly what was happening during the concurrent field experiences allowed for our classroom methods instruction and assessment grounded in reality. Additionally, we were able to have our class meet in the biology lab where one of our co-instructors taught for a frog dissection experience, something that would not have happened under the old model. (Author 3)

Connections between content and practice. A second benefit was that Author 3 was also the field supervisor for the preservice teachers' experience and, as such, was able to situate everything that we were doing in class in the context of what was happening in the science classrooms in the area schools. The ability to engage in frequent communication with the preservice teachers about the similarities and differences between what they were encountering in their field placements and the theoretical science education content we were examining in the methods course was extremely valuable. The few reflection excerpts below are indicative of this point.

The fact that the methods course sets assignments and practices based on the needs of the pre-service teachers' placement and growth in their teaching provides an opportunity for differentiated instruction. (Author 3)

It was refreshing to be surrounded by people who would specifically remind me both in our self-study meetings and during in-class meetings to make explicit connections between theory/content and practice. An example of this would be when we highlighted to the preservice teachers that the things we were doing in class (strategies) were a model that we hoped they would take into their classroom when teaching. (Author 2)

Additionally, in one of the weekly meetings, Author 3 reported how relevant it was for her to observe a preservice teacher implementing a methods course assignment during the lesson she was observing in the field placement. It provided for a timely, teachable moment. Following this, she and a preservice teacher spoke in depth about how an assignment for the methods course assignment impacted the quality of the lesson design. The preservice teacher was especially pleased because she "added it last minute just to meet the requirements of the assignment." In another scenario, the preservice teachers would have

taught the same lesson, but the field supervisor might not have mentioned the salience of that portion of the lesson; the preservice teacher would have just completed the assignment for her methods course without recognizing its potential value within her field placement.

Professional community building in teacher education. Another benefit was the professional community building among the three teacher educators co-teaching the methods course. Openly acknowledging the strengths and weaknesses we brought to the course allowed us to change our thinking when we approached different topics with the students. Again, from our reflections:

[I] Enjoyed weekly debriefing discussions; they were always beneficial to me from a professional practice perspective, (and personally too). [I] Felt like, perhaps, for the first time, I belonged to a community of practitioners who enjoyed [each other's] company and were genuinely interested in hearing multiple perspectives. No one was trying to gain an edge or win an argument. (Author 3)

Personal growth through reflection. Finally, we recognized that we all grew individually as teacher educators as a result of this collaborative experience as evidenced in the following reflection excerpts.

I didn't realize the purpose of a self-study as thoroughly at the beginning as I do now. This is the beauty of reflecting to acknowledge your growth. Interpersonal and intrapersonal relationship to teaching was developed in real time. (Author 2)

As a result of this experience, I was able to be more reflective and more open to change and growth both as a science educator and in allowing for the evolution of specific teaching ideas and strategies. (Author 1)

Watching my colleagues develop and teach their lessons provided me with another perspective on how others go about this process. Not only did this affirm my own practices, but I added more possibilities and appreciated getting access to their lesson resources. I have a lot more tools for my teaching craft as a result of this collaboration. (Author 3)

Challenges of Existing Hierarchies in Co-teaching

Of the challenges we experienced, the one at the forefront worth mentioning was the breaking down of existing hierarchies among the three co-instructors and truly allowing for equal input and ownership. Though frequent discussions addressed this topic, no clear solutions ever became apparent. The three reflection excerpts below are representative of this challenge.

Truly allowing for equal ownership of the course among three instructors was a challenge. (Author 2)

I also worry that I might be dolling out too much work for other people. I really don't want to be seen as a supervisor but as a colleague on an equal level. (Author 1)

Lack of personal/professional clarity: This was [Author 1's] course, and [Author 2] was participating for course credit, so why was I investing my time and energy into someone else's class? The weekly debriefings helped me overcome this lack of clarity, though. (Author 3)

Three-Year Post-Teaching Reflection Analysis

After three years, we revisited the themes discussed above and engaged in one more round of reflections and analyses of those writings. This analysis resulted in some interesting findings that were previously left unconsidered. Most notably, two of us kept returning in our reflections to the lasting impact of our co-teaching experience. Author 3 wrote, "I actively think about some of our lessons and the ways we went about planning them, organically sometimes." Author 1 wrote about how he focuses on life sciences and the role of the laboratory in those disciplines in each of his methods courses in a way that he did not prior to the co-teaching experience. Additionally, Author 1 discussed how he has his current preservice teachers engage in reflective practice as they consider how the content they are learning in methods courses relates to their field experiences. This had not been happening as frequently prior to the co-teaching of the methods course.

All three of us also wrote about the development of a broadened perspective on both the program of study for preservice secondary science teacher preparation and our individual roles within it. According to Author 3,

I was much more open to making program changes to merge and cross list courses to economize resources. I think I would have been resistant and even resentful about this had I not been active in this collaboration. (Author 3)

The benefit for me…was to have a fresh perspective not clouded by any past practices, but to see it [the program of study] as a new whole. (Author 2)

Relationship building was also highlighted in our most current self-reflections. Author 1 wrote, "I see each of my peers as coequal partners in the preparation of future science teachers". Author 3 wrote about an "automatic feeling of collegiately and comradery" that accompanied the co-teaching experience. Author 2 came to understand the specific nature of those relationships. She wrote, "Author 1 really took on the mentor roll to address my concerns and support me. Author 3 reassured me and related her experiences to mine".

The breaking down of existing hierarchies was seen differently by each of us in retrospect. Author 3 acknowledged the existence of a hierarchy, but also described it as a necessary reality. She wrote the following:

I really don't see it [a hierarchy] as a challenge as much as a necessity. Someone must take ownership, call a meeting, create an agenda and a timeline. The primary course instructor who invited us into the co-teaching experience is the person to lead this effort. (Author 3)

Author 2, a science education doctoral student at the time, wrote about an initial resentment that developed into an appreciation.

While I was teaching, occasionally Author 1 would interrupt with insight or comments to the lesson. At that time, I resented this approach because I was teaching and 'in control' but I couldn't comment on this to Author 1 because as a graduate student he was on my committee. Looking back on this now I realize the necessity in what he was doing by offering a perspective I didn't have. I had a lack of knowledge in the co-teaching approach as well that hindered my view at the time. It was a vulnerability that took time for me to realize and now I appreciate how I grew as a result. (Author 2)

Author 1 was most acutely aware of his place of privilege in the co-teaching hierarchy. He reflected,

I feel like I personally was probably sending many unintentional and unrecognized messages that were supporting those hierarchies. This experience helped me to examine my own privileges and biases and to think of ways for others to comfortably confront me when I may be overbearing. (Author 1)

Discussion

Considerations for Implementing Co-teaching

In summary, a number of implications and recommendations can be made from our study. First, we encourage secondary science methods instructors to try and involve more stakeholders in their methods courses (planning, teaching, and/or assessing). In our self-study, the collaboration was timely (with the development of a new course), and all the stakeholders (science and science teacher educators) had invested interests in the course development for individual professional purposes. However, in other similar studies (Hadar & Brody, 2010; Taylor & Znajda, 2015), the professional collaborations involved faculty from a range of various disciplines who shared a common goal for improving some specific aspect of their teaching practice (e.g., learning how to improve students' thinking) or to develop a new course. As such, we suggest that science methods instructors be intentional about finding existing social networks or creating their own to design a collaborative experience around a common goal (e.g., to improve STEM integration efforts to meet the NGSS integrated standards, to help preservice teachers learn to integrate disciplinary literacy more effectively into their lessons, to incorporate art into science lessons, etc.).

Additionally, we suggest that it is important to know your limitations as a methods instructor. For one of us, a felt weakness in teaching methods courses was the planning and implementation/modeling of laboratory experiences for preservice biology teachers. Collaborative work with biology educators was therefore important in our course design. Likewise, we suggest science teacher educators consider engaging new faculty members, graduate assistants, or faculty in other departments with specific expertise to join you in a collaborative project to help fill the gaps in your methods course. In addition, the input of a field supervisor is quite valuable if the methods course runs concurrently with field experiences. This allows for a deeper connection between theory and practice for preserve teachers. Otherwise, these learning experiences may come and go without explicit and informed opportunities for thoughtful reflection. Clearly, these collaborative projects require valuable time that may not be reflected in an instructor's workload. Although time was not an overarching theme that emerged from our reflections in this study, it was subtly present and worth mentioning here due to abundant research citing a lack of time as one of the major barriers to faculty pedagogical change (Anderson, 2011; Brownell & Tanner, 2012; Stevenson et al., 2005). Time is always going to be a limiting factor, so sacrifices will have to be made. Yet there are ways to manage instructor time more effectively, and faculty participation may look different for respective participants. For example, in our study, Author 3 opted not to attend every class period based on her predetermined contributions and learning needs. Time investments early on may result in time savings later. Once a new course is established, there will be less demand in terms of planning and design, just as if it were taught individually. Our self-study revealed that there are many similarities to designing a new course when establishing collaborations, but then time can be split and resources shared across instructors and even departments in future iterations of the course.

In our case, our collaborations and opportunities for our preservice teachers in practice and learning was worth the intensive semester of our initial self-study in our methods course. Many benefits came from our study including reasons previously stated, and others such as academic exploration, which is a valuable endeavor for professional development.

I found teaching a new course outside my college a great way to consider new options for my curriculum. It excites me to consider new assignment types and structures for learning. However, I found myself wanting our preservice teachers to demonstrate more knowledge in science and science communication in our course. It was difficult to put everything I felt was needed into a single semester that included content, methods of instruction and practice in the classroom. It required a great deal of flexibility and responding to the needs of our students. (Author 2)

The hierarchical challenge we faced is typical of academic institutions (Morelock et al., 2017) but rarely openly acknowledged in how we were able to during this study. This challenge, due to existing hierarchies, is especially pronounced when tenure-track and non-tenure-track faculty are involved (Haviland et al., 2017). Add to that mix a doctoral student, as was the case in our co-teaching, and hidden and/or unspoken hierarchical resentments need to be

confronted up front. At the outset, we had agreed on respectful, straightforward communication, allowing us to be open with our concerns. Should there be a need to break down the hierarchy? One instructor needed to take the lead in observing pre-service teachers, one needed to be responsible for students' grades, and whoever had the expertise in a certain area should lead that class period. In our meetings, we decided how the other instructors would act as co-instructors for the upcoming class, such as ensuring we explicitly stated strategies for the classroom to students as learned topics in class, and to do so, we broke up topics based on expertise. Overall, this strategy worked well. However, the course was assigned to only one instructor for entering grades and assuming the responsibility for the success of that group of students, and only one instructor had access to observe students continuously in their field experience. We suggest all instructors be listed as co-instructors for the course and develop a plan for communication at the start. When issues arise, and they will, it will be helpful to have a communication plan in place so that all co-instructors can move forward in a timely fashion. In addition, discussing a personal motive for each instructor in the course will help each individual contributor to acknowledge how their time will be spent working in the course.

I was truly humbled as a result of this collaboration and was able to recognize in ways that I hadn't before the importance of not going it alone when teaching methods courses to diverse groups of future science teachers. I found my relationships strengthed with each of my colleagues and was encouraged about our future work together. (Author 1)

Conclusions

As science methods courses are often taught as a single combined Physics, Chemistry, Earth Sciences, and Biology course, having expertise across all science disciplines would be difficult for a single individual to address. Collaborations are a way in which to provide a more content-inclusive course. With the continued use and advancement of technology, such as Zoom and cloud-based documentation, we also foresee an increase in communication venues that could streamline efforts between the field placement instructor and science methods instructor. In summary, we recommend that others similarly engage in collaborative self-study. It allowed us to truly feel part of a community of science educators on our campus and we felt individual growth as a result. While we have yet to offer this course again in the exact same manner described here, we have continued the partnership between Author 1 (the methods instructor) and Author 3 (the field supervisor). For example, we continue to have the pre-service teachers plan a laboratory experience in the methods course and then implement that same lab in the field. Though the field supervisor is not present in the methods course, Author 1 has continued to require that the field supervisor (Author 3) observe this lab as one of the three required formal observations for the field experience course. By so doing, Author 3 is essentially being compensated for her collaboration with Author 1. We conclude with the following reflection as an example of what happened personally as a result of this work.

There were benefits and outcomes that I did not anticipate. First and foremost, I developed more confidence in myself as a practitioner. This may seem like a moot point for a person who has been teaching in secondary and post-secondary contexts for more than three decades, but instructional validation was definitely a valuable outcome for me. As a result of our collaboration study, I learned that my instructional methods and experiences are similarly creative and effective as my colleagues; likewise, my teaching challenges and even self-doubt at times were similar to theirs. This was apparent during our weekly collaboration meetings as we reflected on what was good about the lesson recently taught and what could be improved upon. Just knowing that I measure up gives me added confidence, which results in my enjoying my teaching and supervising responsibilities even more. Another favorite takeaway from this study was the relationships we developed. Even though I knew my colleagues prior to this study, I grew to appreciate, admire, and respect them throughout our collaboration process. As a result of their own transparency and vulnerability during our weekly reflection time, I developed significant trust and respect for them. I feel more connected and settled in my role as a teacher educator in a much larger university system. (Author 3)

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