Co-teaching Strategies in Action: Selection and Implementation in a Mathematics Course for Pre-service Teachers

Bridget Druken Alison Marzocchi
California State University, Fullerton

Received: June 2023 ll Accepted: July 24

Increasingly, teacher preparation programs are transitioning to a co-teaching model to better prepare future teachers for the co-teaching experiences they will likely encounter in their PK–12 careers when they share a classroom with another teacher. Despite this transition, co-teaching remains rare in undergraduate university courses. To address this issue, two mathematics teacher educators explored on a co-teaching model in an undergraduate mathematics content course for future elementary teachers. An interpretive qualitative analysis was conducted on primary data sources of instructor journal entries and observation protocol forms, with videos of instruction and lesson materials as secondary sources. Episodes of each co-teaching strategy employed was coded for rationale in selection, reflection on implementation, affordances, and limitations. University classroom examples are provided for each strategy. Findings indicate that co-teaching strategies have numerous impacts on the classroom, such as opportunities for students to learn, opportunities for teachers to learn, opportunities for teacher-student interaction, opportunities for teacher-teacher interaction, power dynamics among instructors, and logistics (such as classroom space and available manipulatives). Implications of this research include an increased understanding of a co-teaching model for instructors interested in implementing the model in university courses.

Keywords: ·mathematics teacher education research·mathematics teacher educators·higher education·teacher preparation·teacher preparation·cooperative teaching

Introduction

Co-teaching has been well-documented for over two decades in PK–12 classrooms, most often in classrooms that include students with disabilities (Strogilos & King-Sears, 2018). University faculty members can, however, also benefit from collaborative professional learning such as co-teaching with another instructor (Bacharach et al., 2008; Graziano & Navarrete, 2012; Hiesh & Nguyen, 2015). Despite the professional growth that results from collaborative inquiries to improve student learning, detailed descriptions on planning and implementing co-teaching strategies in higher education remain sparse (Butler et. al, 2019; Lock et al., 2016), particularly among mathematics courses co-taught by mathematics teacher educators (MTEs; Downton et al., 2018). Further, studies on the professional growth and learning of MTEs are rare, often focusing on the teachers or preservice teachers they seek to support (Jaworski, 2001). The goal of this study is to provide co-teaching insights in the context of MTEs preparing future elementary teachers of mathematics, contributing to the growing body of research on the learning and development of mathematics teacher educators (Goos & Beswick, 2021).

Teacher preparation programs are increasingly using co-teaching strategies (Weinberg et. al, 2020; Yopp et al., 2014). Providing the opportunity to experience co-teaching prior to a credential program can benefit preservice teachers, such as in making connections between theory and practice (Downton et al., 2018; Livy et. al., 2017). Graziano and Navarrete (2012) and Mariano-Dolesh et al. (2022) noted that preservice teachers who graduate from teacher preparation programs where co-teaching approaches are taught and modeled in pedagogy courses, will be in high demand for K-12 teaching positions. Since little has been written about co-teaching experiences among MTEs preparing future elementary teachers, this study will contribute to the research literature in this field.

Given a needed focus on research about teacher educators as practitioners (Goos & Beswick, 2021; Jaworski, 2001, 2008; Muir et al., 2018) and a growing demand to prepare pre-service teachers (PSTs) to co-teach, we embarked on this qualitative research study to investigate co-teaching at the university level by MTEs. The purpose of this article is to document and describe how two MTEs co-planned for seven co-teaching strategies to understand better the experience of implementing co-teaching in the context of a university mathematics course for PSTs.

Background

Cook and Friend (1995) are credited with coining the term *co-teaching*, which they defined as "two or more professionals delivering substantive instruction to a diverse, or blended, group of students in a single physical space" (p. 2). Ferguson and Wilson (2011) expand this to include "the ultimate goal of co-teaching is to establish a 'collective responsibility' for what occurs in the classroom such that two experts share and commit to knowledge, and grow professionally during the process" (p. 54). Co-teaching strategies informed by over two decades of co-teaching research include: *one teach one observe, one teach one assist, station teaching, parallel teaching, supplemental teaching, alternative teaching,* and *team teaching* (see Table 1) (Bacharach et al., 2008; Bacharach et al., 2010; Cook & Friend, 1995; Dynak et al., 1997; Ferguson & Wilson, 2011; Graziano & Navarrete, 2012; Sebald et al., 2022). For each strategy, both co-teachers are involved in co-planning, co-teaching, and debriefing of the lesson. Different co-teaching strategies are selected depending on specific learning goals and classroom situations (Ferguson & Wilson, 2011).

Table 1
Description of Seven Co-teaching Instructional Strategies, Informed by Bacharach et al. (2010)

Co-teaching Strategy	Description
One Teach One Observe	One teacher is responsible for leading instruction while the other teacher collections targeted observation data on students or teaching, often decided on prior to instruction.
One Teach One Assist	One teacher assumes the lead and the other teacher helps in a particular way, such as classroom management, distributing/collecting materials, or answering student questions.
Station Teaching	The room is divided, and students rotate among non-hierarchical stations, sometimes with a mix of teacher-led and independent stations.
Parallel Teaching	Both teachers teach the same lesson concurrently to half of the students to lower the student-to-teacher ratio.
Supplemental Teaching	One teacher assumes the primary instructional role and the second teacher works separately with a purposefully selected small group of students who are striving to learn the content or are ready for extension.
Alternative Teaching	Both teachers teach to the same learning goal but use different approaches, such as a visual approach versus a kinaesthetic approach, to half the students in the class.

Co-teaching to Improve University Teaching

Compared to occurrences in K–12 education contexts, co-teaching has been less frequently documented in the university setting (Bacharach et al., 2008), where teaching is generally treated as a solo endeavour (Ferguson & Wilson, 2011). Most accounts of faculty using co-teaching focus on fields other than mathematics, such as reading and language acquisition. A noted exception is Lam et al. (2020), who piloted a co-teaching model that partnered a mathematics instructor with a science or engineering instructor to teach precalculus and calculus. While the challenges to co-teaching reported

by faculty were mostly logistical, benefits included improved faculty knowledge of the applicability of the content and improved student motivation to learn.

In the context of co-taught courses for PSTs, Ferguson and Wilson (2011) co-taught reading methods courses for pre-service teachers to model and experience co-teaching firsthand as a form of professional development on course content and pedagogy. They found that co-teaching provided an authentic professional development experience for the faculty and empowered PSTs to engage in co-teaching themselves. The authors caution that university faculty who have not engaged in co-teaching themselves may not have the foundation to prepare PSTs to co-teach adequately. Graziano and Navarrete (2012) described their co-teaching experience in a second-language acquisition university course for PSTs as both a teaching strategy and a strategy for teacher educator development. Their experience provided opportunities for reflection on teaching practices, themselves as individuals, and their students' learning. They found that opportunities for reflection "allowed us to move beyond the practical application of 'how to co-teach' into a 'how to grow as a teacher and reflective practitioner'" (p. 124). Still, they noted structural obstacles to co-teaching in the university setting, including the need for more planning time than a solo-taught course, a lack of systems in place for collaborative teaching, budget constraints for additional faculty pay or release time, and a shared understanding on how policies and practices for promotion, tenure, and merit reviews will interpret co-teaching endeavours.

Bacharach et al. (2008) found similar reported benefits for faculty participating in co-teaching, noting faculty of ten co-taught teacher preparation courses reported benefits from the use of different teaching strategies, expanded content knowledge, more reflection on teaching through negotiating decisions, and a renewed passion for their profession. Moreover, all faculty reported that they would co-teach again.

Research on the learning and teaching of mathematics teacher educators as practitioners has been described as an area ripe for research (Goos & Beswick, 2021; Jaworski, 2001; Muir et al., 2018). A study by Downton et. al (2018) detailed an effort to connect university faculty to practicing teachers of mathematics through a co-teaching partnership involving a cohort of primary mathematics education candidates. Findings suggested the four benefits to PSTs as: the existence of a direct link to the classroom; the ability for PSTs to connect theory and practice outside of a practicum experience; greater PST engagement with improved mathematical content knowledge and pedagogical content knowledge; and opportunities to elicit PSTs' mathematical thinking, facilitate discourse, and develop a community of practice. Co-teaching was also seen to provide additional support to PSTs who could benefit from individualised instruction.

These studies suggest a benefit of faculty co-teaching in several content areas. In most cases, mathematics courses for PSTs were not included. Further, these studies have focused on the overall experience and processes involved with learning to co-teach (e.g., Ferguson & Wilson, 2011; Graziano & Navarrete, 2012; Hiesh & Nguyen, 2015). Few specifically investigate the implementation of co-teaching strategies, particularly in the context of mathematics education. Thus, our research provides a detailed documentation that explores the implementation of co-teaching strategies in a university mathematics course for PSTs.

Research Questions

Our study investigates co-teaching strategy implementation in the context of a mathematics course for PSTs. The following research questions guided the study:

1. *What factors did mathematics teacher educators consider in the selection and implementation of co-teaching strategies in a mathematics course?*
2. *What did mathematics teacher educators report as the affordances and limitations of co-teaching strategies?*

Answering these questions will increase understanding of how to support university MTEs to better co-teach PSTs of mathematics.

Methods

With the goal of better understanding how co-teaching strategies are selected and implemented in mathematics courses for PSTs, two MTEs researched their co-teaching experience over two semesters using qualitative research methods. This allowed the MTEs to "walk the talk" (Kamen et al., 2011), gaining firsthand experience with the co-teaching model used in their teacher credentialing program. As Jaworski (2001) summarised, "as a result of being aware of what contributes to our own learning, we can create situations finely attuned to learners' attention – "not only 'walking the talk' but 'talking the walk'" (p. 11).

Methodology

The methodology used for this study is an interpretivist/constructivist paradigm (Makenzie & Knipe, 2006). In this paradigm, researchers look to the "participants' views of the situation being studied" (Creswell, 2003, p. 8) and acknowledge how their own backgrounds and experiences impact the research. An interpretivist/constructivist paradigm seeks to "generate or inductively develop a theory or pattern of meanings" (Creswell, 2003, p. 9) via the research process. Researchers make use of qualitative data collection methods and analyses or a combination of both qualitative and quantitative methods (mixed methods). Quantitative data may be utilised in a way, which supports or expands upon qualitative data and effectively deepens the description.

The interpretivist/constructivist paradigm positions the MTEs views of co-teaching as integral to understanding coteaching in a mathematics content course for future teachers. It also acknowledges the background and experiences of MTEs serving as both teachers and researchers. Thus, it supports the following qualitative data collection methods and analyses described in following sections.

Context

The authors teach and research at a large public, comprehensive, four-year, Master's granting university in the southwestern United States with a Hispanic-serving institution and an Asian American and Native American Pacific Islander-serving institution designation. The university used a co-teaching model for teacher credentialing in their multiple-subjects and single subject programs. In the credentialing model, a university clinical coach supports a teacher candidate throughout the year as they co-plan and co-teach with a mentor teacher in an actual K–12 classroom setting. We, the authors, sought to deepen our understanding of each strategy as a faculty professional development experience.

Three sections of a mathematics course for PSTs were used for this study. The course content included number, operations, and problem-solving for PSTs of K–8 mathematics. In September—November of 2017 (Fall 2017), the authors co-taught the course in two 75-minute sessions weekly and met for two hours to co-plan each lesson, debrief each lesson, and continually suggest improvements for upcoming lessons. In the subsequent Fall of 2018, each author taught their section of the same course with an undergraduate apprentice using the same materials from Fall 2017. The two MTEs and two undergraduate apprentices met weekly for two hours to co-plan and debrief all lessons throughout the 16-week semester. In total, this study involved approximately 60 hours of co-planning/debriefing and 45 hours of co-teaching.

Participants

Two faculty members from the Department of Mathematics and one from the College of Education's Department of Elementary and Bilingual Education served as researchers and participants for this study. Each had a minimum of five years of experience of teaching mathematics courses and/or methods courses for PSTs of mathematics. To replicate the co-teaching model used at our institution, Druken, who had taught the course previously, served as the mentor teacher and Marzocchi who was new to teaching the course in Fall 2017, took on the role of the teacher candidate, and a third colleague from the Department of Elementary and Bilingual Education served as their clinical coach and observed

several lessons in Fall 2017. Druken had taught the targeted course for seven semesters and Marzocchi taught it for the first time in Fall 2017. Marzocchi held a single-subject teaching credential with five years of teaching mathematics and computer science at a public high school.

The authors collaborated previously, including on lesson study experiences, conference presentations, and several semesters of co-planning courses together (Druken & Marzocchi, 2019; Druken et al., 2020). These established professional working relationships prior to co-teaching are important to note as other studies report on co-teaching efforts among teachers new to co-teaching or with little experience working together (e.g., Ferguson & Wilson, 2011).

Ethical considerations include that which is inevitable for researchers engaging in self-study: balancing the simultaneous roles of researcher and participant (Jaworski, 2001). The primary measure taken to address this tension was designating separate meetings for teaching and research. Teaching meetings focused on co-planning, reflection on teaching, assessment design, grading, and other teaching-related activities. Research meetings focused on study design, data collection, data analysis, interpretation of findings, and other research-related activities. Before the start of the research, we secured institutional review board approval for ethical human subject research. Informed consent was collected, and all participants participated voluntarily.

Data Collection

Types of data collected for this study include written journal reflections, observation protocol forms, videos, and lesson materials. Data were collected over two semesters, Fall (2017–2018). Data collected during Fall 2017 included: the MTEs' twice-weekly instructor journal entries (Ferguson & Wilson, 2011; Graziano & Navarrete, 2012) with reflections on the co-teaching process including planning, post-teaching, clinical coach observations; MTE journals that followed targeted lessons; three clinical coach journals that focused on the selected co-teaching strategy of Druken and Marzocchi; three completed focus planning visit forms; two completed POP cycle forms from the coach's lesson observations; two completed Mathematics Classroom Observation Practices Protocol forms from the coach (Gleason et al., 2017); two videos of instruction; and lesson planning materials. The two forms used by the coach were designed and used by the university's credentialing program to focus goals during planning and debriefing: the Focused Visit Form (see Appendix 1) and a Pre/Observation/Post Cycle (POP) form.

In Fall 2018, the MTEs each separately taught a section of the same Fall 2017 course each with an undergraduate apprentice who served as a new co-teacher. Data from Fall 2017 were used to guide selection of one exemplary lesson for each strategy in Fall 2018. Data collected during Fall 2018 included: MTEs' journal entries after targeted lessons and lesson planning materials. During Fall 2018 co-planning meetings, the team discussed the selection of co-teaching strategies. An attempt was made to enact at least one strategy per lesson, and to enact each strategy at least once throughout the semester. Soon after teaching the targeted lessons, each MTE journaled separately about: the rationale behind co-teaching strategy selection, a description of the activity using the strategy, the strategy's visibility to students, the affordances and limitations of the strategy, and any notable occurrences during the enactment of the strategy (see Appendix 2). The journal entries also recorded each targeted lesson's mathematics topic, teaching practices, and learning goals.

Data Analysis

Using an interpretive qualitative analysis (Elliott & Timulak, 2005), in Fall 2017 the authors compiled all MTE journal entries and coded them for evidence of co-teaching strategies. We paid particular attention to excerpts coded under "strategy", used while journaling to capture instances of a co-teaching strategy. We then constructed two tables to record all mentions of co-teaching strategies for each lesson. One table listed all lessons with co-teaching strategies used in each lesson, while the other table listed all seven co-teaching strategies with lessons that enacted each strategy. Both tables supported analysis of the strategy organisation and how to report them. Once compiled, we met to review all 27 lessons and chose seven of the lessons as a focus for Fall 2018—one for each co-teaching strategy. Once the

targeted lessons were chosen, the authors constructed an updated journal template guided by the research questions to document the use of each strategy for Fall 2018.

In Fall 2018, MTEs used the journal template for weekly reflections following the teaching of all targeted lessons. Weekly two-hour research meetings, in addition to weekly two-hour teaching meetings, allowed the authors to review individual journal entries, discuss both authors' observations, and make improvements for the next iteration of a co-teaching strategy. For example, if one author noted the importance of the mathematical learning goal during a particular enactment of one strategy, this was considered while planning for the next week's lessons. At the conclusion of Fall 2018 semester, all journal entries for chosen co-teaching strategies were compiled and aggregated in a table.

All journal entries were thematically coded to identify meaningful accounts of co-teaching strategies and their use (Hatch, 2002). Each author individually coded half of the journal entries. We collectively reviewed all codes to come to consensus on emerging themes. Since our research goal was to provide a comprehensive report of the selection and implementation of co-teaching strategies in a mathematics course for PSTs, the analysis did not involve frequency counts of each co-teaching strategy employed. Instead, we engaged in comprehensive reporting of the firsthand experience of the MTEs for each strategy. Thus, both MTEs' journal entries were carefully reviewed so that the findings were comprehensive. For example, if one MTE reported a particular limitation of a strategy but the second MTE did not, the limitation was still included in the results to provide the reader with information on factors for selecting and implementing co-teaching strategies.

Results

In this section, we detail each co-teaching strategy as implemented in a mathematics course for PSTs by describing the mathematics activity, the rationale for selection, and affordances and limitations of the strategy. Table 2 lists the strategies, the week each strategy was targeted, the topic covered, and the learning goal. Note that supplemental teaching was not targeted when planning for co-teaching.

Table 2
Summary of Lessons Selected for Each Co-teaching Strategy

Co-teaching Strategy	Week & Lesson Title	Topic	Learning Goal
One Teach, One Observe	Week 4 Subtraction Stories	Whole Number Operations	Use discrete and linear models to represent whole-number subtraction. Identify three different subtraction problem types.
One Teach One Assist	Week 2 Giant Venn Diagram	Sets as Basis for Whole Numbers	Interpret set notation in the context of Venn diagrams. Capture real-life contexts in Venn diagrams.
Station Teaching	Week 9 Introduction to Fractions	Fractions – Definition and Equivalence	Recognise and use three representations of fractions (discrete, linear, and area models). Understand $\frac{a}{b}$ as a copies of the unit fraction $\frac{1}{b}$. Specify the referent whole.
Parallel Teaching	Week 3 Andre's Apple Farm	Number Systems in Different Bases	Use manipulatives in a base-five system to better understand place value.
Supplemental Teaching	Not implemented		
Alternative Teaching	Week 10 Fraction Multiplication	Fraction Operations	Model fraction multiplication using discrete, area, and linear models
Team Teaching	Week 5 Lights! Camera! Division!	Whole Number Operations	Represent repeated subtraction and sharing division using discrete, linear, and area models.

One Teach One Observe

In Week 4, we used *One Teach One Observe* during a guided instruction segment of a lesson on subtraction problem types. According to the text used, the three problem types are called take away, missing addend, and comparison where each can be represented with two model types, discrete and linear. While co-planning for this lesson, the MTEs wrote targeted story problems featuring PSTs' names and interests as gathered on a pre-semester survey (See Figure 1). During the lesson, PSTs used a paper number line and a set of counting chips to model problems. MTE1 delivered instruction about the meaning of new vocabulary (e.g., take away subtraction, missing addend, and comparison subtraction) and showed exemplary story problems. She also invited PSTs to model solutions in front of the class. MTE2 actively observed the lesson, noting how MTE1 distinguished between problem types and model types.

Take Away	Missing Addend	Comparison
Leah owns ten plastic lawn flamingos, but unfortunately seven were stolen recently. How many plastic lawn flamingos does Leah have now?	While vacationing in Japan, Jonathan has a goal of visiting ten shrines. If he visited seven shrines so far, how many more does he need to visit to meet his goal?	If Cal swam for seven hours last weekend and their dog swam for ten hours, how many more hours did their dog swim than Cal?
Discrete model	Discrete model	Linear Model

Figure 1. Subtraction problems along with models used during *One Teach One Observe* to support subtraction operation understanding.

Rationale for selection

This lesson was the first of many that would focus on problem types and model types for different operations of whole number and rational numbers. Because of this, we wanted MTE2 to take an observer role during the first of a series of lessons to experience the content and common student questions that arise around subtraction type discussions. In doing so, MTE2 would solidify her own knowledge around these foundational concepts, observe methods for teaching and explaining the categories, and position her to take a more active role in a future lesson.

Affordances of strategy

Due to MTE2 not taking an active role in facilitating the lesson, she was able to focus on building her own understanding of the content and its teaching methods. This allowed MTE2 to focus on learning each subtraction conceptualisation and how to model it with both discrete (counting bears) and linear (number line) tools.

Limitations of strategy

One Teach One Observe is one strategy among others (*One Teach One Assist* and *Supplemental Teaching*) that might suggest that one MTE has more power than the other. Additionally, this strategy required conferencing before the lesson to discuss a focus of observations and meeting afterwards to debrief what the observing MTE noticed.

One Teach One Assist

In Week 2, we designed an activity to build PSTs' understanding of mathematical notation for sets. To set up for the lesson, MTEs went outside of the classroom building prior to the start of class and drew a giant Venn diagram on the walkway. While in the classroom, we explained that one circle represented people who like to sing and the other represented people who own dogs. PSTs were instructed to pair up. One partner would be responsible for physically moving around the giant Venn diagram while the other partner would be responsible for observing and taking notes on a recording sheet with multiple blank Venn diagrams. The class then went outside where MTE1 held up posters with set notation, such as $S \cup D$ (see Figure 2). PSTs who fit the indicated criteria, in this case dog owners or those who like to sing (or possibly both), moved to the appropriate region in the Venn diagram. MTE1 asked questions of PSTs standing in the Venn diagram while MTE2 rotated to the notetakers to ask questions and check for understanding. We headed back into the classroom to summarise and debrief the main ideas.

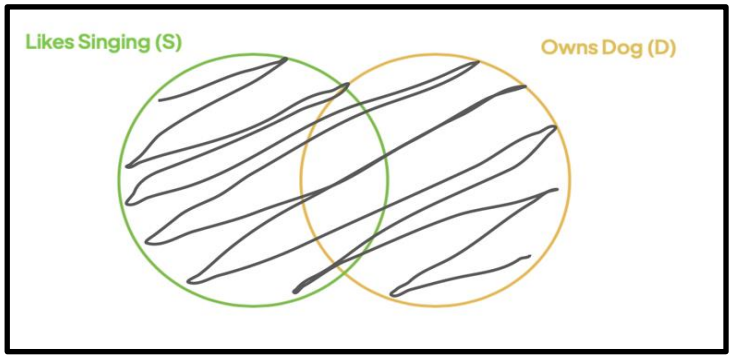

Figure 2. One task in the Venn Diagram activity asking students to physically locate themselves with respect to the characteristics, "Likes singing (*S*)" and "Owns a dog (*D*)."

Rationale for selection

One Teach One Assist was selected to help facilitate the many moving parts of this challenging set notation activity. MTE1 needed to deliberately select set notation signs, monitor the physical movement of the PSTs in and out of the Venn diagram, and instruct PSTs on what to do to facilitate the activity. It would have been challenging for MTE1 to also check PSTs' work on their recording sheets and extend

their understanding while asking questions and facilitating the lesson. It was thus appropriate for MTE2 to assist with this important task while MTE1 focused on the activity's physical implementation within the Venn diagram. Additionally, since MTE2 was the less-experienced teacher, her role of focusing on PSTs' understanding was an opportunity for continued learning about student thinking.

Affordances of strategy

One main advantage of this strategy was that MTE2 could focus on PST thinking in greater detail than one teacher could alone. For instance, MTE2 worked on establishing relationships with PSTs, studying their mathematical thinking about sets, and providing in-the-moment feedback to MTE1 about questions that arose from PSTs. In our implementation, MTE2 shared important misconceptions that she recognised to clarify for all PSTs. For example, some PSTs thought shading D was not to include its intersecting part with S, some PSTs thought the union of D and S did not include the intersection, and others believed that the complement of D only included things within $S \cup D$ (and not D), which disregards the complement of $S \cup D$. This activity was logistically demanding on MTE1, leaving her unable to monitor PST thinking adequately. MTE2 filled this important void.

Limitations of strategy

One Teach One Assist could solidify in PSTs' minds that MTE1 is the main or "real" teacher while MTE2 is secondary. This imbalance of authority could cause issues with classroom management in a K-12 classroom if students do not see the assisting co-teacher as holding the same power as the lead co-teacher. Additionally, if the assisting teacher does not have a focused role, they might miss an opportunity to learn about student thinking. For instance, asking MTE2 to examine how PSTs shaded their Venn diagrams helped to focus the MTE2's responsibilities while rotating around the students. Without a focus, this strategy risks being too broad and missing a learning opportunity for both the assisting co-teacher and the PSTs.

Station Teaching

In Week 9, the targeted lesson introduced a fractions unit and allowed PSTs to build an understanding of the meaning of fractions by rotating to three stations (see Figure 3). One independent station used a discrete model (counting bears) and reinforced the concept of specifying a whole. A teacher-led station made use of a linear model (clothesline number lines) and reinforced the concept of iterating unit fractions. Another teacher-led station used an area model (geoboards) and reinforced the concept of equal-sized pieces. PSTs started at an arbitrary station and rotated with their groups, spending 15-minutes at each station.

Station	Sample Task
Counting Bears	If the number of bears shown represents $\frac{1}{3}$ of a family of bears, how many bears are in half of the family? 
Number Line	After placing 0 and $\frac{3}{4}$ on a number line, precisely locate $\frac{7}{4}$.
Geoboards	Can you partition your geoboards into four parts? What about four equal parts? What about four non-congruent equal-sized parts?

Figure 3. Fraction tasks used during Station Teaching to develop conceptual fraction understanding.

Rationale for selection

This lesson was designed initially through a lesson study collaboration with colleagues in the Elementary and Bilingual Education department. We initially chose Station Teaching because we wanted PSTs to have hands-on experiences with three different types of models for fractions: linear, area, and discrete. Additionally, we wanted to target three foundational ideas regarding the meaning of fractions, which include the importance of specifying the whole (are we taking $\frac{3}{4}$ of 1 whole or of 2 wholes?), iterating unit fractions (that $\frac{3}{4}$ can be viewed as three copies of size one-fourth), and equal-sized pieces (that the four pieces that comprise $\frac{4}{5}$ must be equally sized although not necessarily congruent). We also recognised that these stations were not sequential, which is an important consideration for *Station Teaching*.

Affordances of strategy

A primary affordance of this co-teaching strategy was a lower student-to-teacher ratio. This allowed each MTE to engage with every PST while at a station. Non-verbal body language was more easily detected to support PSTs. It could be argued that this strategy increased PSTs' engagement because PSTs could not "hide"—they were one of a few at each station. Second, MTEs could understand one concept in depth since they repeated the activity to two or more groups of PSTs rotating through their station. It is also conjectured that physically moving around a room might support PSTs in learning a particular subject through active learning (Ratey, 2008). For example, weeks after the lesson, we witnessed PSTs pointing in a particular direction of the room to indicate a station that utilised number lines to unpack the meaning of fractions. Finally, fewer manipulatives were needed since not all PSTs use them simultaneously.

Limitations of strategy

One limitation was that the MTEs often could not study teacher questioning and PST reasoning at stations other than their own. This could be a missed learning opportunity for a newer co-teacher. Another limitation involved the required setup before class for the stations. Lastly, timing must be considered when facilitating the rotation of PSTs through multiple stations.

Parallel Teaching

In Week 3, we used a hands-on activity called Andre's Apples, adapted from Sowder et al. (2016), which builds PSTs' understanding of base-5 place valued numeration systems. The idea behind the task is the following: Andre picks five apples on his apple farm, which he puts in a bag. Five bags fill one basket, and five baskets fill one truck. The maximum number of apples in a bag is four, the maximum number of bags in a basket is four, and the maximum number of baskets in a truck is four. PSTs were asked to explore how individual apples are packaged on his farm, and how many apples are packaged in various situations (see Figure 4).

Sample Question	Mathematical Concept
1. Today Andre picked enough apples to load one truck, four baskets, and three bags. How many apples did he pick? Draw a diagram to justify your answer.	Base five to base ten
2. If Andre picks 508 apples, how many trucks, baskets, bags, and loose apples would that make? Draw a diagram to justify your answer.	Base ten to base five

Figure 4. Base five tasks used during Parallel Teaching to illuminate different base numeration systems.

To facilitate the activity, we split the 40-student class in half and arranged the desks into two mini-classrooms, one at the front and one at the back. Each MTE led the same activity at the same time with 20 PSTs. PSTs worked in groups to use physical manipulatives (counting bears, plastic bags, paper bags, and paper box lids) to bundle apples, simulating regrouping in fives. Each MTE rotated around her mini classroom to assess PST understanding and push their thinking. At times, each MTE called the attention of her full mini class to give instructions, provide clarification, or ask a question of all PSTs.

Rationale for selection

We chose *Parallel Teaching* for this activity to lower the student-to-teacher ratio. Pilot data from a past semester indicated that PSTs had many questions on this challenging topic. The strategy also gave MTE2 the opportunity to lead an activity early in the semester with a smaller group of PSTs. This strategy allowed each MTE to facilitate the same activity with 20 PSTs rather than 40.

Affordances of strategy

The main affordance of Parallel Teaching came from the lower student-to-teacher ratio. This allowed each MTE to attend more closely to PST thinking, feel more comfortable and available to PSTs, and provide informal assessment and immediate feedback. It might also give PSTs increased bravery to speak aloud in front of a smaller group of peers. A second affordance was allowing for gradual induction to teaching for the less-experienced MTE. The ability to directly model the enactment of an activity side-by-side using visual cues from MTE1 helps MTE2 to grow pedagogically. As one MTE journaled, "This seems like a nice 'transition' co-teaching strategy because it gives the [less experienced teacher] a more active role in leading instruction than strategies like One Teach One Observe and One Teach One Assist but it is not whole-class instruction just yet."

Limitations of strategy

This strategy sometimes engendered a noisy classroom. PSTs had to tune out the other MTE's voice while engaging in the mathematical activities. It also took time to arrange the classroom furniture conducive to two mini-classrooms. Further, this strategy did not allow the MTEs to exchange in-the-moment reflections. Thus, one MTE was left alone on her side of the room when an issue arose. Finally, it was challenging to ensure both MTEs timed their lesson similarly. This ran the risk of half of the class being further along than the other half.

Supplemental Teaching

When embarking on this project, we sought to experience all co-teaching strategies in our guiding framework (see Table 1). Yet, *Supplemental Teaching* was never selected during our co-planning. Our pilot study findings suggested that co-teaching strategies should not be forced but rather selected to support the learning goals best. We were concerned about separating PSTs based on course performance and determined this might harm PSTs if others perceived them as "low" students who were not doing well in the class. Consequently, we did not explicitly use this strategy during class time. Instead, we encouraged PSTs to attend office hours or review sessions.

Alternative Teaching

In Week 10, the lesson used linear and area model types to build conceptual fraction multiplication understanding. In this activity, all PSTs worked with the same numerically equivalent expressions (e.g., $\frac{1}{2} \times \frac{1}{4}$ and $2\frac{1}{3} \times \frac{1}{4}$). The difference came when PSTs selected the story situation that was more engaging for them: selling cornbread for a school fundraiser or running laps around a track with friends (See Figure 5). One MTE facilitated the lesson around the cornbread task, strategically designed to use an area model, while the other MTE facilitated the lesson around the track task, strategically designed to use a linear model. This is an example of *Alternative Teaching* because all PSTs worked towards the same learning goal but had a choice in how they experienced the lesson. After working on their selected tasks, PSTs returned to their groups to share what they learned with their peers.

Track (Linear Model)	Cornbread (Area Model)
Task 1: Andi and Christine are running around the track after school. One lap around the track is $\frac{1}{4}$ mile. Andi runs half a lap. How far did she run?	Task 1: Michelle is selling cornbread for a school fundraiser. Armando approaches the table and sees there is $\frac{1}{4}$ of a pan left. He tells Michelle he would like to purchase half of what is left. What fraction of the original whole pan did Armando purchase?
Task 2: Christine is feeling energetic and ends up running $2\ \frac{2}{3}$ laps around the $\frac{1}{4}$ mile track. What distance did Christine run?	Task 2: Ms. Cranberry, the math teacher, approaches Michelle's fundraising table and sees $\frac{1}{4}$ of a pan left. She asks if she can place an order for $2\ \frac{2}{3}$ as much cornbread as what is left. What fraction of a full pan is Ms. Cranberry ordering?

Figure 5. Multiplication tasks used during Alternative Teaching to elicit problem types and model types.

Rationale for selection

When planning this lesson, we knew we wanted to focus on two different model types, linear and area. We thought it beneficial for half the PSTs to work with each model, and then teach their model to the other half. Rather than arbitrarily assigning PSTs to one model or the other, we decided to pique PSTs' interest by allowing them to choose the more engaging context. In this way, PSTs were working towards the same learning goal, but they had a choice in how they experienced the lesson.

Affordances of strategy

One main affordance was the opportunity to introduce student choice into the lesson. Having PSTs choose which context they wanted to explore seemed to increase engagement. PSTs were additionally responsible for teaching one another and asking questions since not everyone chose the same context. Like other strategies, *Alternative Teaching* also lowered the student-to-teacher ratio.

Limitations of strategy

One limitation of this strategy also coincided with the affordance—not every student was on the same page due to contexts chosen. This could introduce a challenge in facilitating coherent whole-class discussions or allow students to practice summarising and teaching the other half of the class. Like other strategies, each MTE focused deeply on one task, thereby missing learning opportunities about PST thinking around the other task.

Team Teaching

The co-teaching strategy for Week 5 was implemented during a lesson on whole number division that used two story problems to illustrate the difference between repeated subtraction and sharing division. *Team Teaching* was used during the guided instruction portion of the lesson that used PST solutions to build understanding around the two problem types (See Figure 6). Later in the lesson, PSTs made mini mathematics movies using their personal mobile devices to demonstrate understanding of each type. The MTEs also switched between lead teacher and secondary teacher roles during other portions of the lesson such as making announcements, sharing learning goals, giving instructions, summarising, and assigning homework.

Division Type	Story Problem	Units	Number Sentence
Repeated subtraction	There are 20 strawberries and each child will be given five. How many children will get strawberries?	Total ÷ size of each group = number of groups	20 ÷ 5 = 4
Sharing division	There are 20 strawberries and five children want to share them equally. How many strawberries will each child get?	Total ÷ number of groups = size of each group	20 ÷ 5 = 4

Figure 6. Division tasks used during Team Teaching lesson to show differences between problem types and model types.

Rationale for selection

This lesson was suitable for *Team Teaching* because there were two categories of division problems. We decided to parse the lesson so that MTE1 led discussions about repeated subtraction and MTE2 led discussions about equal sharing. This worked well because MTE2 could hear what MTE1 said about one problem type, providing a model for what MTE2 would share. In addition to considering mathematics while selecting this co-teaching strategy, we also selected this strategy for reasons related to power and authority of MTE2. MTE2 had taken fewer active roles in the previous two lessons where we used *One Teach One Assist* and *One Teach One Observe* strategies. We were concerned that she might be seen as an aide or assistant rather than as an equal co-teacher. We determined this would be a good strategy for re-establishing MTE2 as a co-teacher in our classrooms since a secondary teacher may appear to the PSTs as "equal" to the lead teacher in Team Teaching.

Affordances of strategy

One affordance of this strategy was establishing MTE2's power and authority. In our context, MTE1 previously taught the class while MTE2 had not. With this strategy, we perceived that PSTs viewed the co-teachers as equal teachers. Another affordance was the ability to stay focused on learning goals. For example, during planning MTEs wanted to connect sharing division to the action of dealing cards one by one. When one MTE forgot to mention this, the other stepped in to model the card scenario. Additionally, the MTEs conjectured that team taught lessons were more engaging since the two MTEs alternated, each using different explanations, gestures, and tone of voice.

Limitations of strategy

One limitation is that *Team Teaching* took prior coordination during co-planning and the lesson, which might not always be feasible. Some parts of the lesson were easy to partition and share, while others were more challenging. When PSTs asked questions, in-the-moment decisions needed to be made that might have important consequences for how PSTs perceive each MTE. Both MTEs journaled about the experience of finding balance of authority. MTEs need to be willing to address issues of power and expertise and address them openly to allow for a collaborative lesson (Ferguson & Wilson, 2011). MTEs found developing relationships among each other to be important so that both felt comfortable taking risks and giving feedback.

Discussion

This qualitative study investigated the implementation of a co-teaching framework in the context of a mathematics course for PSTs. By reporting on factors used while selecting co-teaching strategies during co-planning, discussing lesson implementation, and describing affordances and limitations to consider with each strategy, we document MTE experiences of co-teaching in the university mathematics course for PSTs. This is important since previous co-teaching research has focused on the experience and process involved with co-teaching (e.g., Ferguson & Wilson, 2011; Graziano & Navarrete, 2012; Hiesh & Nguyen, 2015) rather than its implementation (see Dynak et al., 1997 for an exception). This account of

MTEs unpacking our teaching practice provides insights and factors for consideration to other faculty who co-teach mathematics courses for PSTs.

We found four themes from our research on factors for selecting co-teaching strategies. One theme included the importance of considering the learning goal, such as leveraging *Station Teaching* to emphasise three different model types. A second theme included attending to the current level of co-teaching understanding for each MTE. If one of the co-teachers is new to teaching the course, strategies like *One Teach One Observe* and *One Teach One Assist* might allow for more in-the-moment conversations with fellow co-teacher as compared to *Station Teaching* or *Parallel Teaching* when co-teachers facilitate their own group of students. A third theme included considering opportunities for student and teacher interactions – *One Teach One Assist*, for example, allowed the assisting teacher to intentionally rotate to all students, resulting in the co-teacher collecting data on how students learn a particular mathematical concept. Studies like Downton et. al (2018) described greater engagement, individualised instruction and assistance with two teachers in the classroom. The last theme considered while planning for co-teaching was to consider the setup of the physical learning space. Sometimes it took time and preparation to set the room up for the specific co-teaching strategy (e.g., *Station Teaching*) or resulted in a loud learning environment (e.g., *Parallel Teaching*).

In addition to factors documented during the planning for co-teaching strategies, factors were also found when implementing co-teaching strategies. The first implementation theme was to consider the learning goals of the lesson. In the case of *Alternative Teaching,* we were able to target both desired learning outcomes for understanding multiplication of whole numbers—one with the number line model and a second with the area model. In the case of *Team Teaching*, we partitioned teaching responsibilities based on the two mathematical learning goals around division of whole numbers—sharing (also referred to as partitive) division and repeated subtraction (also referred to as quotative) division. A second theme was to choose a co-teaching strategy based on desired co-teacher learning. It may be the case that one of the co-teachers wants to analyse closely students' thinking—in this case a strategy like *One Teach One Observe* or *One Teach One Assist* would support this goal. If a co-teacher wants to practice facilitating their portion of the lesson several times, a strategy like *Station Teaching* would support this goal. A third theme was the recognition of the negotiating of power and authority across teachers. We were cognisant that students may be confused about who is the course leader and wanted to ensure early on that students saw both instructors in positions of power. Other studies cite the importance that differences in positions can afford to students in co-taught classrooms (e.g. Downton et. al, 2018). In future research, we plan to collect student data to analyse perspectives on how co-teaching strategies are perceived by students. Finally, like in planning for co-teaching, the last theme was to consider the logistics, such as number of manipulatives, while teaching.

There were commonalities across the seven strategies in what each afforded the instructors. *One Teach One Observe* was useful for building MTEs' understanding of how to teach the course, along with *Station Teaching*, which allowed MTEs rich insight into the day's lesson from multiple iterations of the activity. *Parallel Teaching* was useful for gradually inducting the less experienced MTE into the role of lead MTE. *One Teach One Assist* allowed for a strong focus on student thinking. *Station Teaching* and *Parallel Teaching* both lowered the student-to-teacher ratio, with *Station Teaching* also increasing student engagement. *Team Teaching* allowed for alignment of learning goals to activities and interactions with students and supported sharing power and authority equally across both MTEs. *Team Teaching, One Teach One Observe*, and *One Teach One Assist* provided time for MTEs to briefly conference during the lesson, sharing in-the-moment reflections around student thinking, learning goals, and other important components of the lesson.

We also found common limitations across co-teaching strategies. Some strategies might not be effective without a focus, such as lacking a specific student observation goal with *One Teach One Assist*. Other strategies were found to require extensive prior planning and time to coordinate responsibilities, such as *One Teach One Observe* and *Team Teaching*. Some strategies required increased physical setup time, such as *Station Teaching* and *Parallel Teaching*, or might create a noisy learning environment that might make it difficult for some students to focus, like *Parallel Teaching*. Coordinating the pace of the lesson might be difficult with *Alternative Teaching, Parallel Teaching*, and *Station Teaching* due to

splitting students by MTE. MTEs may need to negotiate power and authority in the classroom when using strategies like *One Teach One Observe* and *Team Teaching*. Another common limitation was whether the MTEs had time to conference during the lesson (*Team Teaching, One Teach One Observe,* and *One Teach One Assist*) or whether each MTE could access shared in-the-moment thoughts. This might be more challenging with strategies like *Station Teaching, Parallel Teaching,* and *Alternative Teaching* where each co-teacher has more autonomy with their subset of students.

Implications for faculty, teacher candidates, and mentor teachers alike include attending to the learning goals, being mindful of opportunities for teacher-to-student interactions, negotiating power and authority across teachers in the classroom, and considering logistics like time and room arrangement. Teachers who wish to implement co-teaching strategies should consider the affordances and limitations of each strategy—*Parallel Teaching* decreases the student-to-teacher ratio but may limit the co-teachers of opportunities to learn from each other during instruction. Above all, co-teachers should attend to the learning goal and select the strategy that best supports students in meeting the goal. While this research was conducted in the context of mathematics education, teacher educators of all subjects could benefit from a collaborative form of inquiry such as co-teaching.

Limitations and Future Work

While we believe this qualitative study is important for documenting MTEs' experiences with the co-teaching framework in the context of a mathematics course for PSTs, it has several limitations. First, our study reports on only one instantiation of each of the six co-teaching strategies. Future work could explore in greater depth how one strategy might unfold across more lessons. Second, our study of a single co-teaching team for each strategy was not designed to address the relationship between co-teaching selection and student learning, nor did it report on classroom observation data. Collecting data on student perspectives would be powerful to examine our conjectures about *Alternative Teaching* supporting student agency, or whether students experienced greater support in co-teaching environments that lower the student-to-teacher ratio, such as *Station Teaching* and *Parallel Teaching*.

Some research has documented such relationships. Strogilos and King-Sears (2018), after noting the limited research on students' perspectives of co-teaching, described and evaluated the perspectives of middle school students with and without disabilities and their co-teachers. King-Sears et al. (2014) examined perceptions from high school students with disabilities in a co-taught earth science classroom, and the extent to which they aligned with the co-teachers' perceptions of co-teaching. King-Sears et al. (2018) examined how middle school Algebra co-teachers and their students, including students with and without disabilities, perceive co-teaching. Future research studying the link between co-teaching instructional practices and PSTs' mathematical learning and perspectives would provide more nuance and breadth to this research.

Conclusion

The aim of this study was to document how two mathematics teacher educators used co-teaching strategies to better understand implications in its use within a university mathematics course for PSTs. Results revealed important accounts of the selection and implementation of co-teaching strategies across six mathematics lessons for PSTs, including selection rationale, affordances, and limitations. When planning for co-teaching strategies, this study documented considerations made by MTEs, including a strong focus on learning goals, the role of each MTE, opportunities for student and teacher interactions, and the setup of the classroom. For implementing co-teaching strategies, this study documented factors such as the importance of mathematical learning goals, opportunities for co-teacher learning, negotiating power and authority across teachers, and logistical considerations.

Each co-teaching strategy was found to have affordances and limitations, making it critical for MTEs to anticipate this at the onset of a co-teaching experience. Specific recommendations for university faculty planning for co-teaching PSTs include to consider the mathematical learning goals so that a

suitable strategy can be selected, to make explicit the role and familiarity each MTE has with co-teaching, to prioritise student and teacher interactions, and to be intentional and reasonable with what is achievable within the physical learning space. Recommendations for university faculty co-teaching PSTs include to consider the learning goals, the desired co-teacher learning, the negotiation of power and authority across co-teachers, and logistical issues.

Corresponding author

Bridget Kinsella Druken
California State University, Fullerton
800 N. State College Blvd.
Fullerton, CA 92831
United States
bdruken@fullerton.edu

Acknowledgements

The authors thank Amber Mitchell and Kikey Ramos, who went on to earn their high school mathematics teaching credentials, for participating as co-teachers with the authors as part of their undergraduate apprenticeship program at California State University, Fullerton and their consistent support for engaging in co-teaching.

Funding

This research was supported by the Titan EDUCATOR grant.

Ethical approval

Ethical approval for the research was granted by the Institutional Review Board at California State University, Fullerton, and informed consent was given by all participants for their data to be published.

Competing interests

The authors declare there are no competing interests.

References

Bacharach, N., Heck, T. W., & Dahlberg, K. (2010). Changing the face of student teaching. *Action in Teacher Education*, *32*(1), 3–14. https://doi.org/10.1080/01626620.2010.10463538

Bacharach, N., Heck, T. W. & Dahlberg, K. (2008). Co-Teaching in higher education. *Journal of College Teaching & Learning*, *5*(3), 9–16. https://doi.org/10.19030/tlc.v5i3.1298

Butler, E., Prieto, E., Osborn, J., Howley, P. Lloyd, A., Kepert, A., & Roberts, M. (2019). Learning across discipline boundaries through narrative inquiry: A study of collaboration to improve mathematics teacher education. *Mathematics Teacher Education and Development*, *21*(2), 87–105.

Cook, L., & Friend, M. (1995). Co-teaching: Guidelines for creating effective practices. *Focus on Exceptional Children, 28*(3), 1–16. https://eric.ed.gov/?id=EJ545936

Downton, A., Muir, T., & Livy, S. (2018). Linking theory and practice: A case study of a co-teaching situation between a mathematics teacher educator and a primary classroom teacher. *Mathematics Teacher Education Development, 20*(3), 102–118. https://eric.ed.gov/?id=EJ1195986

Druken, B. K., & Marzocchi, A. S. (2019). Strings, bears, & boards: Making fractions meaning-filled. *Ohio Journal of School Mathematics, 83(*1), 54–60.

Druken, B. K., Marzocchi, A. S., & Brye, M. V. (2020). Facilitating collaboration between mathematics methods and content faculty through cross-departmental lesson study. *International Journal for Lesson and Learning Studies, 10*(1), 33-46. https://doi.org/10.1108/IJLLS-06-2020-0033

Dynak, J., Whitten, E., & Dynak, D. (1997). Refining the general education student teaching experience through the use of special education collaborative teaching models. *Action in Teacher Education*, *19*(1), 64–74. https://doi.org/10.1080/01626620.1997.10462855

Elliott, R., & Timulak, L. (2005). Descriptive and interpretive approaches to qualitative research. In J. Miles & P. Gilbert (Eds.), *A handbook of research methods for clinical and health psychology* (pp. 147–159). Oxford Academic. https://doi.org/10.1093/med:psych/9780198527565.001.0001.

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. https://eric.ed.gov/?id=EJ942564

Gleason, J., Livers, S. & Zelkowski, J. (2017). Mathematics classroom observation protocol for practices ($MCOP^2$): A validation study. *Investigations in Mathematics Learning, 9*(3), 111–129. https://doi.org/10.1080/19477503.2017.1308697

Goos, M., & Beswick, K. (Eds.). (2021). *The learning and development of mathematics teacher educators: International perspectives and challenges*. Springer International Publishing. https://doi.org/10.1007/978-3-030-62408-8

Graziano, K. J., & Navarrete, L. A. (2012). Co-teaching in a teacher education classroom: Collaboration, compromise, and creativity. *Issues in Teacher Education*, *21*(1), 109–126. https://eric.ed.gov/?id=EJ986819

Hatch, A. (2002). *Doing qualitative research in education settings*. State University of New York Press. https://sunypress.edu/Books/D/Doing-Qualitative-Research-in-Education-Settings2

Hiesh, B., & Nguyen, H. (2015). Co-Teaching, co-leading, co-learning: Reflection on the co-teaching model in practicum. *Teaching and Learning Together in Higher Education*, *1*(14), 1–9. https://repository.brynmawr.edu/tlthe/vol1/iss14/7/

Jaworski, B. (1998). Mathematics teacher research: Process, practice, and the development of teaching. *Journal of Mathematics Teacher Education, 1,* 3–31.

Jaworski, B. (2001). Developing mathematics teaching: Teachers, teacher educators, and researchers as co-Learners. In F. L. Lin & T. J. Cooney (Eds.), *Making sense of mathematics teacher education* (pp. 295–320). Springer. https://doi.org/10.1007/978-94-010-0828-0_14

Jaworski, B. (2008). Development of the mathematics teacher educator and its relation to teaching development. In B. Jaworski & T. Wood (Eds.), *International handbook of mathematics teacher education: Vol. 4 The mathematics teacher educator as a developing professional.* Sense Publishers.

Kamen, M., Junk, D. L., Marble, S., Cooper, S., Eddy, C. M., Wilkerson, T. L., & Sawyer, C. (2011). Walking the talk: Lessons learned by university mathematics methods instructors implementing lesson study for their own professional development. In L. C. Hart, A. S. Alston, & A. Murata (Eds.), *Lesson study research and practice in mathematics education* (pp. 165–174). Springer. https://doi.org/10.1007/978-90-481-9941-9

King-Sears, M. E., Jenkins, M. C., & Brawand, A. E. (2018). Co-teaching perspectives from middle school algebra co-teachers and their students with and without disabilities. *International Journal of Inclusive Education*, *24*(4), 1–16. https://doi.org/10.1080/13603116.2018.1465134

King-Sears, M. E., Brawand, A. E., Jenkins, M. C., & Preston-Smith, S. (2014). Co-teaching perspectives from secondary science co-teachers and their students with disabilities. *Journal of Science Teacher Education, 25*(6), 651–680. https://doi.org/10.1007/s10972-014-9391-2

Lam, C., Danforth, M., & Hughes, R. (2020 June). *Lessons from a lower-division mathematics co-teaching sequence*. Paper presentation at the 2020 ASEE Virtual Annual Conference Content Access, Virtual Online. https://doi.org/10.18260/1-2--34907

Livy, S., Downton, A., & Muir, T. (2017). Developing pre-service teachers' knowledge for teaching in the early years: Selecting and sequencing. *Mathematics Teacher Education and Development, 19*(3), 17–35.

Lock, J., Clancy, T., Lisella, R., Rosenau, P., Ferreira, C., & Rainsbury, J. (2016). The lived experiences of instructors co-teaching in higher education. *Brock Education Journal, 26*(1), 22–35. https://doi.org/10.26522/brocked.v26i1.482

Mackenzie, N., & Knipe, S. (2006). Research dilemmas: Paradigms, methods and methodology. *Issues in Educational Research, 16*(2), 193–205. http://www.iier.org.au/iier16/mackenzie.html

Mariano-Dolesh, M. L., Collantes, L. M., Ibanez, E. D., & Pentang, J. T. (2022). Mindset and levels of conceptual understanding in the problem-solving of preservice mathematics teachers in an online learning environment. *International Journal of Learning, Teaching and Educational Research, 21*(6), 18–33. https://doi.org/10.26803/ijlter.21.6.2

Muir, T., Bragg, L, & Livy, S. (2018). Engagement and impact: A focus on mathematics teacher educators' studies into practice. *Mathematics Teacher Education Development, 20*(3), 1–9. https://mted.merga.net.au/index.php/mted/article/view/495

Ratey, J. J. (2008). *Spark: The revolutionary new science of exercise and the brain*. Hachette Book Group. https://www.hachettebookgroup.com/titles/john-j-ratey-md/spark/9780316113502/

Sebald, A. M., Howe, J., & Balgopal, M. M. (2022). The impact of co-teaching on the professional practices of veteran, novice, and potential science and mathematics teachers. *School Science and Mathematics*, *122*(1), 4–15. https://doi.org/10.1111/ssm.12508

Sowder, J., Sowder, L., & Nickerson, S. (2014). *Reconceptualizing mathematics.* W. H. Freeman.

Strogilos, V., & King-Sears, M. E. (2018). Co-teaching is extra help and fun: Perspectives on co-teaching from middle school students and co-teachers. *Journal of Research in Special Educational Needs, 19*(2), 92–102. https://doi.org/10.1111/1471-3802.12427

Weinberg, A. E., Sebald, A., Stevenson, C. A., & Wakefield, W. (2020). A scoping review of coteaching in teacher education. *The Teacher Educator*, *55*(2), 190–213. https://doi.org/10.1080/08878730.2019.1657214

Yopp, R. H., Ellis, M. W., Bonsangue, M. V., Duarte, T., & Meza, S. (2014). Piloting a co-teaching model for mathematics teacher preparation: Learning to teach together. *Issues in Teacher Education, 23*(1), 91–111. https://eric.ed.gov/?id=EJ1045811

Appendix 1: Focused Visit Form

***Focused Coaching Visit instructions*:** The Clinical Coach will use this form during 15-20 minute focused visit. When the focused visit is complete, the Clinical Coach will fill out the appropriate and selected target and focus areas in Section 2. The clinical coach will email the form to the teacher candidate within a 24-hour period.

Section 1: Candidate Information				
Teacher Candidate	**CWID**	**Subject Area**	**Semester**	**Date of Visit**
Cooperating Teacher	**School/District**	**Clinical Coach**		
Grade Level	**Content Standard and Lesson Objectives**	**Unit topic**	**Lesson Title**	

Learning Goal: To support the development of professional skills and dispositions		
Teaching Performance Expectations		
TPE 1: Engaging and Supporting All Students in Learning **TPE 2:** Creating and Maintaining Effective Environments for Student Learning	**TPE 3:** Understanding and Organizing Subject Matter for Student Learning **TPE 4:** Planning Instruction and Designing Learning Experiences for All Students	**TPE 5:** Assessing Student Learning **TPE 6:** Developing as a Professional Educator

Section 2: (Based on TPE's)	**Observation notes with explicit support/suggestions from Clinical Coach**
I. ESTABLISHING A LEARNING SET: a. presents lesson objectives b. provides rationale for lesson c. relates lesson to previous lesson d. relates material to student interests e. gains student attention at beginning of lesson	
II. LESSON DESIGN AND DEVELOPMENT: **a.** starts class promptly and has materials ready **b.** relates teacher input to lesson objective **c.** emphasizes key points **d.** keeps students alert and accountable **e.** models task or activity **f.** provides guided practice **g.** provides corrective feedback **h.** provides internal and concluding summaries **i.** plans differentiated instruction	
III. (Co-)TEACHING STRATEGIES: a. ensures that strategies are appropriate b. accommodates different learning styles c. makes instructional adaptations d. allows students time to respond e. probes for clarification, elaboration f. presents material in a logical sequence g. provides comprehensible input for all levels of EL	
IV. TEACHER-STUDENT COMMUNICATION: a. provides clear and concise directions	

b. uses vocabulary appropriate for all learners c. uses the English language orally and in writing with no errors d. supports verbal messages with non-verbal cues e. demonstrates enthusiasm	
V. CLASSROOM CLIMATE: a. effectively manages the classroom b. creates a positive climate for learning c. builds positive self-concept d. encourages cooperation e. communicates high expectations	
VI. ASSESSMENT: a. uses progress monitoring during instruction b. checks for understanding c. uses informal and formal assessments	

Section 3: Target(s) Growth Areas

☐ Held check-in with teacher candidate

☐ Held check-in with mentor teacher

Converted form to PDF and emailed teacher candidate on:

Appendix 2: Instructor Journal Template

This is the template used to collect data.

Lesson [Update] during Week [Update]

1. Date of lesson enactment / timeline:
2. Math topic & practices (link to CCSS):
3. Learning goals:
4. Co-teaching strategy selected:

Individual Responses

1. Why did we select this strategy?
2. Did we consider any other strategies?
3. Describe the activity that made use of this coteaching strategy.
4. How is this strategy visible to students (e.g., set up of classroom, interactions with co-teachers)?
5. Affordances?
6. Limitations?
7. Were there any verbal exchanges between students and/or between co-teachers that highlight a neat aspect of this strategy? Provide play-by-play example.