Professional Development to Support Elementary Mathematics and Co-teaching Practices: Collaborations Between General and Special Education

Kristin E. Harbour
University of South Carolina

Stefanie D. Livers
Missouri State University

Sara C. McDaniel
The University of Alabama

Jim Gleason
The University of Alabama

Joan M. Barth
The University of Alabama

Received: June 3 2022 Accepted: November 4 2022

Professional development is necessary to support and empower teachers in meeting the high stakes demands of mathematics teaching and to ensure equitable, accessible, and high-quality instruction for all students. Using the Interconnected Model of Professional Growth, we designed and implemented a longitudinal, multi-faceted professional development project for teams of elementary general education and special education educators to enhance instruction in their inclusive elementary mathematics classrooms. Focused on high-quality mathematics tasks and co-teaching models, we explored changes in both instructional and collaborative practices. Findings indicated statistically significant increases in educators' mathematics content knowledge and pedagogical content knowledge. Additionally, statistically significant improvements in observed teacher facilitation, student engagement, and co-teaching practices were found. Implications for practice and research are discussed.

Keywords: · mathematics teacher education research · education research · elementary school · mathematics · professional development · special education

Introduction

The stressful demands of high stakes accountability and classrooms of diverse learners require teachers to abandon a universal, untailored approach to teaching and learning (Gregory & Chapman, 2002; Tomlinson, 2017). The steadily growing number of students with identified disabilities served in general education classes (Office of Special Education and Rehabilitative Services, 2018) necessitates mathematics instruction be designed to provide access to meaningful learning opportunities for all students (National Council of Teachers of Mathematics [NCTM], 2014). In the United States of America, the transition from *No Child Left Behind Act* (2002) to *Every Student Succeeds Act* (2015) coupled with the *Individuals with Disabilities Education Act* (2004) further solidified the need to prepare all students for a successful future.

Research, however, indicates that students from historically marginalised groups (e.g., students of colour and students with identified disabilities) are provided fewer opportunities for equitable and effective mathematics teaching and learning (Flores, 2007; Lampert & Tan, 2017; Tan, 2016). Moreover, students with identified disabilities are often provided instruction focused mostly on basic skills and procedural knowledge (Lampert & Tan, 2017; Tan, 2016), and lack a focus on evidence-based practices such as mathematical discourse and high-quality mathematics tasks (e.g., McKenna et al., 2015; NCTM, 2014; Stein et al., 2009). Without a centralised focus on the pervasive issue of opportunity gaps for historically marginalised students this vision for access and equity in mathematics teaching and learning for all students may be at jeopardy.

To accomplish this goal of equal access, many teachers may need to shift from traditional views of mathematics instruction to strategies and technologies that support the needs of all students through meaningful mathematics experiences (NCTM, 2014). Meaningful learning of mathematics includes a shift from instruction solely focused on procedures and rote steps to instruction focused on understanding and reasoning, while building procedural fluency through a conceptually based approach (e.g., NCTM, 2014; Spangler & Wanko, 2017). Instructional shift often creates a crossroads of uncertainty, as teachers may not be prepared for changes in content and practice (Spangler & Wanko, 2017; Swars & Chestnutt, 2016). For instance, general education teachers have reported feeling uncertain in their knowledge of ways to support the learning of students with identified disabilities, and special education teachers may lack mathematics content knowledge and/or knowledge of mathematics teaching reforms (e.g., Maccini & Gagnon, 2002, 2006). Additionally, general and special education teachers may have differing instructional philosophies and approaches regarding mathematics instruction (Greenstein & Baglieri, 2018). Therefore, it is critical that general and special education teachers collaborate to develop a common vision for effective and equitable instruction (Gregory & Chapman, 2002; Tomlinson, 2017).

Literature Review

High-quality Mathematics Tasks

High-quality mathematics instruction provides *all* students opportunities to engage in rich mathematical discussions, express their understanding in various ways and representations, and expand their conceptual understanding through sense-making and problem-solving (e.g., NCTM, 2014). Much of these high-quality learning opportunities hinge on the choice of the tasks explored during mathematics teaching and learning (Stein et al., 2009). Expectations rest with teachers being able to select high-quality tasks for students to engage with that allow students the opportunity to explore mathematical ideas in a real-world context.

Mathematical tasks can be defined by their cognitive demand or "the kind and level of thinking required of students to successfully engage with and solve the task (Stein et al., 2009, p. 1). For a task to be considered high-cognitive demand or high-quality, the task should provide opportunities for students to be occupied and invested in purposeful and complex mathematical thinking and reasoning (NCTM, 2014). High-quality tasks allow students to use multiple entry and exit points, encourages the use of different representations, requires analysis of the task and relevant knowledge, and often situates students within a productive struggle stance during the solving processes (e.g., NCTM, 2014; Stein et al., 2009). Of importance, we are not advocating that all mathematics instruction be of this cognitively demanding as there are instances that the mathematical goals of the lesson may not align with this type of instruction (Stein et al., 2009); however, research indicates the use of high-quality tasks in instruction is imperative for student achievement in mathematics (Jones & Pepin, 2016; Stein et al., 2009). Concerningly, research also indicates students are provided limited experiences with high-quality mathematics tasks, and even more so for students with disabilities (Lampert & Tan, 2017; Tan, 2016).

Co-teaching Practices

Co-teaching is a collaborative approach to serving students with and without identified disabilities in one classroom space where there are two or more classroom teachers/educators[1] who typically have different areas of expertise and teaching roles (Friend & Cook, 2017). Teacher teams can include general education teachers, special education teachers, instructional coaches, paraprofessionals (or teaching assistants), and even teacher candidates. Co-teaching, often viewed as an alternative to separate instruction (e.g., pull-out), provides students with expertise and support from two or more teachers/educators and interaction with same-age peers that would not exist in separate classroom settings (Pearl & Miller, 2007). Effective co-teachers co-plan, take the lead on different lesson components, share assessment procedures for all students, reflect, and evaluate their shared instructional practice (e.g., Murawski & Lochner, 2011). The benefits of co-teaching include (a) varying types of expertise and teaching styles, (b) lowering the student-to-teacher ratio, and (c) decreasing the stigma and labelling effect for students with disabilities (Solis et al., 2012). The primary co-teaching models include (a) one teach, one observe; (b) one teach, one assist; (c) parallel; (d) station; (e) alternative and (f) team teaching (Friend & Cook, 2017). Each co-teaching model requires varying levels of collaboration and cooperation between two or more teachers/educators responsible for all the parts of the co-teaching process. One common need for general and special teachers/educators is effective pre-service and in-service professional development to support these models of instruction and collaboration.

Effective Professional Development Opportunities

Professional development is a widely used practice to support the teaching and learning of mathematics and has been shown to positively impact student achievement (Brendefur et al., 2021; Hill et al., 2005), change teaching practices (Boston & Smith, 2011; Gee & Whaley, 2016; González & Vargas, 2020; Livers, 2022), and increase teacher efficacy (Stevens et al., 2013; Swackhamer et al., 2009). Designing professional development to influence teachers' instructional practice for mathematics can be a complex endeavor (Borko, 2004). For instance, part of the complexity of professional development planning and implementation is addressing the specific needs, demands, and motivations of teachers (Caddle et al., 2016; Desimone, 2009; Goos et al., 2007) and countering misconceptions that interfere with new learning (Weiss & Pasley, 2006).

Co-teaching professional development has shown to have a positive influence on confidence, interest, and attitudes about co-teaching for both general and special education teachers (Pancsofar & Petroff, 2013). Research suggests teachers' engagement with professional learning around co-teaching has a positive relationship with their knowledge about co-teaching and use of different co-teaching approaches (e.g., Pancsofar & Petroff, 2016). There is limited research regarding the influence of professional development in inclusive mathematics classrooms, wherein both mathematics and co-teaching are of focus, as well as professional development with both general and special teachers collectively. We highlight two studies; the first, by Faulkner and Cain (2013), found an increase in mathematical content knowledge for both the general and special education teachers. The second, by Griffin and colleagues (2018), led a yearlong professional development for general and special teachers and found it to impact both teacher practices and efficacy, mathematics content knowledge for teaching, and produced strong feelings of well-being or satisfaction.

Research highlights several findings related to effective professional development design. First, professional development should have a clear purpose with built in supports for learning (Darling-

[1] We use the term teacher to refer to certified teachers, and the term educator to refer to non-certified teachers, such as paraprofessionals.

Hammond et al., 2017; Guskey, 2000; Ingvarson et al., 2005; Joyce & Showers, 2002). Second, specific content focused professional development that provides a concrete context yields better results compared to general professional development related to multiple content areas (Darling-Hammond et al., 2017; Desimone, 2009; Ingvarson et al., 2005). Third, professional development should include activities that foster collaboration, conversations, and peer interactions (Darling-Hammond et al., 2017; Desimone, 2009; Joyce & Showers, 2002). Last, for increased sustainability and implementation, professional development needs to be sustained over time (Desimone, 2009). Informed by these best practices, applied to mathematics instruction across co-teaching and high-quality tasks, our project builds upon this prior research by creating a space in which general and special teachers/ educators learn, collaborate, and teach together to provide all students access to high-quality mathematics learning opportunities.

Teacher Learning and Theoretical Framework

Teacher learning is a complex, multi-faceted experience. Drawing on the *theory of change,* we view teacher learning and growth not in a linear process, but dependent on an integrated bundle of factors, influences, and contexts. Fullan (1992) shifted the view of teacher learning from targets needing reform to partners within the process. For this partnership to produce change, four elements needed to be present (1) investment and participation, (2) expectations and accountability for change at the local level (e.g., school and district administration), (3) changes in teachers' practices, beliefs, and efficacy around these new practices, and (4) authority for growth and change. The complexity of teacher learning includes the context and systems in which the teacher works, Fullan noted the need for pressure and support at the local level, but further analysis would include an understanding of the local context in which the learning is occurring (Goos et al., 2007; Opfer et al., 2011). Moving away from a linear view of professional learning, Clarke (1988) describes teacher learning as cyclic with multiple entry points or points of engagement. Knowledge, practices, and contexts influences teacher learning and engagement with new learning experiences (Novak & Knowles, 1992; Opfer et al., 2011). To plan a professional learning experience based on theory of change, we were intentional in choosing a complimentary framework for the professional development project.

The Interconnected Model of Professional Growth (Clarke & Hollingsworth, 2002) provided the theoretical framework for the current project and a holistic vision of the environment that influences teacher change. The Interconnected Model of Professional Growth is a comprehensive framework for teacher development, recognizing multiple ways of change through growth and learning. The framework consists of four domains of change within growth networks: (1) personal, including knowledge, efficacy, beliefs, and attitudes, (2) external, including sources of information or stimulus, (3) practice, including professional or instructional strategies, and (4) consequence, including outcomes or results. The domains are interconnected, and change occurs within these four domains due to "reflection" and "enaction" (Clarke & Hollingsworth, 2002, p. 951). Prior research has used the same theoretical underpinnings to study peer coaching (Zwart et al., 2007), lesson study (Widjaja et al., 2017), and professional development (Hilton et al., 2015; Perry & Boylan, 2018) on teacher learning and change.

Our project's professional development serves as the external domain influence. The external domain differs from the other three domains in that it occurs outside of the teacher's instructional practice, but it can spark changes with knowledge, efficacy, beliefs, and attitudes (personal domain), and/or instructional practice (domain of practice), or in student or teaching outcomes (domain of consequence). We included elements that recognise the necessity for social collaborations and interactions (Clarke & Hollingsworth, 2002) as the act of processing with others enhances the reflection activities and increases teacher learning and change (Borko, 2004). We realise that professional development is only meaningful if it creates the environment of change, as the domains of change within the growth network are complex and intertwined.

Purpose and Research Questions

The purpose of the current study was to explore how a two-year professional development project centred on improving the teaching and learning of mathematics in inclusive elementary classrooms related to the knowledge, practice, and efficacy of general and special educators. Specifically, the study aimed to answer the following research questions:

1) What was the relationship between the professional development project and educators' mathematics knowledge (i.e., mathematics content knowledge and mathematics knowledge for teaching)?
2) What was the relationship between the professional development project and educators' observed classroom practices (i.e., teacher facilitation and co-teaching practices)?
3) What was the relationship between the professional development project and educators' self-reported instructional practices and problem-solving efficacy?

Method

Setting

Our two-year project was conducted in a rural/town southern school district in the United States. The district served 35 schools across Prekindergarten through Grade 12, with 19 elementary schools (i.e., primary schools), and approximately 19,500 students. Student demographic information include: (a) Race: 28.2% Black, 6.8% Hispanic, 62.5% White, (b) 57.8% Free and/or Reduced Lunch,[2] (c) 3.7% English Language Learners, (d) 15.1 % Students with Disabilities, and (e) 41.8% Mathematics Proficiency as measured by a state-wide, high-stakes assessment. (Note: demographic data measured the initial year of the project; mathematics proficiency data measured the year prior to the project; Alabama State Department of Education, 2018).

Prior to recruitment efforts, researchers met with district leaders to determine the focus and scope of the project. After determining the scope of the project, the recruitment and inclusionary criteria for school participation included: (a) principal interest, (b) principal nomination of co-teaching teams, and (c) two-year commitment to the project and willingness to implement project content. The elementary schools recruited for participation for this project were representative of the varying demographics across the state.

Participants

The educator participants consisted of 12 general education teachers and 10 special education teachers or paraprofessionals[3] (n = 22 educators) for a total of 13 co-teaching teams across six elementary schools (See Table 1 for participating schools' demographics). The participating educators were 100% female, 91% white (4.5% Latina, 4.5% not identified), with a median of 9 years teaching experience. Participants taught Kindergarten through Grade 5 (i.e., primary grades). Throughout the two-year time, a few educators changed positions and roles (e.g., changing grade levels, changing from general education to special education), causing fluidity in the co-teaching team composition.

.

[2] "Free and/or Reduced Lunch" serves as a proxy measure for socioeconomic status.

[3] We recognise that special education teachers and paraprofessionals have vastly different preparation and teaching experiences; however, within the parameters of our project, they served in similar roles and fully engaged throughout the project. Due to the very limited sample size of paraprofessionals, special educators and paraprofessionals were combined for analyses as presented in our analytic approach and limitation sections.

Table 1
Participating Elementary School Demographics

School Name[a]	Number of Students	Race[b]	Free/Reduced Lunch	English Language Learners[c]	Students with Disabilities[c]	Mathematics Proficiency[d]
A	524	51.6% Black 2.3% Hispanic 41.7% White	56.4%	0.8%	12.4%	57.0%
B	553	64.0% Black 19.1% Hispanic 13.6% White	100%	7.6%	19.0%	26.2%
C	223	2.9% Black 7.4% Hispanic 87.3% White	63.0%	2.7%	17.9%	32.3%
D	510	9.9% Black 8.2% Hispanic 79.2% White	61.4%	5.5%	19.4%	53.1%
E	355	61.4% Black 14.8% Hispanic 21.9% White	100%	9.6%	15.2%	47.7%
F	555	69.7% Black 23.7% Hispanic 5.2% White	100%	16.2%	15.5%	24.2%

Note. Demographic data is from the initial year of the project. Mathematics proficiency is from the year prior to the project.
[a] School names blinded.
[b] Percentages to do not equal 100%; the remaining percentage represents non-black, -Hispanic, -white students
[c] As defined by Alabama State Department of Education, 2018.
[d] Mathematics proficiency from state-wide assessment.

Overview of Professional Development Project

Our professional development project served as an external domain of change within our envisioned growth network (Clarke & Hollingsworth, 2002), with two primary components of the project design: (a) synchronous learning opportunities, and (b) asynchronous learning opportunities. Our project design included intentional planning based on educator teams' needs, goals, and interests in lieu of a prescribed, one-dimensional professional development design (e.g., Guskey, 2000; Ingvarson et al., 2005; Joyce & Showers, 2002). While many professional development projects have a prescribed set of standards and activities predetermined by researchers, our project was led by essential concepts for effective collaborative elementary teaching in high-quality mathematics classrooms. As such, our project employed a responsive and adaptive approach to content delivery decisions, allowing for domains of change and growth to be interconnected (Clarke & Hollingsworth, 2002). Responsive decisions were made based on participant data, group discussions, and participant reflections. While prescribed professional learning can be effective, research should continue to explore the best strategies for adapting and responding to participant needs (e.g., Borko et al., 2015), while maintaining core concepts that are addressed

Synchronous Learning Opportunities

Initially whole group activities were devoted to addressing dispositions of target areas (i.e., mathematics teaching and co-teaching) and establishing a productive working relationship among co-teaching teams. Then, whole group activities shifted to include a focus on mathematical content and implementing co-taught mathematics lessons. Mathematical content sessions ranged from topics and high-quality mathematics tasks related to Operations and Algebraic Thinking, Numbers and Operation in Base Ten, Numbers and Operations in Fractions, Measurement and Data, and Geometry. Initially, topics were determined by the university faculty, but then adapted based on the needs and wants of the educators as the project continued. Whole group and small group content sessions (e.g., grade-level groups of K–2 and 3–5) focused on specific mathematics content deepening through problem solving, reinforcement of concepts during mathematics centres, and multiple, rich, mathematical discourse opportunities among the educators. Effective mathematics teaching and learning practices, such as the use of multiple representations (NCTM, 2014), were modeled during all synchronous sessions. The synchronous sessions were universal for all participants except for the interactive small group sessions, where once again we allowed educators to choose topics/ content to fit their needs. Small group numbers were determined by the educator's interest and thus ranged in size from 8–12 educators in a group.

Additionally, the facilitators modelled various co-teaching models, while educators acted out co-teaching models for the others to identify which model was presented. Video clips were used to showcase classroom examples of co-teaching models and teaching practices. Educators also read vignettes (Villa et al., 2013) to prompt discussions on when certain co-teaching models were most appropriate, effective, and efficient based on the design and goal of lessons. Once background knowledge was established, educator teams worked extensively on transforming simple word problems into high-quality mathematics tasks (Stein et al., 2009) coupled with effective co-teaching models to integrate the components (see Table 2a & 2b for specific timeline and content addressed). During Year 2 of the project, the facilitation was even more responsive to educator teams' needs, wherein differentiated synchronous sessions were provided based on requests. For instance, synchronous educator team sessions included additional co-planning time and support for creating and modifying grade-level specific high-quality mathematics tasks.

Table 2a

Overview of Professional Development Project Timeline and Content—Year1

Delivery Mode	Timing	Content/Topic
Autumn[a] Synchronous	Two full days	Dispositions, misconceptions, goal setting Overview of effective practices in mathematics and co-teaching rationale
Autumn Asynchronous	One half-day	Content knowledge development (ALEKS) & readings on mathematics & co-teaching
	One coaching cycle	Individualised based on educator teams; intentional focus on teaming and planning requirements & implementation co-teaching models and high-quality (HQ) mathematics tasks
Winter Synchronous	One full day	Co-teaching basics (strengths)-one-teach, one-observe & one-teach, one-assist Differentiation for mathematics and teaching all students Early childhood mathematics
Winter Asynchronous	One half-day	Content knowledge development (ALEKS) & readings on mathematics & co-teaching
	One coaching cycle	Individualised based on educator teams; intentional focus on planning (practice, forms, reflection) & implementation co-teaching models (practice, reflection, feedback) and HQ mathematics tasks
Spring Synchronous	One full day	Fractions Parallel co-teaching exemplars, planning, and practice
Spring Asynchronous	One half-day One coaching cycle	Content knowledge development (ALEKS) & readings on mathematics & co-teaching Individualised based on educator teams; intentional focus on planning & implementation co-teaching models and high-quality mathematics tasks together, which co-teaching models work best for different tasks and content
Summer Synchronous	Two full days	HQ tasks w/ Geometry & Rules that Expire article Children's literature in mathematics lessons Station and alternative co-teaching and choosing appropriate models for co-teaching
Summer Asynchronous	Optional learning opportunities	Article reading and reflections, unit/lesson planning, content knowledge development (ALEKS)

Table 2b

Overview of Professional Development Project Timeline and Content—Year 2

Delivery Mode	Timing	Content/Topic
Summer Synchronous	Two full days	Operations w/ breakout sessions Modelled a lesson w/ various co-teaching models
Autumn Synchronous	One full day	Share co-teaching experiences, roundtable of co-teaching lessons learned Measurement content and pedagogy
Autumn Asynchronous	One half-day One coaching cycle	Content knowledge development (ALEKS) & designing lessons w/ HQ tasks & co-teaching Individualised based on educator teams; intentional focus on planning & implementation co-teaching models and HQ mathematics tasks
Winter Synchronous	One full day	Task vs. word problems Team teaching Place Value
Winter Asynchronous	One half-day One coaching cycle	Content knowledge development (ALEKS) & designing lessons w/ HQ tasks & co-teaching Individualised based on educator teams; intentional focus on continued planning, debriefing & implementation of co-teaching models with HQ mathematics tasks that yield best outcomes
Spring Synchronous	One full day	Planning Day (w/ Subs and us to support) – individualised based on educator teams
Spring Asynchronous	One half-day One coaching cycle	Prepare presentation & share with others in building Individualised based on educator teams; intentional focus on planning, debriefing, adapting & implementation co-teaching models and HQ mathematics tasks
Summer Synchronous	Two full days	Modifying tasks Planning w/ tasks & co-teaching for sustainability Lesson Planning for the future
Summer Asynchronous	Optional learning opportunities	Educator choice: article reading and reflections, unit/lesson planning, content knowledge development (ALEKS)

[a]*Note*. Meteorological seasons of the Northern Hemisphere

Asynchronous Learning Opportunities

The Assessment and Learning in Knowledge Spaces (ALEKS; McGraw-Hill Education, n.d.) assessment program was used throughout the project for ongoing mathematical content learning; educators were assigned to the course Middle School Math Course 1/LV 6 and were asked to work within this progressive online system to enhance their mathematics content knowledge. Educators were also involved in discussion boards and postings using an online portal (i.e., Blackboard Learning Management System). Educators submitted reflective feedback on assigned readings from the three adopted texts: *The Guide to Co-Teaching* (Villa et al., 2013), *Implementing Standards-based Mathematics Instruction: A Casebook for Professional Development* (Stein et al., 2009), and *Teaching Mathematics Through Problem Solving: Prekindergarten–Grade 6* (Lester, 2003). Additionally, educator teams developed, implemented, and uploaded co-taught, high-quality mathematics lessons. For some of the teaching episodes, teams provided their own reflections using a researcher-created reflection debriefing guide; other teaching episodes were observed by the facilitators and included a coaching debriefing session using a similar reflection guide for consistency. The coaching debriefing sessions (approximately 30 minutes) were designed to assist our educator partners with reflection and growth on the elements of the professional development. The coaching sessions included discussions of positive and challenging elements of the co-taught lesson, as well as goal setting for future lessons (e.g., Harbour & Livers, 2018; see Table 2a and Table 2b for specific timeline and content addressed).

Data Collection Procedures

Data were collected at two time points per year across both years of the project. Data were collected in Autumn and Spring/Summer. Mathematics knowledge and self-report measures were completed at baseline (i.e., August) and each subsequent Summer (i.e., May). Observation data were collected throughout the Autumn and Spring semesters (one time point per semester) in person by a former elementary teacher trained on the use of the observation instruments.

Mathematics knowledge

Two instruments were used to measure educators' mathematics content knowledge and mathematical knowledge for teaching, the Assessment and Learning in Knowledge Spaces (ALEKS) and Learning Mathematics for Teaching (LMT) respectively.[4]

Assessment and learning in knowledge spaces

ALEKS (McGraw-Hill Education, n.d.) is a learning system that uses adaptive questioning to measure mathematics content knowledge. Participants were enrolled in the Middle School Math Course 1/LV 6 (e.g., Grade/Year 6) to cover all elementary mathematics content. Participants took a computer adaptive assessment of approximately 30 items and received a percentage of mastery. Participants then worked independently through individualised learning plans created by the learning system.

Learning mathematics for teaching (LMT)

The LMT assessment (Learning Mathematics for Teaching Project, 2011) was used to measure educators' mathematical knowledge for teaching. The assessed LMT content area focused on Number and Operations (Kindergarten–Grade 6), as this portion of the LMT aligned with the professional development content. The measurement used computer adaptive forms giving a normalised score based on a national sample of elementary teachers (Hill et al., 2004).

Observed teaching practices

To determine the influence of the project on educators' mathematics and co-teaching practices, two observational instruments were used. Observations occurred during co-taught mathematics lessons.

---

[4] ALEKS and LMT are not open access instruments; therefore, we did not provide sample items for these specific instruments.

Mathematics classroom observation protocol for practices

The MCOP^2 measures the alignment between teacher and student actions and best practices in mathematics teaching and learning using a two-factor structure to examine teacher practices and student engagement (Gleason et al., 2017). Each of the two factors has 9 items rated from 0 to 3, with the average of the scores reported. The teacher facilitation factor has an internal reliability Cronbach's alpha of 0.85 and the student engagement factor has an internal reliability Cronbach's alpha of 0.90. An item that targets teacher facilitation is "The lesson promoted modeling with mathematics" (Gleason et al., 2015; p. 10), and an item that targets student engagement is "Students persevered in problem solving" (Gleason et al., 2015, p. 8). To access the instrument and manual see https://jgleason.people.ua.edu/mcop2.html.

Co-teaching observation checklist

The Co-teaching Observation Checklist (Murawski & Lochner, 2011) was used to measure the implementation of co-teaching in the participants' classrooms. This 14-item checklist of "look-fors" and "listen-fors" is grounded in co-teaching literature and focuses on how an effective co-teaching classroom environment is established and enacted. Each of the items are rated on a 0-2 scale, with 0 meaning *didn't see it*, 1 as *saw an attempt*, or 2 as *saw it done well*. Sample "look-fors" items include: (a) "During instruction, both teachers assist students with and without disabilities", and (b) "the class moves smoothly with evidence of co-planning and communication between co-teachers" (p. 181). Sample "listen-fors" items include: (a) "Co-teachers use of language ("we", "our") demonstrates true collaboration and shared responsibility", and (b) "Students' conversations evidence a sense of community (including peers with and without disabilities" (p. 182).

Self-reported practices and efficacy

In addition to the observation of teaching practices, self-reported data were collected to examine changes in educators' practices and efficacy by two instruments described below.

Student-centered practices scale

Participants' views of their classroom practices were measured using an abbreviated version of Swan's (2006) 25-item *practice scale* to specifically measure project-related constructs (i.e., teacher centred versus student centred instructional practices). For the current project, six items that were classified as student-centred practices in the original scale, measured using a 5-point Likert scale, were used, and achieved a Cronbach's alpha internal reliability of 0.70 within our given population. Sample items included: (a) "Students compare different methods for doing questions", and (b) "Students work collaboratively in small groups" (pp. 62–63).

Teaching problem-solving efficacy

Watson's (2014) instrument was used to measure educators' perceived abilities related to the teaching of problem solving. This instrument consisted of 20 items using a 5-point Likert scale. Within our participant group, an internal Cronbach's alpha reliability of 0.89, indicating a high reliability. Sample items include: (a) "Allowing students to choose what maths to use", and (b) "Providing formative assessment of students' problem solving" (p. 88).

Analytic Approach

To explore the relationship between the professional development project and educator knowledge, practices, and self-efficacy, repeated measures analysis of variances (ANOVAs) were conducted across time points using *SPSS Statistics v25* software. As numerous repeated measures ANOVAs were conducted, Bonferroni corrections were used to reduce Type 1 error rates. Descriptive statistics included scores disaggregated for the general education (GE) and special education (SE) teachers for comparative purposes. Participating paraprofessionals (Para) were not represented in the disaggregated data because there was often just one paraprofessional at each time point (i.e., not reported to maintain anonymity). Due to small sample size, repeated measures ANOVAs and *t*-tests were conducted for all educators combined (i.e., GE, SE, and Para).

Results

Research Question 1: Mathematical Knowledge

Descriptive statistics for the ALEKS and LMT at each time point are presented in Appendices A and B for all educators (at each time point) and disaggregated by educator position (i.e., general education or special education). For the educators with scores at all time points (n = 18 for ALEKS; n = 16 for LMT) repeated measures ANOVAs were conducted to determine if there was a significant relationship between educators' content and pedagogical content knowledge and the professional development project. Scores for this subset of educators are presented in Table 3. Results indicated a statistically significant increase on the ALEKS test over time, $F(2, 34) = 63.05$, $p < .001$, $\eta_p^2 = 0.79$, indicating a large effect size (Cohen, 1969; Richardson, 2011). Comparisons between scores at each time point indicated that baseline scores were statistically significantly lower than each of the other time points, and the end of Year 2 scores were statistically significantly higher than the end of Year 1 scores (all analyses included a Bonferroni correction and were statistically significant at $p < .001$). The results suggested that educators' scores on the ALEKS improved over the course of the project. Although the repeated measures ANOVA was not significant for the LMT overall, $F(2, 30) = 2.14$, $p = .14$, a comparison between the baseline and end of Year 2 scores indicated a significant improvement over time, $t(15) = 2.91$, $p = .011$, two-tailed.

Table 3
Mathematics Knowledge for Educators Participating in Two Years of Professional Development

Assessment	Educator Position (n)	Baseline *Mean* (*SD*)	End of Y1 *Mean* (*SD*)	End of Y2 *Mean* (*SD*)
ALEKS[1]*	All (18) [a]	.64	.76	.82
		(.08)	(.08)	(.09)
	GE (10)[b]	.66	.79	.84
		(.10)	(.08)	(.09)
	SE (7)[c]	.60	.71	.78
		(.05)	(.06)	(.07)
LMT[2] **	All (16)[a]	-.20	-.20	.18
		(.50)	(1.07)	(.60)
	GE (8)	-.19	-.18	.12
		(.47)	(1.53)	(.69)
	SE (7)	-.34	-.23	.15
		(.45)	(.39)	(.52)

[1] Scores represent the proportion of concepts mastered
[2] Scores are nationally standardised z-scores.
[a]Data used in analyses
[b] General education educators
[c] Special education educators
* Scores significantly improved over each year ($p < .05$).
** Scores significantly improved between Autumn 2015 and Spring 2017 ($p < .05$).

Research Question 2: Observed Teaching Practices

Appendix C presents the mean classroom observation scores for each of the observation measures (i.e., MCOP[2]) and Co-teaching Observation Checklist) at each time point, including two time points for each academic year (i.e., a total of four time points). As observational instruments were used at the classroom level rather than individual educator level to represent co-teaching teams, comparisons were made for the nine classrooms that participated in the full two years of the professional development project and had classroom observation scores at each time point. Table 4 presents the descriptive statistics for these educators. A repeated measures ANOVA was conducted separately for each of the three measured constructs on the two observation instruments (two measured constructs on MCOP[2] and one measured construct on the Co-teaching Observation Checklist). Each of these analyses indicated a statistically significant improvement over time. Specific information on each construct follows.

Table 4

Observation Scores for Elementary Educators in the Project for Two Years

Scale	Autumn Y1 (Baseline) *Mean* (*SD*)	Spring Y1 *Mean* (*SD*)	Autumn Y2 *Mean* (*SD*)	Spring Y2 *Mean* (*SD*)
Student Engagement [a,1,4]	1.64 (.76)	2.48 (.28)	2.69 (.20)	2.78 (.36)
Teacher Facilitation [a,1,3]	1.57 (.79)	2.18 (.18)	2.47 (.33)	2.68 (.40)
Co-teaching [b,2]	0.91 (.67)	1.42 (.54)	1.55 (.57)	1.84 (.28)

Note. Scores can range from 0 to 3. *n* = 9 classrooms. Each measure showed a significant positive trend.
[a] Measured by MCOP[2]
[b] Measured by Co-teaching Observation Checklist
[1] Autumn Y1 scores were significantly lower than each of the other time points.
[2] Autumn Y1 scores were significantly lower than Autumn Y2 and Spring Y2.
[3] Spring Y1 scores were significantly lower than Autumn Y2 and Spring Y2.
[4] Spring Y1 scores were significantly lower than Spring Y2.

For the construct of Student Engagement measured by the MCOP[2], a statistically significant improvement was found, $F(3, 27) = 12.09$, $p < .001$, $\eta_p^2 = 0.57$, indicating a large effect size (Cohen, 1969; Richardson, 2011). The trend was also significant, $F(1, 9) = 16.57$, $p = .003$, $\eta_p^2 = 0.65$, suggesting that scores improved over time with a large effect size (Cohen, 1969; Richardson, 2011). Comparisons between scores at each time point (with Bonferroni corrections) indicated that the Autumn Year 1 scores were significantly lower than the Spring Year 1 scores ($p = .014$), Autumn Year 2 ($p = .001$), and Spring Year 2 scores ($p = .005$). Spring Year 1 scores were significantly lower than Spring Year 2 scores, $p = .04$. For the construct of Teacher Facilitation measured by the MCOP[2], a statistically significant improvement was found, $F(3, 27) = 9.91$, $p < .001$, $\eta_p^2 = 0.52$, indicating a large effect size (Cohen, 1969; Richardson, 2011). The trend was also significant, $F(1, 9) = 16.05$, $p = .003$, $\eta_p^2 = 0.64$, suggesting that scores improved over time with a large effect size (Cohen, 1969; Richardson, 2011). Comparisons between scores at each time point (with Bonferroni corrections) indicated that the baseline score (i.e., Autumn Year 1) was significantly lower than the scores at each of the other time points, $p = .045$, $p = .004$, and $p = .006$ for comparisons with Spring Year 1, Autumn Year 2, and Spring Year 2, respectively. Additionally, Spring Year 1 scores were significantly lower than the Autumn and Spring Year 2 scores, $p = .011$, and $p = .007$, respectively.

For co-teaching practices, as measured by the Co-teaching Observation Checklist, a statically significant improvement was found, $F(3, 27) = 8.26$, $p < .001$, $\eta_p^2 = 0.48$, indicating a large effect size (Cohen, 1969; Richardson, 2011). The trend was also significant, $F(1,9) = 37.25$, $p < .001$, $\eta_p^2 = 0.81$, suggesting that scores improved over time with a large effect size (Cohen, 1969; Richardson, 2011). Comparisons between scores at each time point (with Bonferroni corrections) indicated that the Autumn Year 1 scores (i.e., baseline) were significantly lower than Autumn Year 2 and Spring Year 2 scores, with $p = .012$ and $p = .001$, respectively.

Research Question 3: Self-Reported Practices and Efficacy

Appendix D presents the descriptive statistics for all educators and disaggregated by educator position for each time point, which included Autumn Year 1 (baseline), Spring Year 1, and Spring Year 2 measured by Teacher Self-Reported Practices (Swan, 2006). Repeated measures ANOVAs were conducted on the

17 educators who had scores across each of the three time points. The means are presented in Table 5. Student-Centred Instruction showed a statistically significant improvement, $F(2, 32) = 4.72$, $p = .016$, $\eta_p^2 = 0.23$, indicating a large effect size (Cohen, 1969; Richardson, 2011). The trend was also significant, $F(1, 16) = 6.77$. $p = .017$, $\eta_p^2 = 0.30$, suggesting that scores improved over time with a large effect size (Cohen, 1969; Richardson, 2011). Comparisons between scores at each time point (with Bonferroni corrections) indicated that the Autumn Year 1 scores were significantly lower than Year 1 ($p = .044$), but not statistically lower than Year 2 scores ($p = .058$).

Additionally, Appendix D presents the descriptive statistics for each scale for all educators at each time point, as well as scores disaggregated by educator position as measured by the Teaching Problem-Solving Efficacy Questionnaire (Watson, 2014). Repeated measures ANOVAs were conducted on the problem-solving efficacy measure for the 17 educators with scores at each time point; but it was not significant, $F(2.32) = 2.73$, $p = .081$ (see Table 5 for descriptive statistics used in analyses). However, problem-solving efficacy did significantly increase from Autumn Year 1 to Spring Year 1, $t(27) = 2.14$, $p = .041$, two-tailed, indicating a positive change in efficacy over the first year of the project.

Table 5
Self-Reported Practices and Problem-Solving Efficacy for Elementary Educators in the Project for Two Years

Measure	Educator Position (n)	Autumn Y1 *Mean* (*SD*)	Spring Y1 *Mean* (*SD*)	Spring Y2 *Mean* (*SD*)
Student-Centred*[,a]	All (17)[c]	3.12 (.68)	3.54 (.89)	3.61 (.69)
	GE (9)[d]	3.42 (.63)	3.85 (.75)	3.72 (.76)
	SE (7)[e]	2.88 (.59)	3.31 (.95)	3.60 (.57)
Problem Solving*[,b]	All (17)[c]	3.67 (.54)	3.91 (.63)	3.94 (.56)
	GE (9)	3.50 (.58)	3.85 (.48)	3.92 (.48)
	SE (7)	3.95 (.41)	4.15 (.70)	4.01 (.71)

Note. Scores can range between 1 and 5.
[a] Measured by a modified version of the Teacher Self-Reported Practices
[b] Measured by the Teaching Problem-Solving Efficacy Questionnaire
[c] Data used in analyses
[d] General education educators
[e] Special education educators
* Significant improvement between Autumn Y1 and the other time points.

Discussion

Each student deserves high-quality, effective mathematics learning opportunities (e.g., NCTM, 2014); however, research indicates that not all students have access to this type of mathematics instruction, particularly students who have identified disabilities (Lambert & Tan, 2017; Tan, 2016). To provide more inclusive and high-quality mathematics experiences for all students, professional development may be required to support educators as they navigate the complexities of shifting their instructional practices (e.g., Darling-Hammond et al., 2017; Desimone, 2009; Gee & Whaley, 2016; Joyce & Showers, 2002). Moreover, when considering an inclusive and collaborative environment, co-teaching is often considered as a productive and inclusive instructional model (e.g., Friend & Cook, 2017; Solis et al., 2012); and just as support is needed for mathematics instructional shifts, support is needed to establish and implement co-teaching effectively (Scruggs et al., 2007), wherein all educators' expertise is leveraged to provide equitable mathematics learning opportunities. To provide the support teams of co-teachers needed to enhance their inclusive mathematics teaching, we designed a two-year professional development project with general and special education elementary educators with both synchronous and asynchronous modes of professional learning. Relying on the Interconnected Model of Professional Growth (Clarke & Hollingsworth, 2002), our professional development project served as the external domain influence when considering educator change. The goal was for the external domain (i.e., our professional development project) to influence the personal, consequence, and practice domains as change is complex and intertwined. As such, we explored the relationships among our professional development project, educators' knowledge, instructional practices, and self-efficacy. Several important findings arose with implications for both research and practice.

Results for Research Question 1, the relationship between the external domain and domains of practice and consequence (i.e., mathematical knowledge; Clarke & Hollingsworth, 2002) showed significant improvements in educators' mathematical content knowledge across the project (i.e., across time) as measured by ALEKS. In contrast, educators' mathematical knowledge for teaching did not show significant improvements across time, as measured by the LMT; however, educators' mathematical knowledge for teaching (measured by the LMT) did significantly improve from baseline to end of year two (i.e., final data collection point). Previous research on professional development showing improvements on the LMT have been associated with increased enactment of high-quality mathematics teaching practices (e.g., Bell et al., 2010; Polly et al., 2014). One explanation for our findings could be the nature of our project design. Specifically, mathematical knowledge for teaching is a broad topic that we centralised across the synchronous sessions; we engaged in this work in an incremental nature, building new knowledge for teaching around different content areas across the two-year project. This suggests the culmination and sustained duration of the experience may be related to the increase on the LMT as a pre-post project measure.

Results for Research Question 2 (i.e., observed teaching practices) indicated a statistically significant improvement over time for student engagement, teacher facilitation, and co-teaching, as measured by the $MCOP^2$ and the Co-teaching Observation Checklist respectively. These findings indicate a relationship between the external domain (i.e., professional development project) and the practice and consequence domain (Clarke & Hollingsworth, 2002). We highlight these findings as they indicate educators' critical transition from theory to practice (e.g., Korthagen et al., 1999). While this study is not causal in nature, the findings are encouraging as we consider creating classrooms where general and special educators collaborate to engage students in high-quality mathematics tasks. Through the collaborative nature of our project, general and special educators learned alongside one another, focusing on effective co-teaching practices and the use of high-quality mathematics tasks to create an inclusive learning environment; we then built in a focus on implementing tasks and co-teaching models into their specific settings, allowing for authentic learning opportunities for both educators (Grossman et al., 2009).

Results for Research Question 3 (i.e., self-reported practices and efficacy) also showed positive findings. Educators' self-reported practices related to student centred instruction, as measured by Teacher Self-Reported Practices, showed a statistically significant improvement over time, indicating a relationship between the external domain (i.e., professional development project) and personal domain (i.e., educators' efficacy; Clarke & Hollingsworth, 2002). Similar positive findings on teachers' self-reported practices were found by Gee and Whaley (2016), wherein they built a community of teachers that focused on increasing the teachers' use of problem-based learning (i.e., use of high-quality tasks in teaching). The significance of the upward trend may be related to the importance of longitudinal projects (i.e., sustained duration) when working to influence the complex practices of effective teaching and learning (e.g., Darling-Hammond et al., 2017; Desimone, 2009; González & Vargas, 2020). When looking at educators' problem-solving efficacy, as measured by Teaching Problem-Solving Efficacy Questionnaire, results were not significant across time, but were significant when comparing Autumn Year 1 to Spring Year 1 scores indicating a positive change in efficacy over the first year of the project only. A potential explanation for the significance occurring only across Year 1 of the project is educators' initial scores on problem-solving efficacy were high at the start of the project leading to a potential ceiling effect during Year 2 of the project; although, there was still room for some growth. Additionally, dispositions were focused on a great deal more during Year 1 of the project, which could explain the increase of self-efficacy during the year in which the focus was aligned more in nature, although further exploration is warranted.

Limitations and Future Research

As is the case with most educational research, this study is not without limitations and the findings should be interpreted with these in mind. First, we did not have a comparison group; therefore, the findings indicate relationships rather than causation. Future research should employ a causal design to build upon our findings. Second, our limited sample size did not allow for exploration between specific roles of the educators (e.g., general educators, special educators, and paraprofessionals). While our findings indicated a positive relationship with this collaborative professional development, future research should consider increasing the sample size to determine if differences exist based on the roles in which the educator is positioned and/or prepared. Additionally, as noted earlier, we recognise that paraprofessionals do not engage in the same preparation as certified educators; therefore, either excluding them from data analysis or increasing the sample size to allow for analyses of this specific role should be considered (*Note:* We do not believe paraprofessionals should be excluded from participating in these projects, only that methodological considerations are needed).

As we consider our project design, one consideration is the structure of the co-teaching teams. Two of the co-teaching teams or pairs did not remain consistent across both years, causing new pairs and teams to spend time getting acquainted and working on instructional practices for the first time across project years. For instance, a dual-certified teacher first worked as a special educator in Year 1, and then as a general educator in Year 2 of the project. Shifts in roles within schools is common (Atteberry et al., 2017); however, a commitment between administrators and co-teachers to remain in the same role throughout professional development may be beneficial to promote efficiency (e.g., less time building relationships) and effectiveness (e.g., less time identifying areas of focus).

Conclusion

Creating inclusive mathematics classrooms where all students are provided high-quality learning opportunities is a vision embodied by many educators, schools, and professional organizations; however, this vision is often not actualized, particularly students from historically marginalised groups (Flores, 2007; Lampert & Tan, 2017; Tan, 2016). We believe that one step in moving towards more inclusive mathematics classrooms where equitable and meaningful mathematics teaching and learning occurs is to establish a collaborative teaching model that capitalises on both general and special educators' expertise (Friend & Cook, 2017). To support these efforts through a lens of influencing educator change (Clarke & Hollingsworth, 2002), we designed a hybrid, longitudinal professional development project for general and special education elementary educators in two areas: high-quality mathematics tasks and co-teaching. By means of responsive planning to meet the needs of educators, the project was designed in a way to leverage multiple delivery models (e.g., whole group session, small group session, coaching cycles), and the expertise of all of those involved. A variety of quantitative instruments were used to capture the relationship between the project and educators' knowledge and practices. Results indicated statistically significant increases in educators' mathematics content knowledge and pedagogical content knowledge, as well as statistically significant improvements in observed teaching (i.e., teacher facilitation and student engagement) and co-teaching practices. While this study is not causal in nature, the findings are encouraging as we consider creating the collaborative nature of professional development as an important facet when determining how to leverage the two adults in inclusive classrooms to provide access and opportunity to all students. As this is an area with limited research, additional examination is needed to determine a causal relationship between the collaborative professional development project and change in educators' knowledge and practice, as well as the relationship with student outcomes.

Acknowledgements

This work was supported by the Alabama State Department of Education under a Mathematics and Science Partnership [Project No. U600171, U700137].

References

Assessment and Learning in Knowledge Space. (n.d.). McGraw-Hill Education. https://www.aleks.com

Atteberry, A., Loeb, S., & Wyckoff, J. (2017). Teacher churning: Reassignment rates and implications for student achievement. *Educational Evaluation and Policy Analysis, 39*(1), 3–30. https://doi.org/10.3102/0162373716659929

Bell, C. A., Wilson, S. M., Higgins, T., & McCoach, D. B. (2010). Measuring the effects of professional development on teacher knowledge: The case of developing mathematical ideas. *Journal for Research in Mathematics Education, 41*(5), 479–512. http://www.jstor.org/stable/41110411

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher, 33*(8), 3–15. https://doi.org/10.3102/0013189X033008003

Borko, H., Jacobs, J., Koellner, K., & Swackhamer, L. E. (2015). *Mathematics professional development: Improving teaching using the problem-solving cycle and leadership preparation models*. Teachers College Press.

Boston, M. D., & Smith, M. S. (2011). A 'task-centric approach' to professional development: Enhancing and sustaining mathematics teachers' ability to implement cognitively challenging mathematical tasks. *ZDM Mathematics Education, 43*(6–7), 965–977. https://doi.org/10.1007/s11858-011-0353-2

Brendefur, J., Champion, J., Strother, S., Thiede, K. W., & Osguthorpe, R. D. (2021). The effects of mathematics professional development on elementary student achievement. *International Journal of Science and Mathematics Education*, *20*(6), 1079–1097. https://doi.org/10.1007/s10763-021-10184-z

Caddle, M. C., Bautista, A., Brizuela, B. M., & Sharpe, S. T. (2016). Evaluating mathematics teachers' professional development motivations and needs. *Journal of Research in Mathematics Education*, *5*(2), 112–134. http://dx.doi.org/10.17583/redimat.2016.2093

Clarke, D. J. (1988). Realistic assessment. In D. Firth (Ed.), *Maths counts—who cares?* (pp. 187–192). Mathematical Association of Victoria.

Clarke, D., & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and Teacher Education*, *18*(8), 947–967. https://doi.org/10.1016/S0742-051X(02)00053-7

Cohen, J. (1969). *Statistical power analysis for behavior sciences.* Academic Press.

Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2017). *Effective teacher professional development*. Learning Policy Institute.

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher*, *38*(3), 181–199. https://doi.org/10.3102/0013189X08331140

Every Student Succeeds Act, Pub. L. No. 114–95. (2015).

Faulkner, V. N., & Cain, C. R. (2013). Improving the mathematical content knowledge of general and special educators: Evaluating a professional development module that focuses on number sense. *Teacher Education and Special Education*, *36*(2), 115–131. https://doi.org/10.1177/0888406413479613

Flores, A. (2007). Examining disparities in mathematics education: Achievement gap or opportunity gap? *The High School Journal, 91*(1), 29–42.

Friend, M. & Cook, L. (2017). *Interactions: Collaboration skills for school professionals* (8th ed.). Pearson Education.

Fullan, M. (1992). *Successful school improvement: The implementation perspective and beyond*. McGraw-Hill Education (UK).

Gee, D., & Whaley, J. (2016). Learning together: Practice-centred professional development to enhance mathematics instruction. *Mathematics Teacher Education and Development*, *18*(1), 87–99.

Gleason, J., Livers, S.D., & Zelkowski, J. (2015). *Mathematics classroom observation protocol for practices: Descriptors manual.* http://jgleason.people.ua.edu/mcop2.html

Gleason, J., Livers, S. D., & 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

González, G., & Vargas, G. E. (2020). Teacher noticing and reasoning about student thinking in classrooms as a result of participating in a combined professional development intervention. *Mathematics Teacher Education and Development*, *22*(1), 5–32. https://mted.merga.net.au/index.php/mted/article/view/449

Goos, M., Doles, S., & Makar, K. (2007). Designing professional development to support teachers' learning in complex environments. *Mathematics Teacher Education and Development*, *8*, 23–47.

Greenstein, S., & Baglieri, S. (2018). Imagining mathematical thinking for inclusive curriculum: A conversation. *Investigations in Mathematics Learning, 10*(3), 133–144. https://doi.org/10.1080/19477503.2018.1467091

Gregory, G. & Chapman, C. (2002). *Differentiated instructional strategies: One size doesn't fit all*. Corwin Press.

Griffin, C. C., Dana, N. F., Pape, S. J., Algina, J., Bae, J., Prosser, S. K., & League, M. B. (2018). Prime online: Exploring teacher professional development for creating inclusive elementary mathematics classrooms. *Teacher Education and Special Education*, *41*(2), 121–139. https://doi.org/10.1177/0888406417740702

Grossman, P., Hammerness, K., & McDonald, M. (2009). Redefining teaching, re-imagining teacher education. *Teachers and Teaching: Theory and Practice, 15*(2), 273–289. https://doi.org/10.1080/13540600902875340

Guskey, T. R. (2000). *Evaluating professional development*. Corwin Press.

Hill, H. C., Rowan, B., & Ball, D. L. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research Journal, 42*(2), 371–406. https://doi.org/10.3102/00028312042002371

Hill, H. C., Schilling, S. G., & Ball, D. L. (2004) Developing measures of teachers' mathematics knowledge for teaching. *The Elementary School Journal*, *105*(1), 11–30. https://doi.org/10.1086/428763

Hilton, A., Hilton, G., Dole, S., & Goos, M. (2015). School leaders as participants in teachers' professional development: The impact on teachers' and school leaders' professional growth. *Australian Journal of Teacher Education*, *40*(12), 104–125. http://dx.doi.org/10.14221/ajte.2015v40n12.8

Harbour, K. E. & Livers, S. D. (2018). Using coaching cycles to transfer and sustain effective instructional practices. In T. E. Hodges, G. J. Roy, & A. M. Tyminski, (Eds.), *Proceedings of the 40th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (pp. 374–377). Greenville, SC.

Individuals with Disabilities Education Act, 20 United States Code (U.S.C.) § 1400 (2004).

Ingvarson, L., Meiers, M. & Beavis, A. (2005). Factors affecting the impact of professional development programs on teachers' knowledge, practice, student outcomes & efficacy. *Education Policy Analysis Archives*, *13*(10), 1–28. https://doi.org/10.14507/epaa.v13n10.2005

Jones, K., & Pepin, B. (2016). Research on mathematics teachers as partners in task design. *Journal of Mathematics Teacher Education, 19*(2–3), 105–121. https://doi.org/10.1007/s10857-016-9345-z

Joyce, B., & Showers, B. (2002). Student achievement through professional development. *Designing training and peer coaching: Our need for learning.* Association for Supervision and Curriculum Development.

Korthagen, F. A., & Kessels, J. P. (1999). Linking theory and practice: Changing the pedagogy of teacher education. *Educational Researcher, 28*(4), 4–17. https://doi.org/10.3102/0013189X028004004

Lambert, R., & Tan, P. (2017). Conceptualizations of students with and without disabilities as mathematical problem solvers in educational research: A critical review. *Education Sciences, 7*(2), 51. https://doi.org/10.3390/educsci7020051

Learning Mathematics for Teaching Project. (2011). Measuring the mathematical quality of instruction. *Journal of Mathematics Teacher Education, 14*(1), 25–47. https://doi.org/10.1007/s10857-010-9140-1

Lester, F. K. (2003). *Teaching mathematics through problem solving: Prekindergarten-Grade 6*. National Council of Teachers of Mathematics.

Livers, S. D. (2022). A whole school agreement: Professional learning with a focus on environmental STEM. *Investigations in Mathematics Learning, 14*(1), 49–62. https://doi.org/10.1080/19477503.2021.2023843

Maccini, P. & Gagnon, J. C. (2002). Perceptions and applications of NCTM standards by special and general teachers. *Exceptional Children, 68*(3), 325–344. https://doi.org/10.1177/001440290206800303

Maccini, P. & Gagnon, J. C. (2006). Mathematics instructional practices and assessment accommodations by secondary special and general educators. *Exceptional Children, 72*(2), 217–234. https://doi.org/10.1177/001440290607200206

McKenna, J. W., Shin, M., & Ciullo, S. (2015). Evaluating reading and mathematics instruction for students with learning disabilities: A synthesis of observation research. *Learning Disability Quarterly*, *38*(4), 195–207. https://doi.org/10.1177/0731948714564576

Murawski, W. W., & Lochner, W. W. (2011). Observing co-teaching: What to ask for, look for, and listen for. *Intervention in School and Clinic, 46*(3), 174–183. https://doi.org/10.1177/1053451210378165

National Council of Teachers of Mathematics. (2014). *Principles to actions: Ensuring mathematical success for all*. National Council of Teachers of Mathematics.

No Child Left Behind Act of 2001, Pub. L. No. 107–110, 20 U.S.C. 6301 (2002).

Novak, D., & Knowles, J. G. (1992, April). *Life histories and the transition to teaching as a second career.* Paper presented at the annual meeting of the American Educational Research Association, Chicago, IL.

Office of Special Education and Rehabilitative Services. (2018). *40th Annual Report to Congress on the Implementation of the Individuals with Disabilities Education Act, 2018.* Office of Special Education Programs, US Department of Education.

Opfer, V. D., Pedder, D. G., & Lavicza, Z. (2011). The role of teachers' orientation to learning in professional development and change: A national study of teachers in England. *Teaching and Teacher Education*, *27*(2), 443–453. https://doi.org/10.1016/j.tate.2010.09.014

Pancsofar, N., & Petroff, J. G. (2013). Professional development experiences in co-teaching: Associations with teacher confidence, interests, and attitudes. *Teacher Education and Special Education*, *36*(2), 83–96. https://doi.org/10.1177/0888406412474996

Pancsofar, N., & Petroff, J. G. (2016). Teachers' experiences with co-teaching as a model for inclusive education. *International Journal of Inclusive Education*, *20*(10), 1043–1053. https://doi.org/10.1080/13603116.2016.1145264

Pearl, C. E., & Miller, K. J. (2007). Co-taught middle school mathematics classrooms: Accommodations and enhancements for students with specific learning disabilities*. Focus on Learning Problems in Mathematics, 29(2),*1–20.

Perry, E., & Boylan, M. (2018). Developing the developers: Supporting and researching the learning of professional development facilitators. *Professional Development in Education*, *44*, 254–271. https://doi.org/10.1080/19415257.2017.1287767

Polly, D., Neale, H., & Pugalee, D. K. (2014). How does ongoing task-focused mathematics professional development influence elementary school teachers' knowledge, beliefs and enacted pedagogies? *Early Childhood Education Journal, 42*(1), 1–10. https://doi.org/10.1007/s10643-013-0585-6

Richardson, J. T. E. (2011). Eta squared and partial eta squared as measures of effect size in educational research. *Educational Research Review*, *6*(2), 135–147. https://doi.org/10.1016/j.edurev.2010.12.001

Scruggs, T. E., Mastropieri, M. A., & McDuffie, K. A. (2007). Co-teaching in inclusive classrooms: A metasynthesis of qualitative research. *Exceptional Children, 73*(4), 392–416. https://doi.org/10.1177/001440290707300401

Solis, M., Vaughn, S., Swanson, E., & McCulley, L. (2012). Collaborative models of instruction: The empirical foundations of inclusion and co-teaching*. Psychology in the Schools, 49,* 498–510. https://doi.org/10.1002/pits.21606

Spangler, D. A. & Wanko, J. J. (2017). *Enhancing classroom practice with research behind Principles to Actions.* National Council of Teachers of Mathematics.

Stein, M. K., Smith, M., Henningsen, M., & Silver, E. (2009). *Implementing standards-based mathematics instruction: A casebook for professional development* (2nd ed.). Teachers College Press.

Swackhamer, L. E., Koellner, K., Basile, C., & Kimbrough, D. (2009). Increasing the self-efficacy of inservice teachers through content knowledge. *Teacher Education Quarterly, 36*(2), 63–78. http://www.jstor.org/stable/23479252

Swan, M. (2006). Designing and using research instruments to describe the beliefs and practices of mathematics teachers. *Research in Education*, *75*(1), 58–70. https://doi.org/10.7227/RIE.75.5

Swars, S. L., & Chestnutt, C. (2016). Transitioning to the Common Core State Standards for Mathematics: A mixed methods study of elementary teachers' experiences and perspectives. *School Science and Mathematics*, *116*(4), 212–224. https://doi.org/10.1111/ssm.12171

Tan, P. (2016). Developing mathematical understanding and students with emotional and behavioral disorders: A review of the literature. *Emotional and Behavioral Difficulties, 21*(4), 361–376. https://doi.org/10.1080/13632752.2016.1201639

Tomlinson, C. A. (2017). *How to differentiate instruction in academically diverse classrooms* (3rd ed.). Association for Supervision and Curriculum Development.

Villa, R. A., Thousand, J. S., & Nevin, A. I. (2013). *A guide to co-teaching: New lessons and strategies*. Corwin.

Watson, S. (2014). *The impact of professional development on mathematics teachers' beliefs and practices* [Doctoral dissertation, The University of Nottingham].

Weiss, I. R., & Pasley, J. D. (2006). Scaling up instructional improvement through teacher professional development: Insights from the local systemic change initiative. CPRE Policy Briefs. RB-44. *Consortium for Policy Research in Education.*

Widjaja, W., Vale, C., Groves, S., & Doig, B. (2017). Teachers' professional growth through engagement with lesson study. *Journal of Mathematics Teacher Education*, *20*, 357–383. https://doi.org/10.1007/s10857-015-9341-8

Zwart, R. C., Wubbels, T., Bergen, T. C. M. & Bolhuis, S. (2007). Experienced teacher learning within the context of reciprocal peer coaching. *Teachers and Teaching, 13*, 165–187. https://doi.org/10.1080/13540600601152520

Kristin E. Harbour
College of Education
Instruction and Teacher Education
University of South Carolina
820 Main Street, 234 Wardlaw
Columbia, SC 29208
kharbour@mailbox.sc.edu

Stefanie D. Livers
College of Education
Childhood Education and Family Studies
Missouri State University
423 Hill Hall
901 S. National Street
Springfield, MO 65897
417.836.6099
stefanielivers@missouristate.edu

Sara C. McDaniel
College of Education
Department of Special Education and Multiple Abilities
The University of Alabama
215D Autherine Lucy Hall; Box 870232
Tuscaloosa, AL 35487
scmcdaniel@ua.edu

Jim Gleason
College of Arts and Sciences
Department of Mathematics
The University of Alabama
Gordon Palmer Hall 327C
Tuscaloosa, AL 35487
jgleason@ua.edu

Joan M. Barth
Institute for Social Science Research
The University of Alabama
Box 870216
Tuscaloosa, AL 35487
jbarth@ua.edu

Appendix A

Descriptive Statistics on ALEKS for each Educator Position at each Time Point

		Time Point		
Teacher Position		Autumn Y1(Baseline)	End of Y1	End of Y2
All[a]	Mean	0.63	0.76	0.79
	(SD)	(.12)	(.10)	(.11)
	n	33	31	22
GE[b]	Mean	0.65	0.79	0.80
	(SD)	(.13)	(.09)	(.12)
	n	21	20	13
SE[c]	Mean	0.62	0.71	0.77
	(SD)	(.06)	(.06)	(.08)
	n	10	9	8

Note. Scores represent the proportion of concepts mastered.

[a] Data used in analyses
[b] General education educators
[c] Special education educators

Appendix B

Descriptive Statistics on LMT for each Educator Position and each Time Point

		Time Point		
Teacher Position		Autumn Y1(Baseline)	End of Y1	End of Y2
All[a]	Mean	-0.20	-0.06	0.11
	(SD)	(.71)	(1.05)	(.74)
	n	30	33	20
GE[b]	Mean	-0.01	0.08	0.06
	(SD)	(.65)	(1.14)	(.89)
	n	17	22	11
SE[c]	Mean	-0.30	-0.38	0.08
	(SD)	(.39)	(0.91)	(0.51)
	n	10	9	8

Note. Scores are nationally standardised *z*-scores.

[a] Data used in analyses
[b] General education educators
[c] Special education educators

Appendix C

Descriptive Statistics on MCOP² and Co-Teaching Checklist for Educator Position and Time Point

Measure		Time Point			
		Autumn Y1 (Baseline)	Spring Y1	Autumn Y2	Spring Y2
Student Engagement[a]	Mean	1.51	2.48	2.61	2.81
	(SD)	(.66)	(.30)	(.24)	(.30)
	n	19	23	19	15
Teacher Facilitation[a]	Mean	1.42	2.22	2.47	2.70
	(SD)	(.70)	(.23)	(.32)	(.34)
	n	19	23	19	15
Co-Teaching[b]	Mean	0.76	1.08	1.48	1.84
	(SD)	(.65)	(.75)	(.59)	(.25)
	n	19	23	19	15

Note. Scores can range from 0 to 4.
[a] Measured by MCOP²
[b] Measured by Co-teaching Observation Checklist

Appendix D

Descriptive Statistics on Self-Reported Practices and Problem-Solving Efficacy for Educator Position and Time Point

Measure	Teacher Position		Time Point		
			Autumn Y1 (Baseline)	Spring Y1	Spring Y2
Student Centred Instruction[a]	All	Mean	3.04	3.49	3.59
		SD	(.64)	(.69)	(.64)
		n	37	35	20
	GE[c]	Mean	3.22	3.60	3.67
		SD	(.62)	(.65)	(.70)
		n	24	22	11
	SE[d]	Mean	2.87	3.36	3.60
		SD	(.50)	(.76)	(.53)
		n	10	11	8
Problem Solving[b]	All	Mean	3.56	3.88	3.95
		(SD)	(.58)	(.59)	(.53)
		n	36	35	20
	GE	Mean	3.50	3.89	3.92
		(SD)	(.62)	(.56)	(.47)
		n	24	22	11
	SE	Mean	3.80	3.95	4.03
		(SD)	(.45)	(.63)	(.66)
		n	10	11	8

Note. Scores range from 1 to 5.
[a] Measured by a modified version of the Teacher Self-Reported Practices
[b] Measured by the Teaching Problem-Solving Efficacy Questionnaire
[c] General education educators
[d] Special education educators