COACHING THE COACH:

BUILDING A SCHOOL-BASED COACH'S CAPACITY

FOR DEEP MATHEMATICS DISCUSSIONS

by

Amy Brown

An education leadership portfolio submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Doctor of Education in Educational Leadership

Spring 2023

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ABSTRACT

Seaford School District has allocated significant resources and launched multiple initiatives to increase the achievement of Seaford Middle School mathematics students. These included adopting high quality instructional materials, hiring a school-based mathematics coach, purchasing curriculum materials, ensuring collaborative grade level planning time, and scheduling time for the school-based coach/ administration/ district leader to collaborate. Despite these initiatives and resources, nearly three-fourths of Seaford Middle School students scored below or well below the math proficiency level on the Smarter Balanced Assessment Consortium (SBAC) test between 2018 and 2021.

Seaford School District partnered with PDCE in the fall of 2021 with two goals for the partnership: to support teachers to develop knowledge, skills, and mindsets around strong mathematics instruction to implement their problem-based high-quality instructional materials, and to support district and school leaders, including the school-based mathematics coach, in developing knowledge, skills, and mindsets around strong mathematics instruction and support the high-quality implementation of Illustrative Mathematics. As the PDCE Instructional Specialist assigned to this partnership, I focused on curriculum-specific professional learning in the form of content-focused coaching cycles and purposeful PLC planning meetings.

Researchers posit that growth in a coach's capacity to facilitate deep and specific lesson-planning conversations with teachers predicts improvement in creating opportunities for students to engage in cognitive thinking (Russell et al., 2017; Russell et al., 2020; Stein et al., 2021). We anticipated that supporting the school-based mathematics coach to have deep, mathematically rich lesson-planning conversations with her teachers would have an impact on how teachers planned and implemented their lessons. We hoped that this shift would in turn have an impact on student achievement.

During the three-month study, I audio recorded three planning discussions between Ms. Boyce, Seaford Middle School's mathematics coach, and myself and three discussions Ms. Boyce facilitated with a team of five 6th-grade mathematics teachers and myself. In specialist-coach planning sessions, I engaged Ms. Boyce in deep, specific discussions about each lesson's mathematical goals, student thinking, and pedagogy. These discussions were intentionally designed to build her capacity to support teachers in planning goal-focused, student-responsive lessons. Following the specialist-coach discussions, Ms. Boyce facilitated lesson planning discussions with 6th-grade mathematics teachers focusing on the mathematical point of the lesson, student thinking, and teaching strategies that elicit, build on, and extend student thinking. I attended, contributing to the discussion strategically as needed.

Through data analysis, I found evidence of a possible relationship between the depth and specificity of specialist-coach conversations and that of the coach-teacher conversations. Ms. Boyce's planning documents became increasingly more detailed

and purposeful. Additionally, I found evidence of shifts in coach-teacher lesson planning norms, namely an increased focus on the mathematical point of a lesson and changes in teacher talk about students.

Chapter 1

INTRODUCTION

For this Educational Leadership Portfolio (ELP), my goal was to learn more about the resources and initiatives Seaford district and administrators invested in to improve student achievement in mathematics, make some conjectures as to why these efforts did not have the desired impact on teaching practices and student achievement, and then design a series tools I could use with the building coach to help her support teachers to plan for ambitious teaching and learning classroom experiences. I provide the rationale for targeting coaching and describe the implementation of deep, specific specialist-coach discussions about mathematical content, student thinking, and pedagogy during lesson planning sessions. I explain my methodology for collecting and analyzing data and report my findings (*Artifact 4: Methodological Memo).* I present my conclusions, study limitations, and possible next steps. The remainder of the portfolio is arranged in chapters logically sequenced to the guide the reader's understanding of the problem, the initiative to address the problem, the results and conclusions of the initiative, and reflections on the processes.

In chapter 2, I provide more information about the possible reasons for the low student achievement scores on standardized tests by Seaford Middle School students despite multiple efforts to improve student achievement. I share details about curriculum use, coaching practice, and teacher planning practices in place before this study and state my organizational role in supporting the administrators, coach, and teachers at Seaford

Middle school to shift planning practices to have an impact on teaching practice and student achievement.

In chapter 3, I describe the actions I took to support Seaford Middle School 6th-grade teachers' planning and teaching practices, including completing a literature review to situate my work in current research (*Artifact 2: Literature Review on Ambitious Teaching and High-leverage Coaching Practices).* I describe my rationale for focusing on building the capacity of school-based coaches to shift teaching practice and my overall improvement design as well as the implementation of my improvement strategies. I include details on the creation of each improvement strategy, including a suite of tools and protocols (*Artifact 3: Suite of and Introduction to Tools and Protocols)* and the revision processes of each improvement strategy (*Artifact* 4*: Methodological Memo).*

In chapter 4, I describe the results of the actions I took to build the capacity of Seaford Middle School's mathematics coach to support 6th -grade teachers to plan goal-focused, student-responsive mathematics lessons. I use evidence from the coach and specialist's planning tools and the recorded discussions between specialist/coach and specialist/coach/teachers to describe the results.

In chapter 5, I describe conclusions about whether targeting the school-based coach's capacity to facilitate deep, specific mathematics discussion helped Seaford Middle School mathematics teachers plan goal-focused, student-responsive lessons. I include my rationale for my conclusions and discuss what went well and what needs to be redesigned. I include discussion on a district assessment tool created but not used in the study (*Artifact 6: Self-assessment Tool for District Personnel).* I end the chapter with recommendations and next steps to continue improving mathematics teaching, including

methods to disseminate findings through a white paper (*Artifact 5: White Paper)* and professional learning (*Artifact 7: Coach the Coach PL).*

In chapter 6, I reflect on my growth as a scholar, problem-solver, and partner. I include how the graduate coursework and ELP process supported changes in my capacity to find and use data, effectively solve problems, and strategically partner with a variety of stakeholders.

Lastly, I provide supporting documentation for my work in this ELP in the appendices. In Table 1, I describe the artifacts that I created and the rationale for their creation.

Table 1 Complete List of Artifacts Provided in the Appendices of the ELP

Artifacts	Rationale for Artifact
Artifact 1: PDCE Policy & Change Map	To describe how I will instigate the policy and practice changes into PDCE. This map includes a policy practice timeline (historical and forward-looking), name the supports using systems-level policy thinking and incorporate the finding of the study.
Artifact 2: Artifact 2: Literature Review on Ambitious Teaching and High-leverage Coaching Practices	To situate my work in the current mathematics education research and literature on teacher learning and coaching, including the potential high-leverage coaching practice facilitating deep, specific lesson-planning discussions to support ambitious teaching.
Artifact 3: Artifact 3: Suite and Introduction to Tools and Protocols	To clearly describe the tools, guides, and protocols developed from this study to district administrators, building administrators, and school-based coaches. There are eight tools in the suite--four for Instructional Specialists and four for School-based Coaches and included planning, data collection, and reflection tools.
Artifact 4: Methodological Memo	To detail my methodological process. It includes my data collection processes, coding

	scheme and technique, how I analyzed data, and how I synthesized my findings.
Artifact 5: White Paper	To disseminate my findings, rationale, and research base of my study regarding supporting teachers to use ambitious teaching practices through deep discussions of mathematics to district/building administrators and building coaches.
Artifact 6: Self-assessment Tool for District Personnel	To support district and school administrators to assess building coaches' capacity to determine whether and how coaching activity has impacted teacher and student learning.
Artifact 7: Coach the Coach PL	To disseminate current research regarding supporting teachers to use ambitious teaching practices through deep discussions of mathematics to district/building administrators and building coaches to PDCE Instructional Specialists.
Artifact 8: Defense Proposal	To describe the problem and my rationale and plan to address the problem to my ELP committee.

Chapter 2

PROBLEM ADDRESSED

The purpose of this chapter is to provide more information about the possible reasons for the low student achievement scores on standardized tests by Seaford Middle School students despite multiple efforts to improve student achievement. To do this I describe the current state of student performance, of teaching practice, and a brief history of previous initiatives undertaken by the district to impact both teaching and learning. I provide my initial conjectures about why these initiatives have not resulted in lasting impact on student and teacher performance. I share details about curriculum use, coaching practice, and teacher planning practices in place before this study, that could be potential areas of change to support the district and school initiatives to increase student achievement. At the conclusion of this chapter, I state my organizational role in supporting the administrators, coach, and teachers at Seaford Middle school to shift planning practices to have an impact on teaching practice and student achievement.

Seaford Middle School

The Seaford school district administration has allocated significant resources and launched multiple initiatives to increase student achievement. These include using the *Step by Step Curriculum Support Guide* from Instructional Partners (Freitag, 2018) to select, adopt, and implement high quality instructional materials; hiring a full-time school-based mathematics coach; purchasing curriculum materials; ensuring

collaborative grade level planning time; and scheduling time for the school-based coach/administration/district leader to collaborate.

Of the approximately 830 students who attended Seaford Middle School in the 2021-2022 school year, 36% identified as African American, 30% as White, and 24% as Hispanic or Latino. Additionally, 40% of the students are identified as low-income, 17% of the students are identified as students with disabilities, and 16% of Seaford Middle School students are identified as English learners, (Delaware Report Card, n.d.). Nearly three-fourths of Seaford Middle school students scored below or well below the math proficiency level on the Smarter Balanced Assessment Consortium (SBAC) test between 2018 and 2021 (Note: Due to the Covid-19 pandemic, SBAC was not administered in 2019).

Table 2 Seaford Middle School Math Proficiency

Year	Well Below	Below	Meets	Exceeds
2018	***47***	***27***	17	9
2019	***43***	***30***	16	11
2021	***58***	***29***	9	3

Note: Delaware Report Card, n.d. This table shows the percentage of Seaford Middle School students whose scores were well below, below, met, or exceeded the proficiency level on the Smarter Balanced Assessment.

In line with the Delaware Department of Education's initiative, *DE Delivers Supporting HQIM Adoption and Implementation* (*Delaware Department of Education (2021)* to put High Quality Instructional Materials (HQIM) into the hands of every

teacher, Seaford District leaders adopted Illustrative Mathematics (IM) for Seaford Middle School in 2018 and partnered with the Southern Regional Education Board (SREB) for the 2018-2019 school year for professional learning. Three of the five current math teachers and two of the six current special education teachers were working at Seaford Middle during the 2018-2019 school year, meaning that 40% of the current math teachers and 67% of the current special education teachers have been teaching the IM curriculum without the initial training SREB provided. The professional learning teachers received from SREB focused on evidence-based teaching practices such as the Five Practices for Orchestrating Effective Discussions (Smith & Stein, 2018), however, it was not curriculum specific or tailored to IM. Recent research suggests that when teachers participate in curriculum specific professional learning, student achievement increases (Jackson & Makarin, 2018).

In discussions with Dr. Kelly Carvajal-Hageman, Director of Curriculum and Instruction, Seaford Middle School Principal Jim Cave, and Math Coach, Amber Boyce, we identified the need for teachers to become more familiar with the IM materials and problem-based learning to engage in ambitious teaching practices that build conceptual understanding and are responsive to student ideas (Lampert & Graziani, 2009). Ambitious teaching practices include creating opportunities to make student thinking public (Lampert & Ghousseini, 2012; West & Staub, 2003) and holding students accountable for learning goals (Kazemi et al., 2009; Windschitl et al., 2012) while building mathematical knowledge, applying that knowledge to solve authentic problems, and explaining or constructing arguments about their solution paths (Lampert & Ghousseini, 2012).

Organizational Role

I joined PDCE as a mathematics instructional specialist in August 2019, after 28 years of teaching mathematics at the elementary, middle, and high school levels in Maryland public and independent schools. My responsibilities as an instructional specialist include creating and implementing professional learning (PL) programs to enhance the mathematical knowledge and pedagogy of district curriculum supervisors, school leaders, and teachers; coaching teachers to enact HQIM so students develop mathematical understanding and skills prioritized by CCSS-M; and participating in the development and implementation of PDCE's policies and initiatives which enable us to meet these objectives. I collaborate with PDCE colleagues and district/ school leaders to design and implement evidence-based PL sessions that support each district's goals for improving student achievement. PL sessions strategically focus on improving participants' mathematical knowledge for teaching (MKT) and effective teaching practices to ensure that every student has access to high-quality mathematics instruction. In subsequent professional learning communities (PLCs), teachers and I collaboratively extend the work of the PL sessions through rehearsals of evidence-based practices, reflections on current practices, review of student data, and goal setting for next steps. Additionally, within a coaching cycle of planning, observation, and debriefing, individual teachers and I decide which teaching practice on which to focus (i.e., facilitating student mathematical discussion) and collaboratively plan a goal-focused, student-centered lesson by discussing the lesson goals, solving the math tasks in multiple ways, anticipating student thinking, and understanding how the tasks support the goals. Through this process, the teacher now has a vision of what student-centered, problem-

based lesson could look like in their classroom. Together we decide the role I will play in the classroom (modeling, co-teaching, real-time coaching, etc.) and the data I will collect that will inform our next steps. After each lesson, we reflect on the lesson using the IC tool and student formative and summative data to develop next steps.

In the fall of 2021, Seaford School District partnered with PDCE. The goals of the partnership were written to include:

- supporting Seaford Middle School teachers to develop knowledge, skills, and mindsets around strong mathematics instruction to implement their problem-based high-quality instructional materials.
- supporting district and school leaders, including the school-based mathematics coach, in developing knowledge, skills, and mindsets around strong mathematics instruction; and
- supporting school-based coaches, and administrators to lead, coach, and support the high-quality implementation of Illustrative mathematics.

In discussions with Dr. Kelly Carvajal-Hageman, Jim Cave, and Amber Boyce, we determined that my role would be to ensure a renewed focus on strong, curriculum-specific professional learning in the form of content-focused coaching cycles and purposeful PLC planning meetings.

My responsibilities as an outside instructional specialist for Seaford Middle School included: co-creating and implementing a professional learning (PL) program with Ms. Boyce to enhance the mathematical knowledge and pedagogy of teachers; supporting Ms. Boyce to develop coaching practices that support deep mathematical discussions; and supporting the school administrators to recognize ambitious teaching

practices using the IM materials. I chose to focus my ELP on supporting Ms. Boyce to develop coaching practices that support deep mathematical discussions.

I scheduled three-day coaching cycles approximately twice a month. During each of these cycles, I met with Ms. Boyce to purposefully prepare for lesson-planning sessions with grade-level groups of teachers. We collected and reflected on observation data, prepared to debrief with teachers, identified trends in teaching and learning, and decided on next steps in supporting ambitious teaching practices. We discussed coaching practices, including facilitating deep, specific discussions about math content, student thinking, and pedagogy, often referring to the literature. Ms. Boyce and I reflected on our coaching practices, including successful practices and those we needed to improve.

In these three-day cycles Ms. Boyce and I supported teachers in purposefully planning goal-focused, student-centered lessons. We met with grade-level teams of teachers for twenty minutes the day before each lesson observation. We facilitated conversations about the mathematical goals, possible student strategies, and teaching moves that support student thinking.

During the three-day coaching cycles, Ms. Boyce and I met with school administrators to discuss trends in teaching practices, including planning and implementation practices and student learning data (exit tickets, formative assessment results, etc.). To support administrators' ability to recognized ambitious teaching practices we discussed in detail what ambitious teaching strategies look like and how those strategies support student thinking. We discussed next steps for supporting ambitious teaching practices, including needed resources and goals for upcoming PL sessions.

Problem Statement

Nearly 75% of Seaford Middle School students performed below or well below proficiency on SBAC Assessment from 2018-2021. Further, lesson planning in which teachers focus on what students should come to understand (mathematical goal), anticipate student solutions paths by doing each math task, and choose ambitious practices like posing advancing questions to support students to build conceptual understanding lessons was not a norm at Seaford Middle School. While Seaford Middle School teachers sometimes incorporated several ambitious teaching practices into their lessons, instruction remained largely teacher centered.

In the next chapter I describe the actions I took to help Seaford Middle School improve their planning and teaching practices. I describe my overall improvement design as well as the implementation of my improvement strategies and timelines for my work.

Chapter 3

IMPROVEMENT GOAL AND STRATEGIES

The purpose of this chapter is to present my plans and actions for supporting Ms. Boyce, the school-based coach, to shift her planning practices with teachers. I begin by reviewing research on ambitious teaching practices. I define the terms *deep* and *specific* as used in the phrase *deep, specific mathematics discussion* or *deep, specific lesson planning discussion.* I discuss my rationale for focusing on building the capacity of school-based coaches to facilitate deep, specific lesson planning conversations with teachers to support ambitious teaching practice. I then provide detailed descriptions of each improvement strategy and the reasoning behind each strategy. I include details on the creation and revision processes of each improvement strategy.

To support school-based coaches' growth and strengthen our model, I began by researching ambitious teaching, how it supports student learning, what teachers need to know to teach ambitiously, potential high-leverage coaching practices that support ambitious teaching, and how coaches learn these practices (see Appendix B). I read seminal studies about ambitious teaching and effective coaching. I studied recommendations from educational organizations such as the National Council of Teachers of Mathematics (NCTM), a mathematics teacher organization focused on improving the standards of mathematics education, and the National Council of Supervisors (NCSM) of Mathematics, a mathematics educational leadership organization

that supports mathematics leaders to support, sustain, and inspire high quality mathematics teaching and learning. I engaged in a one-hour Zoom discussion with Dr. Stein and Dr.Yureli who are currently working on building tools for supporting coaches and studying their efficacy. They discussed their model for supporting coaches to engage teachers in rich lesson planning conversations and listened to my idea about supporting coaches to facilitate such conversations by engaging them in rich conversations prior to meeting with teachers. I include a portion of my literature review in the next section, for the full literature review, please see Appendix B.

Literature Review – Artifact #2

Ambitious Teaching

The wide adoption of Common Core State Standards-Mathematics (CCSS-M) and rigorous college-and-career readiness standards requires a change in mathematics teaching from traditional teacher-centered, algorithmic-based practices (i.e., direct instruction, think: "I do-We do-You do") to teaching that is concept-building and responsive to student ideas, referred to in the literature as "ambitious mathematics teaching" (Lampert & Graziani, 2009, p.492). At the heart of ambitious teaching is a vision of all students as mathematics learners and doers. Teachers using ambitious teaching practices treat students as sense makers, maximizing opportunities for all students to engage in rigorous mathematical work (Lampert et al., 2013). Teachers create opportunities to make student thinking public (Lampert & Ghousseini, 2012; West & Staub, 2003) and hold students accountable for learning goals (Kazemi et al., 2009; Windschitl et al., 2012) while they are building mathematical knowledge, applying that knowledge to solve authentic problems, and explaining or constructing arguments about

their solution paths (Lampert & Ghousseini, 2012). By using ambitious teaching strategies, teachers support a broad range of students in various learning environments (Witherspoon et al., 2021) to develop deep, connected, and flexible conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive dispositions (Lampert & Graziani, 2009; Lampert et al., 2011; Kazemi et al., 2009).

Ambitious teaching requires teachers to possess mathematical knowledge beyond rules and algorithms and engage every student in rigorous work and in-depth discussions that develop their understanding of both the what and the why of the mathematical concepts (Kazemi et al., 2009; Lampert & Ghousseini, 2012). To teach mathematics ambitiously, teachers must know mathematics content deeply in ways that make the knowledge useful for teaching (Ball & Forzani, 2010; Ball et al., 2008). They need to understand big math ideas (Silverman & Thompson, 2008) and possess the mathematical and pedagogical knowledge necessary for effective instruction, referred to as mathematical knowledge for teaching (MKT) (Ball et al., 2008). MKT includes knowledge of how students learn mathematical content and knowledge to recognize, interpret, and remediate errors, evaluate various solution methods, analyze the affordances and constraints of representations, know the rationale behind procedures, and decompress mathematical knowledge (Ball et al., 2008). Researchers posit that when teachers possess a deep conceptual understanding of specific math content, including the rationale behind procedures and multiple solution pathways, they are equipped to develop these skills in their students (Hill et al., 2005).

Mathematics Coaching

While researchers posit that ambitious teaching practices are effective in supporting students in developing a deep and flexible understanding of mathematics, shifting teaching practices is challenging because of the content, and pedagogical knowledge teachers need to possess (Lampert & Ghousseini, 2012). To teach mathematics ambitiously, educators must plan cognitively challenging tasks (Jackson et al., 2013) that support specific mathematical goals (Hiebert et al., 2018), anticipate student thinking (Smith et al., 2008) and prepare for class discussions in which students engage with each other's ideas as they develop a conceptual understanding (Franke et al., 2015). To increase student achievement by improving the quality of mathematics instruction, school districts are hiring mathematics coaches to target teachers' understanding and actions (Campbell & Malkus, 2013) and support teachers' development of ambitious instructional practices (Kane & Saclarides, 2022).

Researchers describe mathematics coaching as job-embedded, ongoing professional development through which teachers advance their knowledge and implementation of practices that support student learning by working with more knowledgeable colleagues (Campbell & Malkus, 2011; Coburn & Russell, 2008). While many mathematics coaching models share key components, there is no universal set of features or practices defining all coaching models. Russell and colleagues (2020) and Stein and colleagues (2021) models focus on one-on-one coaching cycles of planning, enacting, and reflecting on a specific lesson to build teachers' capacity to implement mathematics tasks that support student thinking and reasoning. Gibbons and colleagues (2017) envision mathematics coaching as supporting groups of teachers to examine standards, study student thinking and enact lessons together. A common

component shared by these models is to use lesson planning sessions to (1) plan effective instruction that supports students' understanding of key mathematical concepts and (2) develop teachers' capacity to teach mathematics ambitiously.

To better understand the effects of mathematics coaching, researchers need to identify and explain coaching practices that support the development of ambitious teaching practices. Literature identifying high-leverage mathematics coaching practices is limited. Gibbons and Cobb (2017) conducted a conceptual analysis identifying potentially productive coaching activities supporting ambitious mathematics and science teaching practices. They examined teacher education literature and identified five characteristics of high-quality professional development that researchers appeared to agree on: intensive and ongoing; focuses on challenges of teachers' daily work; focuses on student thinking; fosters teacher communities to provide opportunities for professional discourse; and provides opportunities to explore and practice specific pedagogical routines (Desimone, 2009; Garet et al., 2001). Gibbons and Cobb used these characteristics to identify potentially productive *content*-focused coaching activities to use with groups of teachers. These activities are analyzing classroom videos, engaging in lesson study, engaging in the content, and examining student work.

While co-designing lessons met their criteria for high-quality professional development, Gibbons and Cobb concluded that "the description in the research of what teachers had opportunities to learn from [this activity] was insufficient to include in the final analysis" (p. 416). However, Russell and colleagues (2018, 2020) and Stein and colleagues (2021) suggest that engaging teachers in deep and specific lesson-planning conversations around math content, student thinking, and pedagogy is a potential high-

leverage coaching practice and posit that deep and specific discussions between teachers and coaches predict improvement in instructional practices.

Deep and Specific Mathematics Discussions

Researchers at the University of Pittsburgh, in conjunction with professional development providers from the Institute for Learning and the Tennessee Department of Education, created a model to improve teaching practices that included "one-on-one coaching that targets planning, enacting, and reflecting on a specific lesson" (p. 442, Russell et al., 2020). In several studies (Russell et al., 2018; Russell et al., 2020; Stein et al., 2021), the researchers examined deep and specific mathematics discussions between a coach and a teacher to see whether these conversations predicted teaching improvement and how coaches learned to facilitate these conversations. These conversions centered around the mathematical ideas of the lesson (mathematical goals), pedagogy (advancing and assessing questions), and student thinking. The researchers posited that planning sessions should include in-depth discussions about the mathematical goals of the lesson, time to do each task in multiple ways, and discussion about the constraints and affordances of each solution pathway to prepare teachers to notice and interpret student thinking. When coaches push teachers to articulate the goals of the lessons clearly, teachers develop an understanding of how tasks support students' reasoning about the mathematical ideas of the lesson. Discussing multiple solution paths and identifying advancing questions prime teachers to monitor, select, and sequence student solution paths and to recognize, build on, and extend student thinking during instruction (Hiebert et al., 2018).

Witherspoon and colleagues (2021) used a mix-methods, case-comparison design to study lesson planning conversations in which coaches and teachers explicitly discussed specific, ambitious teaching practices, when to use the practices, and why those practices might be effective during lesson planning. Their results suggested that when coaches and teachers discuss when and why certain practices should be used teachers continued to implement ambitious teaching practices in later lessons, suggesting that teachers developed adaptive reasoning. These findings add nuance to a vision of what deep and specific lesson planning as a high-leverage coaching practice looks like.

Russell and colleagues (2020) suggest that engaging teachers in deep and specific lesson-planning conversations around math content, student thinking, and pedagogy improves teachers' capacity to provide opportunities for students to "engage in conceptual thinking during lessons" (Russell et al., 2020, p. 459). They further posited that growth in the coach's capacity to facilitate deep, specific mathematics conversations when co-planning with teachers predicted teaching improvement. Focusing on building the capacity of school-based coaches to support teachers' development of ambitious teaching may be a way to amplify teachers' professional development and capitalize on local expertise.

Russell and colleagues (2020) describe deep and specific discussions as those discussions that are focused on interactions among students, teachers and mathematical content known as the instructional triangle (Cohen et al., 2003). Russell and colleagues (2020) use the phrase "deep, specific mathematics conversations" throughout their work. They define *deep* to mean "deep in substance (as opposed to focusing on superficial features)." I conceptualized "deep in substance" to mean discussions that explicitly

connect tasks and lesson goals to broader mathematical ideas. I conceptualized deep discussions as providing teachers with opportunities to generalize the underlying mathematical concepts for future tasks.

Russell and colleagues (2020) described discussions as "*specific* in regards to what they target." I conceptualized *specific* conversation as discussions that intentionally and explicitly target the mathematical point of the lesson. Discussions of anticipated student strategies and what these strategies reveal about students' understanding of the mathematical goals are specific because they connect the student understanding to the goals. A discussion of advancing questions that could potentially support students' understanding of the mathematical point of the task or lesson would also be specific, because an explicit connection is made between the student understanding and the goals. (Stein et al., 2021).

With these definitions in mind, I embarked on designing a suite of coaching tools to support the building coach to develop their practice around holding conversations that are both deep and specific through their work of planning, holding discussions, collecting data, and reflecting on their practice. I intentionally attended to aspects of depth by including prompts to explicitly connect tasks and lesson goals to broader mathematical ideas. I attended to specificity in my suite of tools by intentionally including prompts for the coach to connect the student understanding to the goals through talk of student strategies and advancing questions. I then designed tools to reflect through these lenses of depth and specificity.

Improvement Strategies

Suite of Tools and Protocols

My first Improvement Strategy was to use the high-leverage coaching practice for deep mathematical discussions to create a suite of planning protocols and tools to assist PDCE Instructional Specialists in building the capacity of school-based coaches to support teachers to facilitate rich student discourse that is responsive to student ideas (see Appendix C). Prior to this study, I gathered anecdotal evidence that suggests that coach/teacher conversations vary in depth among PDCE instructional specialists. Coburn and Russell (2008) suggested that the depth of conversations between coaches and teachers about teaching and learning vary. These protocols and tools were designed to support school-based coaches' uptake of deep and specific mathematics discussions. I drafted a suite of eight tools for supporting the coach to facilitate planning sessions with teachers during which they engage in rich discussions about mathematics, student thinking, and pedagogy—four for Instructional Specialists and four for School-based Coaches (see Table 3). Tools included planning tools, discussion guides, reflection tools and data collection tools.

Table 3 Suite of Coaching Tools

Tool	Description
Coaching the Coach through Lesson Planning Tool	A planning template for Instructional Specialists to Plan a discussion to focus on deep mathematical ideas with the school-based coach.
Coaching the Coach Discussion Guide	A Discussion Guide for PDCE Instructional Specialists to guide the discussion with the school-based coaches.
Coaching the Coach	A Data Collection tool to collect data on the impact of the

Data Collection Tool	discussions on school-based coaches' practice.
Coaching the Coach Reflection Guide	A tool to guide a reflection on the impact of the discussions of the Instructional Specialist with the school-based coach.
Coaching Through Lesson Planning Tool	A Planning Template for school-based coaches to plan a discussion to focus on deep mathematical ideas with teachers.
School Based Coach Discussion Guide	A Discussion Guide for school-based coaches to guide the discussion with teachers.
School-based Coach Data Collection Tool	A Data Collection tool to collect data on the impact of the school-based coach's discussions on teacher practice.
School-based Coach Reflection Tool	A Reflection tool to reflect on the influence of the discussions of the school-based coach on teacher practice.

School-based Coaching Tools

I began by adapting PDCE Teacher Planning Tool (see Appendix I). I added guiding questions to the tool to focus teachers' attention on the mathematical point of the lesson and how each task contributes to student understanding of the point to directly address the ideas of depth and specificity. Questions included which teaching moves they planned to use to support student learning and why these questions supported teachers' metacognition of pedagogical choices. The tool provided an artifact of each teacher's planning of a goal-focused, student-centered lesson.

While teachers are responsible for teaching mathematics, coaches are responsible for helping teachers develop their mathematical knowledge for teaching (MKT). Therefore, I created a coach planning tool by adapting the teacher planning tool to include questions that support coaching moves they plan to use to support teachers' thinking. This tool included space to record questions/ideas teachers contribute during planning. The tool provided an artifact of teachers' planning sessions to identify any changes in the focus and depth of planning conversations and inform the coach's choice

of areas of teachers' planning practice to focus on in the next planning session. I drafted a protocol sheet (see Appendix C) to accompany the tool to (1) support coaches in using the tool to plan a goal-focused, student-centered lesson; (2) facilitate in-depth lesson-planning conversations around content, pedagogy, and student thinking; (3) build teachers' capacity to plan these types of lessons in the future.

Ms. Boyce and I examined and discussed the tools prior to the start of the study. We made several changes that we thought could improve the effectiveness of the tools to support specialist/coach in supporting deep, specific mathematics discussions. We changed the organization of the planning tools to make them more user-friendly by adding color, changing font sizes, and editing column sizes. At Ms. Boyce's suggestion, we added "Previous Next Steps: Check Progress" and "Data Collection" categories to the coach planning tool. These additions were aimed at focusing the coach's and teachers' attention on a common goal to support pedagogy and data collection concerning the goal (Witherspoon et al., 2021).

I revised several of the guiding questions in the tools so there was a tighter alignment to the ideas of depth and specificity. As an example, the question "What moves might you make to support student understanding?" was changed to "What strategies and questions will you use to make the key ideas stand out and why?" Lesseig and colleagues (2017) suggested that the kinds of questions that are embedded within a protocol can open or close opportunities to build teachers' mathematical knowledge for teaching. I believed the wording of this new question would open opportunities for teachers to share strategies related to the math goals and explore reasoning for doing so. The final Coaching Through Lesson Planning Tool (Figure 1) explicitly prompts the coach and

teacher to attend to the lesson purpose and goals, how students will build knowledge toward the lesson purpose, what successful student thinking and understanding will look like and sound like, how each individual task is connected to the goals, what anticipated student thinking would indicate student understanding, and what strategies and questions the teacher will use to ensure the goals stand out.

Unit:	**Lesson:** **Date:**	**Teacher:**	
Standards	**Building on:** **Addressing:**	**Record possible questions/strategies to explicitly address content, student thinking, & possible teaching strategies.**	
Lesson Section	**Guiding Questions to Consider**	**Coach moves/questions**	**Teachers' Thinking/Input**
Read Lesson Narrative and Synthesis	What is the purpose of this lesson (the big math ideas)? How will students build knowledge toward this purpose?		
Lesson Goals	What should students **know** and be able to **do** at the end of the lesson?		
Cool-Down **(Do the math)**	How can students show understanding of the learning goal? What might incomplete understanding/ misconception look like? Where can you address them in the lesson?		
Warm-Up Do the math to anticipate how to support **students' understanding**	What is the task's purpose & connection to goals? What do you expect to see/hear that indicates student understanding? What strategies & questions will you use to make the key ideas stand out?		
Activity 2 Do the math to anticipate how to support **students' understanding**	What is the task's purpose & connection to goals? What do you expect to see/hear that indicates student understanding? What strategies & questions will you use to make the key ideas stand out?		
Activity 3 Do the math to anticipate how to support **students' understanding**	What is the task's purpose & connection to goals? What do you expect to see/hear that indicates student understanding? What strategies & questions will you use to make the key ideas stand out?		

Lesson Synthesis	How will you support **students** to **generalize/connect their understanding** of the lesson concepts? of the unit concepts?		
Previous Next Steps: Check-In on Progress			
Collect Data On:			

Figure 1 Coaching Through Lesson Planning Tool

I designed a discussion guide for the coach to use with the Coaching Through Lesson Planning Tool, to support the coach in preparation for the coaching conversation and facilitating it. The prompts in the discussion guide (see Figure 2) align with focusing the coach and teacher thinking on the lesson goals, the big mathematical ideas, how students interact with the goals, the questions that teachers can ask to help students build connections, as well as prompts for holding a discussion.

Lesson Planning Duration: 20 minutes 1 to 2 days before teaching the lesson.
Attendants: School-based coach and grade level group of teachers or individual teacher.

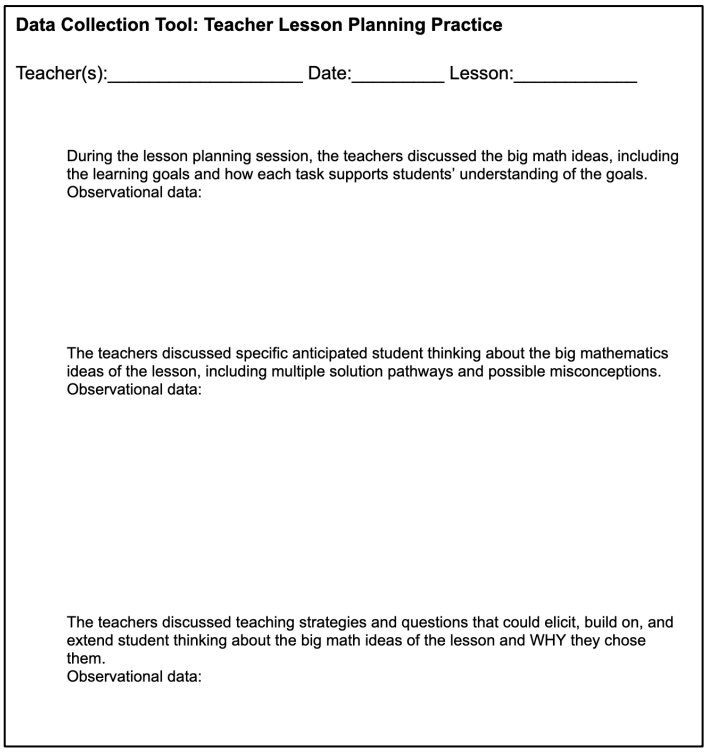
1. **Before the lesson planning session,** the teacher(s) and coach read the lesson (including narrative, syntheses, and goals), clearly articulate the mathematical idea(s) of the lesson and complete the math tasks in multiple ways to anticipate student thinking.
2. Coach and teacher engage in deep and specific discussion of the math goals, anticipated student thinking, and teaching moves to support student learning. Specifically, teachers and coach:
    a. Identify the specific mathematical concepts addressed and what students should know and be able to do by the end of the lesson. The purpose of the discussion is to ensure everyone has a clear understanding of the mathematical point of the lesson.
    b. Discuss multiple solution paths students might use to solve tasks, identifying possible misconceptions and ways to address them. Preliminarily decide which solution paths to elicit and build on to support the lesson goals.
    c. Discuss questions the teacher plans to use to advance student thinking toward the lesson's goals, explicitly **focusing on why** the teacher chose those questions **and when** to ask them.
        i. Questions that encourage students to clarify their thinking.
        ii. Questions that encourage students to connect their thinking with others.
        iii. Questions that encourage students to evaluate their own and others' thinking.
    d. Questions may be chosen from the curricular materials or created by the teacher/coach. It is suggested that teachers have these questions ready during the lesson.
3. The coach will use open-ended probing and advancing questions to facilitate discussion. Questions will be both pre-planned and in response to the teachers' thinking and focus teachers' attention on

the mathematical purpose of the lesson and student thinking. When needed, the coach may follow up questions with direct suggestions/ideas and reasons for them.

4. The coach will keep a written artifact of the conversation using the PDCE coaching tool to refer to when observing teachers, planning debriefing sessions, and planning their next steps for supporting teachers.

Figure 2 School-based Coach Discussion Guide

I created an observation data collection tool (Figure 3). This tool includes prompts to focus attention on the mathematical goals of the observed lesson, ambitious teaching practices teachers implemented, and whether and to what extent those strategies supported student



Data Collection Tool: Teacher Lesson Planning Practice

Teacher(s):_____ Date:_____ Lesson:_____

During the lesson planning session, the teachers discussed the big math ideas, including the learning goals and how each task supports students' understanding of the goals.
Observational data:

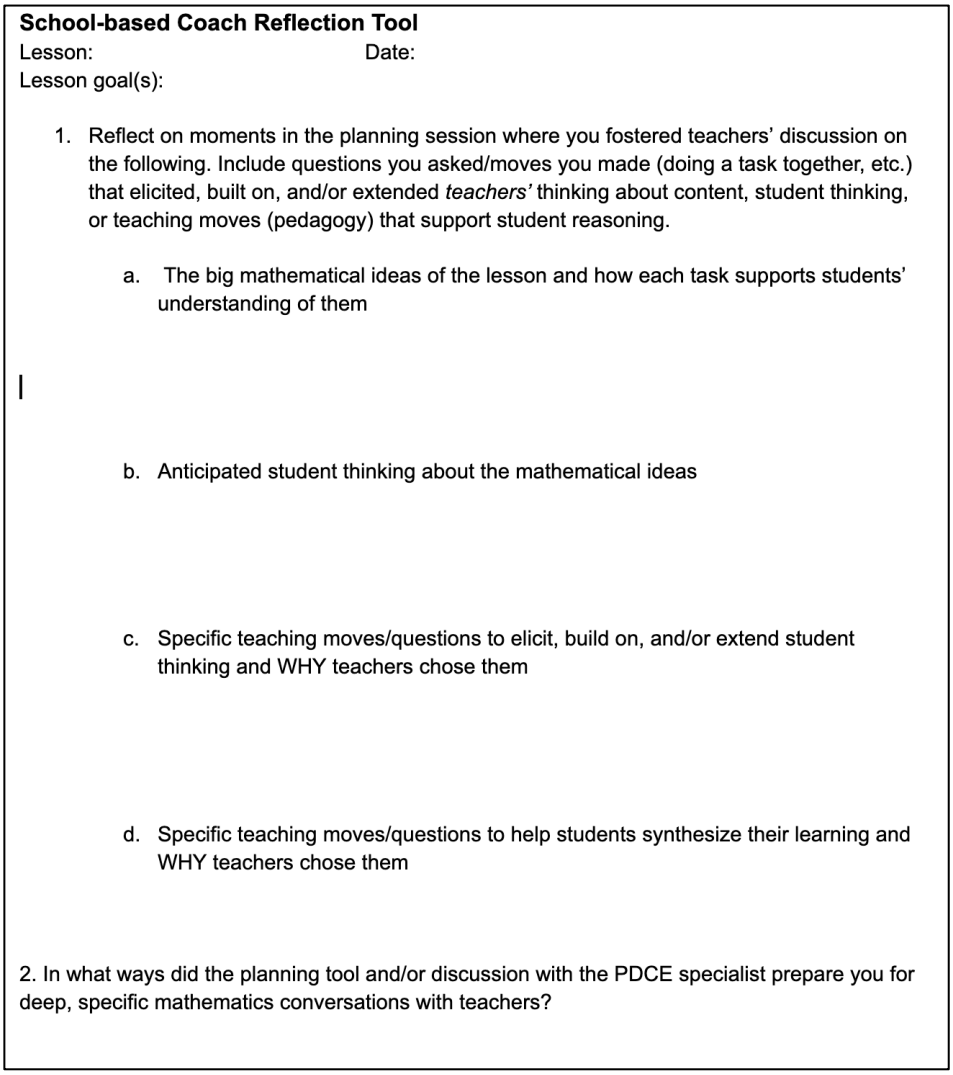
The teachers discussed specific anticipated student thinking about the big mathematics ideas of the lesson, including multiple solution pathways and possible misconceptions.
Observational data:

The teachers discussed teaching strategies and questions that could elicit, build on, and extend student thinking about the big math ideas of the lesson and WHY they chose them.
Observational data:

Figure 3 Data Collection Tool: Teacher Lesson Planning Practice

thinking. I also created a coach reflection tool which prompts coaches to reflect on their coaching practice during one specific coaching cycle (Figure 4). Note: These tools were

not utilized in this study, since this study focused on pre-planning meetings during the coaching cycle.



School-based Coach Reflection Tool

Lesson: Date:

Lesson goal(s):

1. Reflect on moments in the planning session where you fostered teachers' discussion on the following. Include questions you asked/moves you made (doing a task together, etc.) that elicited, built on, and/or extended *teachers'* thinking about content, student thinking, or teaching moves (pedagogy) that support student reasoning.

    a. The big mathematical ideas of the lesson and how each task supports students' understanding of them

    b. Anticipated student thinking about the mathematical ideas

    c. Specific teaching moves/questions to elicit, build on, and/or extend student thinking and WHY teachers chose them

    d. Specific teaching moves/questions to help students synthesize their learning and WHY teachers chose them

2. In what ways did the planning tool and/or discussion with the PDCE specialist prepare you for deep, specific mathematics conversations with teachers?

Figure 4 School-based Coach Reflection Tool

Coaching the Coach Tools

I created a suite of coaching the coach tools that I used to guide my planning and coaching work. These tools provided questions to prompt my thinking in support of building school-based coaches' capacity to facilitate deep and specific mathematical

conversations with teachers. Each tool had space to record possible questions I would use to support the coach in planning for deep, specific mathematics discussions with teachers and coach's responses. These tools provided an artifact of specialist-coach planning sessions and can be used to show changes in coaches' capacity to preplan in-depth planning conversations with teachers. It also informed the specialist's choice of areas of focus for future planning sessions.

A protocol sheet also accompanies the *Coaching the Coach Through Lesson Planning Tool* to support specialists in using the tools to (1) plan a goal-focused, student-centered lesson; (2) build the specialists' capacity to facilitate in-depth lesson-planning conversations around content, pedagogy, and student thinking with building coaches and (3) build the school-based coach's capacity to facilitate in-depth lesson-planning conversations with teachers around content, pedagogy, and student thinking. These tools were largely based on the *Coaching the Teacher Through Lesson Planning Tool*, with some specific modifications to ensure the coach focused on both the teachers' thinking as well as the student thinking. Figure 5 provides an example of the shift from the *Coaching the Teacher Through Lesson Planning Tool* to the *Coaching the Coach Through Lesson Planning* Tool. Note the shift in language from student focused on the *Coaching the Teacher Through Lesson Planning Tool* to the focus on *both* teachers and students in the *Coaching the Coach Through Lesson Planning Tool*.

Final Version of the Coaching the Teacher Through Lesson Planning Tool

Warm-Up Do the math to anticipate how to support **students' understanding**	What is the task's purpose & connection to goals? What do you expect to see/hear that indicates student understanding? What strategies & questions will you use to make the key ideas stand out?

Final Version of the Coaching the Coach Through Lesson Planning Tool

Warm-Up Do the math to anticipate how to support **students' understanding**	What is the task's purpose & connection to goals? What do you expect teachers to see/hear that indicates student understanding? What strategies &questions might teachers use to make the key ideas stand out? What questions will you ask to elicit, build on, and extend teachers' thinking on ways to support **students'** understanding of key ideas?

Figure 5 Shifts from Coaching the Teacher to Coaching the Coach

To support a systems approach, I created an assessment tool to help district and school administrators determine whether and how coaching activity has impacted teacher and student learning (see Appendix E). This tool was adapted from NCSM (2019), NCTM (2014), and PDCE IC tools and supports educational leaders who may not be experts in mathematics education. It includes descriptors of teaching practices ranging from teacher-centered to student-centered to enable educational leaders to gather data determine whether and how coach-led planning sessions focused on mathematical goals, classroom discourse, and student thinking have impacted teacher practice and student learning. Due to the scope of this study, the tool was not implemented.

Pilot Tools and Protocols

My second Improvement Strategy was to pilot the tools to determine ease of use, accessibility, and professional learning needs for the school-based coach at Seaford Middle School. I piloted these tools with all nine middle school math teachers at Seaford Middle School. Beginning in October, participants had access to the planning tools in

Seaford Middle School's shared mathematics drive and on paper. Ms. Boyce and several teachers used the tools and protocols over the course of three coaching cycle in the fall of 2022 (Note: teachers were encouraged, but not required to use the planning tool). As the instructional specialist, I used *the Coaching the Coach Through Lesson Planning* tool to intentionally plan each mathematics lesson, focusing on how to build the capacity of the school-based coach to facilitate deep, specific mathematics discussions when planning with teachers. I asked Ms. Boyce questions such as those embedded in the tool. The tool included this prompt, "What is the purpose of this lesson (the big math ideas)? How will students build knowledge toward this purpose?" In this excerpt from the November specialist-coach conversation I provide an example of how I worked to maintain the focus on the depth and specificity of the mathematics as it connects to the goals, tasks, student thinking, and to pedagogical choices. In italics, I highlight aspects of this November 14th Specialist-Coach conversation that make it deep and specific:

> Brown: Unit three lesson, one intro lesson. So, what do you think they're going to say the *goals of the lesson are?*
>
> Boyce: so, knowing them it'll be this *rate for one*. Whenever it comes up in the last ones, it's where they go quickly. So, really trying to get them to keep in mind and have the *kids keep in mind the context* and the *importance of the rate for one because of the context*. And why is it useful to find and use that idea of a per one when we're talking about this gigantic problem.
>
> Amy Brown: I think that you're probably right. I think they're going to miss that part of the usefulness, right? It's going to go right to that per one.
>
> Boyce: as just the calculation. Yeah,
>
> Brown: So, what kinds of *things do you think you're gonna say or do to get them to get past that*?
>
> Boyce: So I think, like, even the cool down, asking how they *[teachers] anticipate some kids thinking about it where it's, adding thirty-three every second, or multiplying thirty-three by eleven seconds*. If you're still seeing those different, you know, different strategies or different levels of understanding that far down in the lesson. *What kinds of questions can you ask around the context throughout the different activities to really help kids understand how this idea of finding for one helps them find it more quickly*. And maybe even *what questions could you ask the Kids*? Maybe that aren't included in the activity that could get them to maybe jump from that *additive to that multiplicative idea* and push them a little bit.

> Amy Brown: I think that's great. This one goes back to what we were talking about this morning, about how it's *just not about that rate per one, but it's about. How do they want them to look at it? What is the goal really saying? They want them to be able to explain how you do it, and looking at it, it is when it's useful. How it's useful. It's not really about, It's not specifically about finding it. It's really about. Why would I do it this way?* And how could I do it even in a as cumbersome problems as these are
>
> Boyce: right. *One of the goals how to solve problems involving rates in less familiar contacts*. And *evaluate the usefulness like That's the actual goal.* Evaluate the usefulness of it, um. So is it *more useful to add thirty-three every time I do it? Or is it more useful to multiply thirty-three by eleven?* Um!

Through this part of the discussion, I was focused on making sure Ms. Boyce was focused on the goals of the lesson. I asked directly about the goals. I probed about the usefulness of *finding the rate per one* when solving complex problems. I asked her what she would say or do to get teachers to see that. She responded, "really try to get them to keep in mind and have the kids keep in mind the context and the *importance of the rate for one because of the context.*" I asked why and she stated, "Asking how they *anticipate some kids thinking* about it and what can you ask around the context can really help *kids understand how the idea of finding for one helps*." In this way, I used the tool to create opportunities for Ms. Boyce to think deeply about questions to ask teachers, when to ask them, and why.

Ms. Boyce used the Coaching Through Lesson Planning tool in a similar way, intentionally planning each lesson and creating opportunities for the teacher to engage in deep, and specific conversations about the mathematical point of the lesson, possible student solution strategies, and how to support student understanding of the lesson goals. In the following excerpt from the December 5th coach-teacher conversation, I provide an example of how Ms. Boyce worked to maintain the focus on the depth and specificity of the mathematics as it connects to the goals, tasks, student thinking, and to pedagogical

choices. In italics, I highlight aspects of this December 5th Coach-Teacher conversation that make it deep and specific:

> Boyce*:* Alright? So, we are going to look at unit 3 lesson 10 today. So *what are the goals for this lesson?*
>
> T3*: To be able to have a double number line and percent in dollar amounts*
>
> Boyce: Okay. And actually, the *double number line is part of the goal. What about the other one*?
>
> T1: and the *knowing that it's a rate for 100, which goes in with that task with the money*. There are 100 cents as a dollar
>
> Boyce*:* anything else? (pause of 12 seconds)
>
> Boyce: I think it's just *nice that they're accessing it with something that they're familiar with.*
>
> T1: and then always like every year. So far this has been a great lesson because *they catch on really quick, because it is money that they are used to*.
>
> Boyce: Alright, so, looking at the cool down, and I actually have your slides up here because Amy and I were going through them a little bit earlier. *How are students showing their understanding here*?
>
> T2: Well, number *one ties right into understanding the percentages using dollars*. Oh, oh, it's! I mean that's the student facing learning goal, oh. percentage using dollars and cents as an example. So, this way, they they're looking at it. Okay, *it's 80 cents. They should be coming up with 80% of a dollar.*
>
> T1: It's not asking them really to create a double number line, but *they can definitely create a double number line*, using it.
>
> T2: I think a lot of them will use it to figure out more than 100%
>
> T1: right, and then it's the combination for it to be any combination it doesn't have to be like multiple different ones. It could be like 130 pennies, or you know I mean. It's *any combination that will add up to a dollar 30 and understanding that dollars a 100% of a dollar*. And then being able to go over that.
>
> Boyce: We're going to talk a little bit more about that idea when we transition from the first activity to the second activity. But that's huge, because *it's a big piece of it*, but it's also a *difference between the first activity, and the second with just a slight change in the wording.*

Through this part of the discussion, Ms. Boyce specifically focused the teachers on the goals of the lesson first, creating opportunities for them to articulate their understanding of the mathematical point of the lesson. Ms. Boyce adds depth to the discussion by stating prior knowledge students will access as they build understanding of

percentages. Ms. Boyce pointedly asks how students will show understanding, prompting teachers to specifically discuss anticipated student strategies and what they indicate about student understanding. Ms. Boyce then begins calling teachers' attention to the differences in the upcoming tasks by specifically noting a slight change of wording. It is worth mentioning that Teacher 1 corrects themselves when they refer to the student facing goals instead of the teacher facing goals, since teacher facing goals include a deeper and more detailed description of the mathematical point of the lesson. This vignette illustrates what both the depth and specificity sound like in coach-teacher discussions.

Ms. Boyce and I piloted using the planning tools and maintaining records of their use in a shared drive. Olanoff, Masingila, and Kimani (2021) suggest that recording activity provides opportunities for reflection and meaningful change. I recorded some of Ms. Boyce's contributions to planning discussions on my planning tool and used it to reflect on my coaching practices and make necessary changes in my practice for the next conversation. For example, in the October specialist-coach planning session, I began by stating the lesson goals and then asked Ms. Boyce if she agreed. I nearly missed an opportunity to address a misconception she had by telling instead of using questions to support her answers. I noted this on my planning document, reflected on my practice, and intentionally planned questions that would support Ms. Boyce's capacity to identify the mathematical point of the November lesson. Ms. Boyce recorded evidence of the coach-teacher conversation to identify and analyze changes in teachers' discussions about mathematical content, student thinking, and ambitious strategies they could implement to elicit, build on, and extend student thinking.

Study Impact of Tools/Protocols on Planning Practices

My third improvement strategy was to study the impact of the use of the tools/protocols on Ms. Boyce's practice in planning sessions with teachers. The diagram summarizes the lesson discussion process (Figure 6). In this study, we examined only the shapes in dark pink.

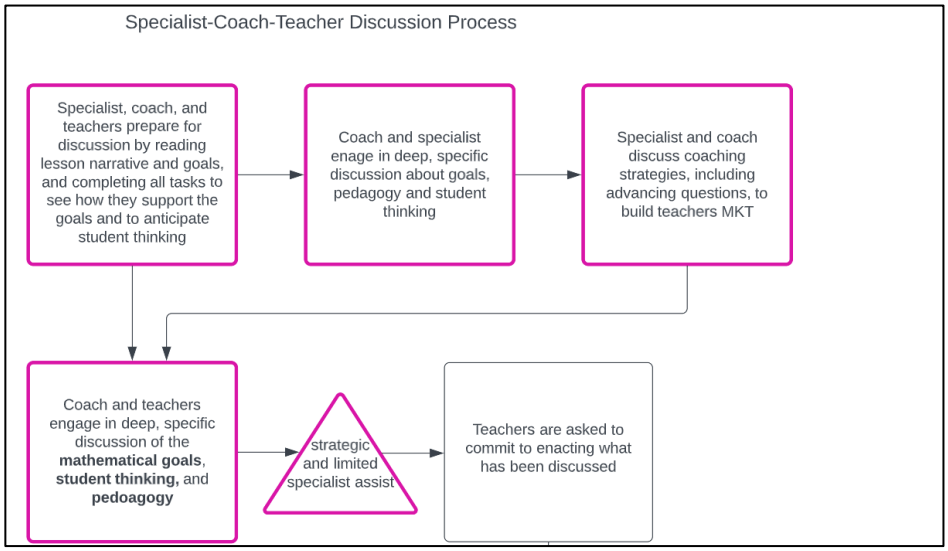


Figure 6 *Specialist-Coach-Teacher Discussion Process. Note:* Adapted from Stein et al., 2021. The highlighted shapes indicate those protocols examined in this study.

These planning protocols call for all participants to plan an upcoming lesson prior to our discussion by reading the goals and narratives and completing each math task to discover how they support student thinking about the mathematical point of the lesson. This step is necessary due to limited time available for grade-level coaching sessions. The instructional specialist and school-based coach engage in deep, specific discussions about the mathematical goals, student thinking, and teaching strategies that support student thinking prior to planning with teachers. They discuss how to support teachers to develop

a deep understanding of the mathematical point of the lesson, how they might collect data about student thinking and what that data tells them about students' understanding of the mathematical goals. The specialist and coach prepare questions that would push teachers to examine strategies they might use to support student thinking, including when and why to use them. With strategic assistance from the instructional specialist, the coach then engages teachers in rich planning discussions focusing on the mathematical goals, student thinking, and ambitious teaching strategies that elicit, build on and extend student thinking.

During the fall of 2022, Ms. Boyce and I engaged in planning sessions to prepare to facilitate deep, specific discussions with teachers. Researchers posit that coaches may benefit from practice-embedded learning opportunities like those used with teachers, in which a facilitator establishes a purpose, presses for, and listens to explanations and evidence, and maintains focus on the disciplinary content (van Es, et al., 2014). Prior to their 20-minute discussion session, the Ms. Boyce and I independently planned the upcoming lesson, including completing each math task in multiple ways to anticipate student thinking. We then engaged in deep, specific discussions about the mathematical goals of the lesson, possible strategies and reasoning students might use them, and ambitious teaching practices that could support student thinking, including posing purposeful questions. We discussed coaching practices (like asking advancing questions) that support teachers to plan and implement student-centered, goal-focused lessons as well as when and why to implement those coaching practices.

Within 24 hours of the specialist-coach discussion, Ms. Boyce, the 6th-grade teachers (three mathematics teachers and two special education support teachers), and I

engaged in a deep, specific conversation about the mathematical point of an upcoming lesson, possible student solution strategies, and effective teaching strategies to build on and extend student thinking. Because these meetings were 20 minutes in length, each participant independently planned the lesson ahead of time, including completing each math task in multiple ways.

Following the format of the specialist-coach discussions, the coach facilitated deep, specific mathematics discussions aimed at first clarifying the mathematical point of the lesson, including ways in which students were expected to interact with the mathematics. (For example, were students to recognize equivalent ratios or create them). The coach and teachers then discussed possible strategies and reasoning students might use to solve tasks and what students' choice of strategy revealed about their thinking. Next, they discussed ambitious teaching practices, including advancing questions, that could support student thinking, why they might be effective, and when to use them.

Measuring Progress for Attaining the Improvement Strategy

To study whether and in what ways the use of the tools and protocols changed Ms. Boyce's practice in planning sessions with teachers, I analyzed data on the iterative use of tools prepared before specialist/coach and coach/teacher discussions and made modifications to these tools when they did not support deep and specific discussions. Table 4 outlines the data I collected and analyzed during this three-month study.

I analyzed my own planning tools for evidence of components that assisted me in building the coach's capacity to facilitate rich lesson planning discussions with

teachers, by examining whether and how clearly the guiding questions supported the coach to make connections among the mathematical point of the lesson, student thinking, pedagogy and assist teachers in making similar connections. I made the prompts more specific if the response to the prompt did not elicit what I hoped it would. For example, the pilot version of the specialist tool included the questions *How does this task support goals? How will students build understanding?* These questions did not guide me to target Ms. Boyce's capacity to facilitate rich planning discussions. I changed the guide questions to include *What strategies and questions might teachers use to make the key ideas stand out? What questions will you ask to elicit, build on, and extend teachers' thinking on ways to support students' understanding of key ideas?* This revision focused my attention on supporting the coach to guide teachers to plan goal-centered, student-responsive lessons. I analyzed the coach's planning tool for evidence of questions that assisted the coach to facilitate rich planning discussions with teachers, by examining how clearly the questions assisted the coach in guiding teachers' thinking about the mathematical point, student thinking, and pedagogical strategies to support student thinking. For example, the question *What moves might you make to support student understanding?* did not explicitly connect the mathematical point of the lesson to teaching strategies teachers might use. I changed the question to *What strategies & questions will you use to make the key ideas stand out?* to more focus attention on the connection between the mathematical point and teaching strategies to support it.

Discussions were audio recorded and transcribed using Zoom transcription. I printed the transcriptions and cleaned them by hand, leaving the "ums" and repeated phrases, or

dropped thoughts in the cleaned transcriptions as indicators of thinking/processing and to help capture the true flow of the discussions.

Table 4 Data Cycles

Coaching Cycle	**Description of data collected and analyzed in this study**
10/24-10/26 Unit 2 lesson 10	Audio recording of specialist-coach planning discussion Audio recording of coach-teacher planning discussion. Digital copy of coach's planning tool Digital copy of Specialist's planning tool
11/14-11/16 Unit 3 lesson 1	Audio recording of specialist-coach planning discussion Audio recording of coach-teacher planning discussion. Digital copy of coach's planning tool Digital copy of Specialist's planning tool
12/5-12/7 Unit 3 lesson 10	Audio recording of specialist-coach planning discussion Audio recording of coach-teacher planning discussion. Digital copy of coach's planning tool Digital copy of Specialist's planning tool

I minimally adapted the rubric developed Russell and colleagues (2020) and further revised by Stein and colleagues (2021) for scoring the depth and specificity of key components of the recorded coach-teacher discussions (see Figure 7). The key components are identifying the mathematical point (goal) of the lesson, discussing multiple student solution strategies, and choosing advancing questions that will extend student understanding of the goals.

Component	Rubric
STUDENT THINKING Multiple Solution Strategies Discussed Definition: Coach and teacher identify multiple solutions paths for the task	0—No solution paths mentioned or discussed 1—All discussed in superficial ways 2—One discussed in more than superficial way 3—At least two discussed in more than superficial ways
PEDAGOGY Advancing Questions Identified Definition: Advancing questions asked by the teacher to challenge students or move students beyond their current thinking	0—Not named 1—One or more named but not discussed (e.g., when to use, potential teacher or student responses that are procedural or logistical in nature) 2—Discussed with depth (e.g., likely student answers and potential teacher responses as long as responses are related to probing student thinking and go deeper into the math idea)
MATHEMATICAL CONTENT Mathematical goal is discussed with specificity Definition: The discussion of the mathematical goal went beyond broad topics (e.g., fractions) to include identification of specific mathematical concepts or principles that are the goal for student learning	0—No goal named 1—Broad topics named 2—Gives a mathematical definition or a procedure as the goal 3—Discussion of students acquisition of the underlying meaning of a concept

Figure 7 Coach/Teacher Discussion Analysis Rubric. Note: (Adapted from Stein et al., 2021)

I made adaptations to create the specialist-coach rubric (see Figure 8). I used the same criteria as the coach/teacher rubric but modified the rubric after my initial round of coding. I realized that a nuanced understanding of pedagogy wasn't being captured. In conversations with the school-based coach, we began discussing when teachers might use a question to advance student thinking and the importance of the teachers knowing why it was a good time to use it. Researchers Witherspoon, Ferrer, Correnti, Stein, and Schunn

(2021) posit that coach-teacher discussion on when and why certain practices should be implemented predicted gains in ambitious instruction. My advisor and I concluded that I needed one more level of coding within my current pedagogy code.

PEDAGOGY	0—Not named
Advancing Questions Identified Definition: Advancing questions to be asked by the teacher to challenge students or move students beyond their current thinking	1—One or more named but not discussed (e.g., when to use, potential teacher or student responses that are procedural or logistical in nature) 2—Discussed with depth (e.g., likely student answers and potential teacher responses as long as responses are related to probing student thinking and/or go deeper into the math idea) 3-Meta discussions of the *what, when, why, and how* of the specific teaching situation to support teachers' capacity to plan advancing questions in the future.

Figure 8 Specialist/Coach Discussion Analysis Rubric (Pedagogy only). *Note:* (Adapted from Stein et al., 2021 and Witherspoon et al., 2021)

This new coding level captures discussion on when, how, and why advancing questions are used. You can see this addition in the Pedagogy section, level 3—"Meta discussions of what, when, why, and how of the specific teaching situation to support teachers' capacity to plan advancing questions in the future."

I coded the audio transcripts of each specialist-coach planning conversation using the specialist-coach rubric. I coded the audio transcripts of each coach-teacher lesson planning conversation using the coach-teacher rubric. Initially I used phrases as the unit of measure. As an example, when asked what the big math ideas of the lesson were, one teacher responded, "Trying to decide if situations had the same rate." I coded this as *Math Content 1* due to the broadness of the statement. After completing my first round of

coding, I realized that this unit of measure did not capture the context of the moments surrounding discussion of math content, pedagogy, and student thinking that taken together showed depth of discussion not captured in one phrase.

To revise my unit of measure, I chose shifts in topic (for example, discussion moved from mathematical goal to student strategies) as my unit of measure and coded the transcripts again. By using codes to capture discussion on topics rather than individual statements, I captured how deeply and/or specifically the coach and teachers discussed mathematical content, student thinking, and pedagogy. The vignette below illustrates an example of this new approach to coding:

> Boyce: *So, thinking about either strategy that they're going to use or representations that they're going to use. How are you going to collect data while they're working, and then once you collect that data, what order will you sequence these in to share out?*
>
> T1: I was looking for this *double number line*, and that will probably be the first thing that I show, is the double number line, and then, if somebody does the math, when they just take three times three and forty-seven times three, without the double number line, or the *division or multiplication without the double number line* and still get to that point. And then, if they, *if I had anybody who did unit rate*, that would be the last thing that I showed.
>
> ---
>
> Boyce: *So, once you have these representations of the double number line, the multiplication, the unit price, how will you get students to make connections between them?*
>
> T2: If somebody comes out with just the multiplication or division, *where do you see it in this double number line? How could we do that in this double-number line?*

Using the original unit of phrase, I coded the first two lines as a level 2. After revising my coding to look at sections of conversations that dealt with the same theme (in this case, student thinking), I coded this section of conversation as level 3 because the discussion as a whole included multiple likely student responses and teacher responses that prompt students to think deeper about the mathematical content by having them make connections among representations/strategies. Ms. Boyce prompted teachers to

think about *when and how* they would assist students to make connections among the strategies, elevating this discussion to level 3 as described in the rubric.

To explore whether and in what ways the coach's discussions with the specialist changed the school-based coach's facilitation of deep, specific mathematics discussion with teachers, I examined the depth and specificity of specialist-coach preplanning mathematics discussion and the depth and specificity of coach/teacher mathematics discussions. I created tables of specialist-coach conversations and its subsequent coach-teacher conversations (See Appendix D - Artifact 4- Methodological Memo). Each relevant moment was recorded along with its rubric level number and the transcript lines. I modified the transcripts recorded in the table slightly by removing "ums" and repetitive words (ex. Students, the students, the students, um, they might…). I analyzed these tables to look for patterns between levels of depth and specificity of discussions between specialist and coach and coach and teachers. Table 5 illustrates an example of an excerpt from a paired Specialist-Coach and a Coach-Teachers conversation.

Table 5 Comparing Depths of Pedagogy Conversation (November)

Specialist-Coach Level 2 Lines 187-206	**Coach-Teachers** Level 2 Lines: 159-181
Brown: Are there any other ways you were thinking about this that I didn't ask questions about?	Boyce: So, *what about the lesson synthesis, thinking about the lesson goals?*
Boyce: The lessons synthesis. Amy Brown: Okay,	*Boyce:* So, *I'm going to read the two goals to you again and keep these lessons in this question. So, evaluate the usefulness of calculating a rate for one when solving problems involving unfamiliar rates, and explain orally or in writing, and through other representations, how to solve a problem involving rates in less familiar context.*
Boyce: I don't. *I want them to think about these questions* [in IM] because I think it's in there. It says, reinforce the use of this quantity is by asking questions such as, but if they just put those in there I feel like it just goes back to the	*T3*: Here it's already given, the rate for one and

calculations. *Brown:* Okay, So *Boyce: Can we focus it more on the process* and less on how that was knowing they can wash five-sixths or that it takes one and one fifth minutes to wash one window help us find how many minutes it would take to wash ten thousand. *But somehow trying to reword that, to focus it more on How does it help you, not what is the answer?*	then in this *T1*: it's what IM is telling us to do, is to display the rates per one, um, which I mean… *Boyce: I'm just curious about this emphasis on the usefulness of it. So, it's less about the calculation and more about the usefulness.* *T3:* It's almost like a discussion like, *What's it easier to solve these problems vs the ones before?* *T1:* Do you think this one would be easier and why? *Boyce: And the lesson goals are actually about the usefulness of calculating which I think are two different things.* *T3:* It just kind of makes the lesson little better, *if it's more emphasized, and having them explain that here we already have the rate per one, so it ties back to the lesson goals much better.*

My conversation with Ms. Boyce provided space for her to reason through how to support teachers to analyze synthesis questions provided in the curricular materials, recognize when adaptations might be warranted, and make appropriate adaptations. Ms. Boyce's conversation pushed teachers to interact with the curriculum deeply by thinking about how the given synthesis questions support goals. They discussed modifying them if necessary to support those goals. This conversation suggests to the teachers their autonomy AND their responsibility to focus on lesson goals when making decisions.

In the next chapter I describe the results of the actions I took to help Seaford Middle School improve their planning and teaching practices. I use evidence from the coach and specialist's planning tools and the recorded discussions between specialist/coach and coach/teachers to describe the results.

Chapter 4

IMPROVEMENT STRATEGY RESULTS

In this chapter I describe the results of the actions I took to help Seaford Middle School mathematics teachers improve their planning and teaching practices by targeting the school-based coach's capacity to facilitate deep, specific mathematics discussion. I designed a framework for building the capacity of Seaford Middle School's mathematics coach to facilitate deep, specific lesson planning discussions with teachers by engaging her in purposeful discussions concerning the mathematical point of lessons, student thinking, pedagogy, and advancing questions she could use to support teachers' mathematical knowledge for teaching. Two themes emerged when I analyzed the data: the coach and teachers appeared to shift their planning norms over the course of the study to include more specific and detailed use of planning materials to focus on the mathematical point of the lesson, student thinking, and pedagogy; and the specialist-coach and subsequent coach-teacher conversations seemed to increase in depth and specificity around the mathematical point of the lesson, student thinking, and pedagogy. Further, there appears to be a relationship between the depth and specificity of the specialist-coach discussions and that of the subsequent coach-teacher discussions. I use evidence from planning tools and recorded lesson planning conversations between specialist/coach/teachers to describe these themes.

Changes in Use of Planning Materials

The coach and teachers were asked to read the lesson goals, narratives, and syntheses and complete the student tasks prior to the October, November, and December planning meetings. Table 6 illustrates the artifacts that the coach and teachers brought and used in each coaching session. (Note that September is included to illustrate the artifacts the coach and teachers brought to the planning meetings prior to the study.)

Table 6 Artifacts Brought to Planning Meetings

Month	Artifacts C*oach* Brought to Planning Meeting	Artifacts T*eachers* Brought to Planning Meeting
September	Digital Teacher's Edition, copy of teachers' presentation slides	Digital Teacher's Edition, presentation slides
October	Digital copy of Coaching Through Lesson Planning tool, copy of teachers' presentation slides, Digital Teacher's Edition	Digital Teacher's edition, presentation slides, 1 teacher had problems worked out on student edition handout
November	Digital Teacher's Edition, Digital copy of Coaching Through Lesson Planning tool, copy of teachers' presentation slides, IM student edition handout with all problems worked out.	Digital Teacher's edition, presentation slides, 2 teachers had digital version of planning tool completed, 2 teachers had problems worked out on paper
December	Digital Teacher's Edition, Digital copy of Coaching Through Lesson Planning tool, copy of teachers' presentation slides, IM student edition handout with all problems worked out.	Digital Teacher's edition, presentation slides 1 teacher had digital version of planning tool completed, 2 teachers had student edition handout with all problems worked out, 1 teacher had problems worked out on paper

While not required to use the Teacher Planning tool, teachers had access to both digital and paper versions of the tool. One teacher chose to use the Teacher Planning tool in November and December. In addition, by the December meeting all three 6th-grade mathematics teachers completed the student tasks prior to the meeting. Ms. Boyce

brought a digital copy of the Coaching Through Lesson Planning tool to each planning session in the study. She brought white paper with task problems worked out to the October meeting and a student edition handout with all problems worked out in several ways to the November and December meeting. These data show changes in the ways the coach and teachers prepared for the planning sessions over the course of the study.

The coach appear to have shifted lesson planning norms over the course of the study. The coach recorded increasingly specific and detailed notations on her planning document (see Table 6) over the course of the study. Table 7 illustrates an example of changes in depth and specificity of the notations Ms. Boyce included on her planning documents concerning the mathematical point of the lessons and planning tasks to support student thinking about the mathematical point.

Table 7 Changes in Depth/Specificity of Ms. Boyce's Planning Documents

	October	**November**	**December**
Mathematical point of the lesson	Different situations = same rate or not • Equivalent ratios • How many for 1	Using and reasoning about "rate per 1" in context - not using that language. How does the context of this lesson help build this "usefulness" of per one?	Percentage as a rate per 100 (using money) Part/whole relationship Quantities of another quantity
Planning for a Task	Concert tickets, Did they pay the same rate? Find the same number of tickets and compare price (price for 3 tickets), double number line, Price per 1	Launch: Does the Notice/Wonder lead to Info-Gap feel? Once given the list of information and the question - what information do you need/not need? Give students a good reason to need "rate per 1" - TIME PER WINDOW Division to find unit rate	MLR 3: Clarify, Critique, Correct Linger moment: Questions 3 and 4 - percentage of collection of coins. Activity Synthesis - how do you elevate student synthesis of each activity? What is the difference

	Any other strategies? 20-minute activity: how do you chunk/debrief?	between the first set of questions and the second? How can we take the habit of editing and elevate it?

Prior to each specialist-coach planning session, Ms. Boyce recorded planning information on her digital planning tool and uploaded it to our shared folder. Over the course of the study, Ms. Boyce notations increased in specificity and depth when describing the mathematical point of the lesson on her planning document. For example, as you can see in Table 7, in October Ms. Boyce described the lesson goal in part as how many for one. However, the goal was to reason about ratios directly instead of using unit rate reasoning. She described the lesson goal, but in an incomplete manner and missed the main purpose of the lesson, namely, to reason using not unit rate, not to find the unit rare. In November, Ms. Boyce captured the mathematical points of lesson using language similar to that used in IM's lesson goals, including reasoning about rate per one in context without specifically introducing that term yet. The notation illustrates she attended to what students should specifically learn by the end of the lesson. Ms. Boyce wrote the question *How does the context of this lesson help build this "usefulness" of per one?*. The inclusion of this question suggests she is preparing to focus teachers' attention on the usefulness of per one thinking, not just on how to procedurally find the unit rate. In December, Ms. Boyce captured the specific point of the lesson (introducing students to the concept of percentages) and included how student will acquire that understanding (using their prior knowledge of money to build an understanding of percentages). Her notations suggest she was planning to discuss how students' knowledge of money helps

to create a conceptual understanding of the meaning of percentages. This is important because she is shifting focus from what teachers will teach to how they will help student connect their current knowledge to the mathematical goal.

Ms. Boyce's notations concerning lesson tasks also increased in depth and specificity. For example, in October Ms. Boyce noted the task question and several student solution strategies. In November, her notation specifically connected the task to the lesson goal (usefulness of finding per one). She noted launch ideas, an anticipated strategy, and questions to pose to the teachers. These questions indicate she is planning to support the teachers' depth of thinking by opening discussion about how students will use information, additional student strategies, and how teachers will debrief the task. In December, Ms. Boyce specifically noted a mathematical language routine (MLR) that teachers could use to support students to think deeply about percentages and highlights a "linger moment" in which teachers should slow down and support students to make connections. Her notations on the lesson and task syntheses suggest she is preparing to facilitate a deep discussion with teachers that pushes their current practice of having students edit their work after class discussions and elevate it to supporting students to actively synthesize their learning. Ms. Boyce prepared to use the lesson planning discussion to both plan a specific lesson and extend teachers' practice to included ways to support student synthesis in this lesson and future lessons.

Changes in Depth and Specificity of Discussions

After coding the audio recordings of the specialist-coach planning conversations using the rubric adapted from Stein et al., (2021), I calculated the percentage of times

each level of depth/specificity of the discussions around the mathematical content (goals), student thinking, and pedagogy occurred (See Table 8).

Table 8 Levels of Specialist-Coach Discussions

	Mathematical Content (goals)	Student Thinking	Pedagogy
October	Level 0- 0% Level 1- 0% Level 2- 100% Level 3- 0%	Level 0- 0% Level 1- 33.3% Level 2- 33.3% Level 3- 33.3%	Level 0- 0% Level 1- 25% Level 2- 50% Level 3- 25%
November	Level 0- 0% Level 1- 0% Level 2- 40% Level 3- 60%	Level 0- 0% Level 1- 0% Level 2- 20% Level 3- 80%	Level 0- 0% Level 1- 16.7% Level 2- 33.3% Level 3- 50%
December	Level 0- 0% Level 1- 0% Level 2- 0% Level 3- 100%	Level 0- 0% Level 1- 0% Level 2- 25% Level 3- 75%	Level 0- 0% Level 1- 0% Level 2- 33.3% Level 3- 67.7%

Clear understanding of the lesson goals are critical for planning high-demand lessons that build on student thinking (Hiebert et al., 2018). In the October Specialist-coach planning session, the three times we focused the discussion on the mathematical goals, we spoke of them in terms of procedure or definition but did not discuss student acquisition of the underlying meaning, therefore the 100% of the discussion on mathematical goals was coded as a level 2. In November, we discussed the mathematical goals in terms of procedures or definitions (level 2) 40% of the time, and 60% of our discussion on about the mathematical goals included how students would acquire the underlying meaning of the concepts (level 3). In December, each time we discussed the mathematical goals we did so in connection with student acquisition of the underlying meaning of the concept, resulting in 100% of the discussion around mathematical goals

being coded as a level 3. These data suggest that over the course of the study, Ms. Boyce and I increased the depth and specificity of our discussions around the mathematical lesson goals as defined by the coding rubric.

The changes in the specialist-coach conversations suggest a trend toward deeper and more specific conversations around pedagogy over the course of the three coaching cycles. Witherspoon et al., (2021), posit that discussing the conditions when a pedagogical move is appropriate and why it may be effective can support teachers to develop the capacity to adapt pedagogical moves in future lessons. In October, only 25% of our conversations around pedagogy included the when, what, and why advancing questions moved students beyond their current thinking (level 3). Half of the November and two-thirds of the December conversations about pedagogy included these meta discussions to support teachers' capacity to plan advancing questions in the future (level 3). These changes suggest growth depth and specificity of the specialist-coach discussions concerning pedagogy.

The data on discussions on student thinking show an increase in the depth and specificity of the discussion from October to November, and no appreciable change in depth and specificity of the discussion on student thinking between November and December.

After coding the audio recordings of the coach-teacher planning conversations using the rubric adapted from Stein et al., (2021), I calculated the percentage of times each level of the discussions around the mathematical content (goals), student thinking, and pedagogy occurred (Table 9).

Table 9 Levels of Coach-Teacher Discussions

	Mathematical Content (goals)	Student Thinking	Pedagogy
October	Level 0- 0% Level 1- 50% Level 2- 50% Level 3- 0%	Level 0- 0% Level 1- 66.7% Level 2- 16.7% Level 3- 16.6%	Level 0- 0% Level 1- 25% Level 2- 37.5% Level 3- 37.5%
November	Level 0- 0% Level 1- 0% Level 2- 33.3% Level 3- 66.7%	Level 0- 0% Level 1- 25% Level 2- 50% Level 3- 25%	Level 0- 0% Level 1- 0% Level 2- 75% Level 3- 25%
December	Level 0- 0% Level 1- 0% Level 2- 22.2% Level 3- 77.8%	Level 0- 0% Level 1- 0% Level 2- 33.3% Level 3- 66.7%	Level 0- 0% Level 1- 14.4% Level 2- 42.8% Level 3- 42.8%

The data suggest that the levels of coach-teacher discussions on the mathematical goals increased in depth and specificity over the course of the study. In October, 50% of the discussion on goals was naming broad topics (per one) and 50% of the discussion was giving a mathematical definition or a procedure as the goal (level 2 on the rubric). The mathematical goals were not discussed at level 3. In November and December, 100% of the discussion around the mathematical goals was at level 2 or 3. In November, 66.7% of the discussion was at level 3 (discussion of student acquisition of the underlying meaning of a concept) and in December 77.8% of discussion around the mathematical goal of lesson was at a level 3. It appears that coach-teacher discussions about the mathematical goals increasingly included attention to how students will acquire that understanding. This shift is important because establishing specific mathematics goals enables teachers to focus on what students will understand by the lesson's end and possible effective teaching moves that will support students in building that understanding (Smith et al., 2017; Hiebert et al., 2007).

The coach and teachers increased the depth and specificity of discussions around student thinking over the course of the study. In October, 66.7% of the discussions about possible student solution paths was superficial, 16.6% of the discussions were level 2 (one solution path discussed in depth) and 16.6% at level 3 (at least two solution paths discussed in depth). In November, 25% of the discussion on student thinking was at level 1, 50% of the discussion was at level 2 and 25% at level 3. In December, 33.3% of discussion was at level 2 and 66.7% of the discussion at level 3. I see a trend toward increasingly deep conversations about possible student solution paths. This finding is important because anticipating student solution paths prior to enacting a lesson allows teachers to recognize and build on student thinking during the lesson (Smith & Sherin, (2019).

Advancing questions are a critical pedagogical move for connecting student thinking to the overall learning goal of a lesson (p. 335, Stein et al., 2021). In October, the coach and teachers focused 25% of their discussion on pedagogy (advancing questions) at level 1(questions named but not discussed), 37.5 % of their discussion at level 2 (questions discussed in depth, including likely student responses), and 37.5% of their discussion at level 3 (discussions included likely student responses AND when and why to use questions). In November, 75% of their discussion on pedagogy was at level 2 and 25% at level 3. In December, 14.4% of the discussion was at level 1, 42.8% at level 2 and 42.8% at level 3. These data represent the changes the coach and teachers made in the depth and specificity of their lesson planning discussion on pedagogy and suggest mixed results in supporting teachers to deepen their discussions on pedagogy.

Comparing Depth of Specialist-Coach and Coach-Teacher Conversations

After coding the **specialist-coach** planning discussion transcripts and the **coach-teacher** discussion transcripts for October, I began to see what appeared to be possible connections between the depth of discussions about student thinking, pedagogy, and math content (mathematical goals) that occurred during the specialist-coach session and the subsequent coach-teacher session. Table 10 shows an example of my analyses. *NOTE: I have removed utterances (like ums and repeated words; "I, I, I think" became "I think") from these snippets of conversations. Words in [ ] have been inserted when the spoken pronoun may leave the reader uncertain to whom the phrase refers.

Table 10 Analyzing Depth of Specialist-coach and Coach-Teacher Discussions (October 2022)

Math Content (goals)

specialist/coach discussion	**coach/teacher discussion**
LEVEL 2 *Amy Brown*: the purpose of the lesson, the big math ideas is within context, reasoning directly about ratios rather than using scaling up or unit rates, they can use that, but really not the focus. So, they pick the math specifically so you'd have to compare them to each other to see what it means when something's at the same rate. And then actually, part of it is creating diagrams for that reasoning. Did you say it in a different way? *Boyce*: no. But just adding on that I think it helps students to have a context around it to do that with.	LEVEL 2 *Amy Brown:* What are the big math ideas of this lesson? *T2*: It's trying to decide if situations are happening at the same rate. *Amy Brown*: Okay, anything else? T1: And just finding the equivalent ratios and deciding if they are the same rate in certain situations, not just naked numbers like we talked about before, but in context. *Amy Brown*: And if I look at the learning goals that Kendall Hunt puts out, the actual one of their goals is: create diagrams that help to compare. So the actual diagrams are part of the lesson goal, too.

In the October specialist-coach planning session, as illustrated in Table 10, *I* named the goals of the lesson at the beginning of our discussion and Ms. Boyce merely agreed. We referred to the goals in general terms two more times during our discussion but neglected to specifically connect the mathematical goals to each task or synthesis opportunity. *I* began the coach-teacher planning session by asking teachers what the mathematical point of the lesson was and later, Ms. Boyce directed the conversation to the mathematical goals as written in the teacher edition, but she never referred to them again. Much of the lesson planning discussion focused on task implementation. So, when I as the specialist did not purposefully model connecting the goals to each task of the lesson, Ms. Boyce did not highlight the purpose of the lesson much as she talked with teachers.

When I examined Ms. Boyce's October planning document, I found that Ms. Boyce had written "how much for one" as the mathematical point of the lesson. The mathematical point of the lesson, however, was for students to use context to reason directly about ratios to compare situations. Students experienced what it means to happen at the same rate before being introduced formally to the notion of unit rate and methods for calculating it. It seemed that Ms. Boyce had missed the point of the lesson herself and went into the planning conversation without having thought deeply about the mathematical goals. I realized I had not asked questions to elicit Ms. Boyce's thinking about the mathematical point of the lesson. Instead, I proceeded with the discussion with the erroneous assumption that she recognized the mathematical point of the lesson and did not build on her current thinking.

I had not specifically connected the lesson tasks to the goals. I wanted the mathematical point of the lesson to be the driving force of Ms. Boyce's discussions with teachers to set the stage for every part of planning and facilitating lessons. I decided to make sure I was more explicit about why this was such an important practice, and to model it the next time we planned. I believed that if we established specific mathematics goals, then the focus of specialist-coach and coach-teacher discussions would be about what students need to understand by the lesson's end and effective moves that support their understanding. A deeper understanding of the mathematics would allow the teacher to imagine their impromptu responses to student thinking and support students to develop their own understanding without the teacher taking over the thinking.

I purposefully planned the November specialist-coach conversation to foreground the mathematical point of the lesson and ways Ms. Boyce could support teachers to connect the mathematical point to each part of the lesson. Below is the same portion of the November specialist-coach planning conversation I used to illustrate depth and specificity of discussions. This time the italicized phrases indicate how I specifically assisted Ms. Boyce to foreground the mathematical point of the lesson and ways she could support teachers to do the same.

> Brown: Unit three lesson, one intro lesson. So, *what do you think they're going to say the goals of the lesson are?*
>
> Boyce: so, knowing them it'll be this rate for one. Whenever it comes up in the last ones, it's where they go quickly. So, really trying to get them to keep in mind and have the kids keep in mind the context and the importance of the rate for one because of the context. And why is it useful to find and use that idea of a per one when we're talking about this gigantic problem.
>
> Amy Brown: I think that you're probably right. I think they're going to miss that part of the usefulness, right? It's going to go right to that per one.
>
> Boyce: as just the calculation. Yeah,

Brown: So, *what kinds of things do you think you're gonna say or do to get them to get past that?*

Boyce: So, I think, like, even the cool down, asking how they [teachers] anticipate some kids thinking about it where it's, adding thirty-three every second, or multiplying thirty-three by eleven seconds. If you're still seeing those different, you know, different strategies or different levels of understanding that far down in the lesson. What kinds of questions can you ask around the context throughout the different activities to really help kids understand how this idea of finding for one helps them find it more quickly. And maybe even what questions could you ask the Kids? Maybe that aren't included in the activity that could get them to maybe jump from that additive to that multiplicative idea and push them a little bit.

Amy Brown: I think that's great. *This one goes back to what we were talking about this morning, about how it's just not about that rate per one, but it's about. How do they want them to look at it? What is the goal really saying? They want them to be able to explain how you do it, and looking at it, it is when it's useful. How it's useful. It's not really about, It's not specifically about finding it. It's really about. Why would I do it this way?* And how could I do it even in a as cumbersome problems as these are

Boyce: right. One of the goals how to solve problems involving rates in less familiar contacts. And evaluate the usefulness like That's the actual goal. Evaluate the usefulness of it. So, is it more useful to add thirty-three every time I do it? Or is it more useful to multiply thirty-three by eleven?

I explicitly asked questions Ms. Boyce questions, including, *"How do you want [teachers] to look at it? What is the goal really saying?"* I listened to Ms. Boyce's description of the mathematical goals, and asked *"What kinds of things can you do in the meeting to push them past [never really getting to the goals]?"* This question opened another opportunity for Ms. Boyce to articulate the mathematical goals and extend her thinking to how she could support teachers in foregrounding the goals in each instructional decision. We examined how each task supported students to build understanding of the goals (evaluating the usefulness of finding a rate per one to solve a problem in context and explaining how to find a rate per one in unfamiliar context) and questions she might ask to focus teachers' attention on how each task supported the mathematical point.

During the subsequent November planning session with teachers, Ms. Boyce redirected the discussion back to the mathematical goals *nine times*, asking teachers how each task and synthesis question supported the mathematical goals. For example,

when teachers discussed several anticipated student strategies to find how high a climber can ascend in various amounts of time (double number lines, tables, scaling up), Ms. Boyce reminded teachers that the *mathematical point of the lesson was for student to evaluate the usefulness of calculating a rate for one when solving problems involving unfamiliar rates. She asked teachers how they were going to help students connect strategies to the goal and which strategies to linger on*. These questions prompted a discussion in which teachers decided they would display a double number line and ask students to show how their strategy could be seen on it. At this point, *Ms. Boyce reminded teachers of the lesson goals again* and pushed them to think about how students will see the usefulness of using unit rate when comparing strategies. This reminder prompted them to use questions that focused on the useful of unit rates in solving complex problems, not the calculations for finding unit rate. One teacher stated, "If [usefulness] is emphasized, it ties back to the lesson goals much better."

These examples provide evidence that when the specialist and coach have a deep conversation that focuses on the mathematical goals, and the coach is asked to reason and analyze the mathematical purposes of the tasks and how the task can be used to motivate a discussion about the key ideas, the coach is poised to hold a similar conversation with teachers. Ms. Boyce did not simply repeat the questions I asked her when we planned, but she was able to respond to the needs of the teachers and prompt a discussion so the teachers themselves were able to develop a deeper understanding about the mathematical purposes of the lesson through the included tasks.

Shifting Planning Norms

When analyzing the coded data from the planning discussions, I noticed that when Ms. Boyce and I engaged in rich, specific discussions that prepared her to support teachers to develop a deeper understanding of the mathematical purposes of lessons and how to support students to develop a deep understanding, the focus of the coach-teacher conversations shifted. Table 11 illustrates a general trend that the level of coach-teacher conversations increased in depth and specificity as specialist-coach conversations grew richer. I noticed that as the percentage of levels indicating rich specialist-coach conversations (levels 2 and 3) in each focus area increased, so too the percentage of levels indicate rich coach-teacher conversations (levels 2 and 3) in each focus area increase.

Table 11 Comparison of Percentages of Specialist/coach and Coach/teacher Richness Levels (levels 2 & 3)

	October		November		December	
	specialist/coach	coach/teacher	specialist/coach	coach/teacher	specialist/coach	coach/teacher
Content						
Level 2	100	50	40	33.3	0	22.2
Level 3	0	0	60	67.7	100	77.8
Student thinking	33.3	16.7	20	50	25	33.3
Level 2	33.3	16.6	80	25	75	67.7
Level 3						
Pedagogy	50	33.3	33.3	50	33.3	28.6
Level 2	25	44.5	50	50	67.7	42.8
Level 3						

Mrs. Boyce and the teachers no longer focused only on implementing tasks and creating lesson slides, but on the mathematical purpose of the tasks and how to use tasks

to develop students' conceptual understanding of the lesson goals. In this way, the coach and teachers created a planning norm of developing a deep understanding of the mathematical point of lessons and ways to support student thinking about the mathematical point. This is an important shift because when teachers anticipate multiple student responses and create a systematic plan to elicit student thinking, they are prepared to develop students' conceptual understanding of the mathematical goals of the lesson (Coburn & Russell, 2008; Stein et al., 2021).

Lesson planning norms also shifted in an unexpected way. Prior to the intervention, teachers talked about what they thought students *could not do* during lesson planning sessions. Data from audio-recorded coach-teacher lesson planning conversations include no references to what students could not do. This is interesting to see because teachers engaging in ambitious teaching practices must treat students as sense makers to maximize opportunities for all students to engage in rigorous mathematical work (Lampert et al., 2013). I wonder whether intentionally focusing on the mathematical goals and what students would do, impacted teachers' thinking about students' capabilities.

Foregrounding Mathematical Goals

When analyzing the coded transcripts, I found evidence of a shift in coach-teacher lesson-planning practices from discussing tasks and slides to prioritizing the mathematical point of lessons. Table 12 illustrates the number of times Ms. Boyce and/or teachers referred to the mathematical lesson goals during each recorded coach-teacher planning session. (Note: several references could have occurred in within one code since the measure was change in topic, not phrase.)

Table 12 Times the Coach and Teachers Referred to the Mathematical Goals during Planning

	Number of times the mathematical goals are referred to by coach	Number of times the mathematical goals are referred to by teachers
October	2	1
November	9	5
December	8	7

In the October coach-teacher planning session, I began the session by asking the teachers what the mathematical goals of the lesson were. Ms. Boyce and the teachers did not refer to the goals when discussing tasks. For example, when discussing the warmup, she asked, *"What are some strategies students might use to answer who is running faster?"* This question led to a discussion on how students might solve but did not include discussion of the lesson goals. Data show that the teachers discussed the lesson goals only once, when I asked what the goals were. Ms. Boyce referred to the goals only twice during the session.

In the November coach-teacher planning session Ms. Boyce and the teachers began by discussing the mathematical goals of the lesson. Ms. Boyce extended teachers' thinking about the goals by asking questions including *"What are the big math ideas/goal for this introductory lesson?" How does the context of this lesson help build this idea of usefulness around something for one?"* When the coach and teachers discussed anticipated student strategies for task 2, their discussions centered on the mathematical point. Ms. Boyce asked, *"Going back to the lesson goal, evaluate the usefulness of calculating a rate for one. How is this useful and how do they know?"* This question ignited additional conversation about focusing on usefulness of finding the rate per one

by having students compare their strategies and discuss how each helps them to find how long it would take to wash all the windows in the Burj Khalifa.

In December, the routine of discussing the lesson goals shifted again. This time the *teachers* began the planning sessions by discussing deeply and specifically the mathematical point of the lesson, adding onto each other's thinking. When one teacher described the goal as being "*able to have a double number line and percent in dollar amounts,"* a teacher clarified that students would build understanding of the meaning of percentages by using the context of money. The discussion continued and they developed a common understanding of the importance of making a connection between dollars and percentages and cents and percentages.

When discussing the lesson synthesis, Ms. Boyce asked teachers to think about the lesson goals again. She read the lesson goals aloud and teachers began to examine the effectiveness of synthesis questions to support the lesson goals. Ms. Boyce asked them to ask themselves, *"What is it that I am really trying to get out of this?"* The teachers pushed each other's thinking about how to word synthesis questions that could support student thinking about the meaning of percentages in the context of money and possible student responses to those questions. Ms. Boyce then said, *"I think you guys did a great job fleshing this out. Do you see what I mean by pushing like this? Is what I am saying, making sense about taking what you have been working on and pushing it one step further and really holding kids accountable for synthesizing?"* This statement sets discussion expectations for future planning sessions.

These examples provide evidence that as Ms. Boyce's capacity to facilitate rich planning discussions evolved, the coach and teachers discussed the mathematical point of

lessons more deeply and more often during planning. By foregrounding the mathematical point of lesson and reflecting on how each part of the lesson must build students' understanding of the mathematical point, the coach and teachers create a vision of what each lesson could look like in their classrooms. This type of planning is important because it reduces the number of in-the-moment decisions teacher will need to make during a lesson.

Teacher Talk

Organizing the coach-teacher conversation codes in tables enabled me to look for trends. I found no example of any 6th grade teachers discussing what students could not do during lesson planning. I reread the transcripts and found no deficit language in any of the discussions. Instead, teachers focused on the mathematical point of the lessons and how to use the tasks to guide students toward a deep understanding of the mathematical point. They discussed varying student strategies and how to connect those strategies to the mathematical point of the lesson. I wonder if shifting the focus so intentionally on the content, student thinking, and teaching strategies, created space only for asset language.

For example, in their December planning session, Ms. Boyce and the teachers discussed the lesson synthesis in the teacher edition. A teacher states, "*I agree where it says that many students may reason by noticing a pattern like 60 cents is 60% but not realize that it's a ratio that we're scaling anything."* Ms. Boyce asked how the teachers can support students to make the connection to scaling ratios and the teachers discussed using students' double number lines to help all students visualize. In other words, they talked about the level of students' understanding and how to support them to advance their understanding.

Summary

Through analyzing data, I found that the specialist-coach discussion process provided strategically planned opportunities for the school-based coach to develop a deep understanding of mathematical point of lessons and create coaching questions to advance teachers' understanding of the mathematical point and teaching strategies to support student thinking about the math. I also found that Ms. Boyce and the 6th-grade teachers planning focused on the mathematical purpose of lessons and how tasks advance students' conceptual understanding. Teachers discussed strategies to build on and extend students' conceptual understanding. Teachers did not use deficit language to talk about students.

In the next chapter, I describe conclusions about how targeting the school-based coach's capacity to facilitate deep, specific mathematics discussion helped Seaford Middle School mathematics teachers improve their planning practices. I include my rationale for my conclusions and discuss what went well and recommendations and next steps to continue improving mathematics teaching.

Chapter 5

REFLECTIONS ON IMPROVEMENT STRATEGY IMPLEMENTATION

Despite efforts from school and district personnel, Seaford Middle School students performed poorly on standardized assessments and mathematics instruction remained teacher centered. I hypothesized that teachers did not have the depth of knowledge they needed to facilitate rich math discussions or even to know the kinds of questions to ask students to get them to play with and think deeply about mathematical ideas. I wanted to shift teachers' lesson planning practices from focusing on tasks to focusing on the mathematical point of lessons, student thinking, and advancing questions that support rich math discussions among students. I anticipated that by building the capacity of the coach to facilitate rich conversations with teachers during planning, teachers would prepare goal-focused, student-responsive lessons.

In this chapter, I describe conclusions about how targeting the school-based coach's capacity to facilitate deep, specific mathematics discussion helped Seaford Middle School mathematics teachers improve their planning practices. I include my rationale for my conclusions and discuss what went well and what needs to be redesigned. I end the chapter with recommendations and next steps to continue improving mathematics teaching.

Conclusions

My analysis of data suggests that Ms. Boyce's capacity to facilitate rich lesson planning discussion with teachers improved by participating in specialist-coach

discussion protocols. These specialist-coach discussions supported the coach's understanding of the mathematical purpose of lessons and coaching strategies, including advancing questions, that would support teachers' understanding of the mathematical purpose of lesson and ways to support students' conceptual understanding. Targeting the Seaford Middle School coach's capacity to facilitate deep, specific mathematics discussion appears to have changed the coach-teacher planning practices in significant ways, including shifting their focus to the mathematical purpose of lessons and ways they spoke about students.

How the Coach Learned to Facilitate Rich Discussions

Researchers suggest that when coaches had deep, specific lesson planning conversations with teachers that focused on math content, student thinking and pedagogy, teachers improved their capacity to maintain the cognitive demand of rich tasks (Russel et al., 2020). By examining how Ms. Boyce learned to facilitate deep, specific mathematics conversations with teachers, I provide a model for building the capacity of school-based coaches to support teachers in shifting practices when planning goal-focused, student-responsive lessons.

Through my ongoing analysis of data from three coaching cycles, I found how facilitating deep, specific discussions with Ms. Boyce prepared her for lesson planning with teachers. I engaged Ms. Boyce, in deep, specific discussions focused lesson goals, student thinking, and pedagogy. Our protocol included each of us independently preparing for our discussion by reading the lesson narrative and goals, completing each task in multiple ways, and using our planning template questions to guide our planning. I intentionally planned questions that elicited and extended Ms. Boyce's knowledge of the

mathematics, what student strategies tell us about their thinking and which synthesis questions build on their thinking. I anticipated questions she might pose to teachers, how they supported their MKT and when to ask them.

In our 20-minute meetings, we explored the mathematical point of each lesson by dissecting goals, thinking about how students were to interact with the mathematics. For example, in November we discussed that the primary lesson goal was for students to discover the usefulness of using per one thinking, not just perform unit rate calculations. We discussed how the context of the tasks and syntheses supported students to think about the usefulness of finding the rate per one. We anticipated what teachers would say about the mathematical point of lessons and designed advancing questions to support teachers' understanding of the mathematics and pedagogical knowledge they would need to create a goal-focused, student-responsive lesson.

Relationship Between Depths of Discussions

Through analysis of specialist-coach and coach-teacher discussions, I found that when I intentionally focused specialist/coach conversations on the mathematical point of lessons, student thinking, and questions she could ask to build on and extend teachers' mathematical and pedagogical knowledge, Ms. Boyce intentionally focused the coach-teacher conversations on the mathematical point of the lesson, student thinking, and questions aimed at eliciting, building on, and extending student thinking.

For example, during our November discussion, I asked Ms. Boyce what she thought teachers might think was the mathematical point of the lesson, she said, *"Rate for one. They go there quickly."* She continued, "*So, really trying to get them to keep in mind the context and the importance of the rate per one because of the context. And why it is*

useful." I then asked her how she was going to help them focus on the context to support the idea of usefulness of rate per one thinking in activity 2. She said she would ask them to anticipate what strategies kids would use and be able to do with their strategies, then ask students about how the context of the problem helps determine if their strategy is useful.

During her subsequent planning discussion with teachers, Ms. Boyce asked, *"How does the contexts in this lesson help build this idea of usefulness around something for one? How will you help kids to get it? What types of strategies do you anticipate?"* The teachers discussed several student strategies, including using tables, discrete models, and division and decided to show several student strategies so students can make connections among the strategies and discuss how the strategies helped them solve the problem. One teacher said she would ask, "*where do you see it in the table because the table might lend them to be able to see what to do next?"* Another teacher said, "*When they just do the division, asking what the number represents?* They explained that they thought questions these that helped students connect strategies would lead to student conversations about the usefulness of finding the rate per one.

Through data analysis I found a connection between the quality of the specialist-coach conversations and the coach-teacher conversations. Because of these findings, I suggest a tentative connection between the quality of the specialist/coach conversations and the growth in the coach's capacity to facilitate deep, specific lesson planning discussion with teachers.

Shifting Lesson Planning Norms

Ambitious teaching practices like facilitating rich mathematical discussions are effective in supporting students in developing a deep and flexible understanding of mathematics, yet shifting teaching practices is challenging because of the content, and pedagogical knowledge teachers need to possess (Lampert & Ghousseini, 2012). As Ms. Boyce improved her capacity to facilitate deep, specific lesson planning conversations through her work with the specialist, she and the 6th-grade teachers shifted their former planning norms of planning tasks to engaging in deep, specific lesson planning discussions about mathematics content, student thinking, and teaching strategies that build on and extend their thinking. This shift in the coach-teacher planning norms enabled teachers to anticipate multiple student strategies and create a systematic plan, including creating questions to elicit, build on, and extend student thinking, to develop students' conceptual understanding of the mathematical goals of the lesson.

An unexpected result was that teachers did not use deficit language when talking about students in lesson planning sessions. Perhaps by directing the conversation to the mathematics, anticipating what students would do, and how the teachers would ensure the mathematical point came out, the conversation left no opening to the possibility that students couldn't. Everything we talked about was how to move the students from their current understanding to where we needed them to be. One lingering question I have is whether deep, specific mathematical planning discussions could be used to help teachers view students as sense-makers by purposefully designing opportunities for every student to engage in rigorous mathematical work (Lampert et al., 2013).

Reconsidering Tools

Ms. Boyce already had a system in place for collecting observational data and reflection that she found familiar and effective so did not use the observational data collection reflection tools in *Artifact 3: Suite and Introduction to Tools and Protocols.* We did not change these during our work together. She used a notebook to capture data while in the classroom and then uploaded these to her Seaford drive and added her reflections afterward. She shared her data and reflections with me, and I agreed that her approach was effective. Perhaps these tools could be analyzed to check for alignment and redesigned to be used in future studies to gather additional data on the types of tools and strategies that build the capacity of school-based coaches to support ambitious teaching and learning.

Artifact 6: Self-assessment Tool for District Personnel was designed to support their understanding of what ambitious teaching and learning looks like in classrooms. Using the tool may enable them to evaluate changes in teaching practices by providing descriptions of the progression of teaching from teacher-centered to student-centered. The scope of this study was too narrow to pilot the assessment tools. Future studies should include examining whether and to what extent the assessment tool supports shifts in the practices of school-based coaches in supporting ambitious teaching practices.

Limitations

When defending my work with my committee, one question that came up was that conditions in this school seemed ideal. The school was using HQIM, teachers have common planning, time, teachers had the support of administration, the school hired a knowledgeable coach, and had hired the PDCE as support for their teachers. My response

was that part of our conversations with districts when partnering is discussing the conditions that must be present (PDCE Thoery of Change). I work with teachers of varying levels of math expertise--new teachers, alternative routes teachers, veteran teachers--some of these enabling conditions must be in place. Kaufman et al, (2020) state, "a growing body of evidence suggests that use of instructional materials that are high quality, accompanied by professional learning supports, is associated with improvements in student achievement (e.g., Jackson and Makarin, 2018; Hill et al., 2020)." In 2017, the CCSSO launched High-Quality Instructional Materials and Professional Development (IMPD) Network, with Delaware as a partner district. Although the committee saw this as a limitation, I see it as a necessary condition and will add that the PDCE only provides curriculum-specific professional learning models, because research has shown that curriculum matters. One ELP defense participant asked how important it was to the results of the study that the school was using HQIM? My response was that it was necessary. Without the starting point of the high quality materials, our work would change to a focus to finding and creating high quality tasks, rather than discussing how to implement materials with rich tasks already embedded and aligned to standards.

Although I present insight into a high-leverage coaching practice during planning sessions, there are limitations to the study. This study did not include teacher observations to examine whether the rich planning discussions changed teachers' instruction. Another limitation of this study is that I focused on one school-based coach in one middle school. Neither the coach nor the school is representative of all coaches or schools. Therefore, I do not know the extent to which the findings might be generalized to coaches that differ from Ms. Boyce in their level of coaching capacity and their

relationship with teachers. Future work is needed to explore whether and to what extent coach-related variables affect shifts in the practices of school-based coaches to support teachers to plan goal-focused, student-centered lessons.

Recommendations for Future Work

PDCE should continue to study how to build the capacity of school-based coaches to support ambitious teaching and learning. One next step is to provide professional learning opportunities for PDCE instructional specialists to examine the methodology and data of this study and read and synthesize current literature on supporting coaches presented in *Artifact 7: Coach the Coach PL*. This PL could expand our thinking around targeting coaches to improve student achievement and perhaps lead to refining the tools and protocols examined in this study. An additional step is to distribute *Artifact 5: White Paper* to district and building administrators to provide them with my findings, rationale, and research regarding supporting teachers to use ambitious teaching practices. One final next step is to conduct a larger study on building coaches' capacity to facilitate deep, specific lesson planning discussion. This study could include a larger sampling of coaches with varying experiences. Data could be collected on whether and how instructional practices changed, and results compared to the first study and current literature.

Ms. Boyce was a fantastic partner in this work. She has a strong knowledge of content and is an excellent teacher. Not all coaches share these characteristics. A next step for research would be to determine the skills competencies, and knowledge a coach needs to have to facilitate deep and specific mathematics discussions. We need to develop ways to recognize and measure coaches' levels of mathematical knowledge for

teaching and how it affects their ability to support teachers' level of MKT. Many coaches are assigned a coaching position based on their number of years teaching, their skill as a teacher, or desire to coach. However, being a good teacher of students does not directly translate into being an effective coach of teachers. What specialized knowledge do coaches need?

In my own research for this ELP I wanted more nuanced research about ambitious teaching. I want to know more detailed information about effective teaching strategies to support student thinking and student discourse. I also want to know how coaches can support teachers to implement these practices. I also found relatively few studies on effective coaching practice was very limited. This is an area that could use more research. My study is so small, a study such as mine with larger numbers of coaches across different types of schools would make a great contribution to the literature.

Chapter 6

REFLECTIONS ON LEADERSHIP DEVELOPMENT

In this chapter I reflect on my growth and development as a scholar, as a problem solver, and as a partner in the work of school improvement. This ELP process has shifted my perspectives in many ways.

Development as a Scholar

Over the past three years, my skills as a scholar have changed. One important change has been my relationship with research. Prior to enrolling in the University of Delaware's EdD program, I had an elementary knowledge of what research is, where to find it, and how to read it. Under the expert tutelage of my professors and my advisor, I learned where to access peer reviewed publications and numerous education research articles. Dr. Bailes instructed students how to read research by having us create a bibliography that focused attention on understanding the methods, discussion, and conclusion sections. Dr. Hohensee insisted all articles used in the semester project came from peer-reviewed publications and used an iterative process of reading, summarizing, and synthesizing research and receiving detailed feedback. Dr. Muirhead assigned research for PDCE instructional specialists to read, compare, and connect. Together we learned to understand and synthesize the articles. Through these and similar experiences,

I am continually learning to synthesize research to support (and refute) my burgeoning theories on improving mathematics education.

The ELP process has certainly challenged my skills as a scholar. The level of research and synthesis required to create *Artifact 1: Defense Proposal* surpassed any of my previous experiences. My advisor improved my understanding of how to use a source by challenging several of my citations and helping me understand how to cite a resource for the correct purpose. Feedback and questions from my committee changed the trajectory of my ELP, narrowing its focus. These changes prompted me to think deeply about rich mathematical discussions as professional learning opportunities for coaches and teachers.

As a scholar, I have learned the importance of writing, revising, seeking feedback, reflecting on the feedback, writing again, seeking feedback, and so on. While I sometimes chafe under this iterative process, I recognize that it opens space for both rough-draft thinking and reflection. Dr. Jansen emphasized rough-draft thinking and reflection as powerful tools to support the development and articulation of a deep understanding of an educational problem and possible solutions. With the guidance of Dr. Gibbons, I applied what I had learned about research, rough draft thinking, and reflection to begin to develop an intervention for helping school-based coaches prepare teachers to teach ambitiously by engaging them in deep, specific mathematics discussions during planning. Certainly, the ELP process has been an iterative process. It serves as a reminder that everyone is in a constant state of rough-draft thinking and reflection and should be afforded support, care, and grace.

Russell and colleagues (2020) and Stein and colleagues (2021) studied targeting coaches' capacity to facilitate deep and specific planning conversations around mathematical content, student thinking, and pedagogy through professional development workshops. They posited that growth in a coach's capacity to facilitate deep and specific lesson-planning conversations predicts teaching improvement in creating opportunities for students to engage in cognitive thinking. My study adds to their work by examining whether one school-based coach improved her capacity to facilitate deep and specific discussions with teachers when engaging in job-embedded professional development in the form of deep and specific discussions with a specialist. I created and piloted tools and protocols designed to support specialist-coach and coach-teacher planning conversations around mathematical content, student thinking, and pedagogy and collected and analyzed data on whether and in what ways these tools and protocols increased the depth and specificity of the discussions. I will share my data with PDCE staff to inform our work of expanding our coaching model to include supporting school-based coaches.

Development as a Problem Solver

My problem-solving skills have matured because of the University of Delaware's EdD program. I now seek to understand problems before I look for solutions. I have seen educational interventions produce results that do not improve the situation they were created to support, but I often did not understand why. As I look back, I now wonder if those initiative were based on poorly defined problems. Through my graduate studies and ELP process I have learned that clearly defining a problem is the most critical component of problem solving. Clearly defining a problem requires gathering anecdotal, qualitative, and quantitative data not to support a belief but to acquire knowledge. The way in which

I define a problem determines what I consider as possible solutions and evidence of effectiveness. In a recent example, I struggled to articulate my results in chapter four of this ELP. After grappling with multiple revisions over several days, I reached out to Dr. Muirhead. By asking me questions to elicit my thinking about the chapter, she helped me recognize that the problem was in my organization of the chapter. The headings I had chosen were inhibiting me from presenting my results clearly and succinctly. This experience was a practical reminder of the importance of defining problems carefully before attempting to solve them.

Effective problem solvers determine possible root causes, define goals, and articulate problems with specificity. In EDUC846 I encountered my first fishbone diagram. It expanded my thinking beyond "obvious" root causes to other less visible but perfectly viable ones that I may have missed with it. In several courses I learned to how to articulate goals clearly. In my early writing, I used various terms to make my writing more "creative". I learned that and using terms interchangeably can confuse the reader. In nearly every course, I practiced collecting and analyzing data. EDUC863 Program Evaluation helped me see that data is the connection among all aspects of problem-solving. In creating a logic model and evaluation plan, I used data to define a problem, set goals, choose solution strategies, and assess improvement efforts.

Through the ELP process I have begun to understand that data collection and coding methods determine the quality and usefulness of the data. Looking back on my study, I realize that in future studies I must strategically design data collection and coding methods to uncover relevant data. With the evolution of my understanding of the

importance of data and collection methods, I can collect data purposefully to evaluate and revise my implementation of evidence-based coaching practices.

Development as a Partner

The course that ignited my development as a partner was EDUC890 Leadership Theory and Practice with Dr. Wilson. As I read and discussed leadership styles, I formed the belief that leaders are good partners. I began looking at leadership from that perspective and realized that the most influential leaders in my life are valuable partners. They ask for my perspective and listen to what I say (and don't say). They know and celebrate me as I am and inspire and support me to be a better version of myself. This is the type of leader and partner I strive to be.

Developing as a partner requires expanding professional networks. As a PDCE instructional specialist, my professional network constantly expands and includes stakeholders at the state, district, and school levels. As an EdD student, my network expanded to include researchers. Professors invited researchers to several of my classes. Their willingness to collaborate with us gave me the courage to reach out to researchers working on mathematics coaching. By discussing mathematics coaching with several researchers, including Drs. Gibbons and Stein, I have been able to refine my thinking about high-leverage coaching practices and put them into practice.

Through my work at PDCE, my coursework, and partnering with Drs. Bailes, Carvajal-Hageman, Gibbons, and Muirhead, in the ELP process, I am beginning to develop a system-wide view of support ambitious teaching and learning. Only system wide efforts will equitably maximize learning opportunities for all students. To develop, implement, sustain, evaluate, and improve interventions, I must seek out and value the

contributions from all stakeholders including educational leaders, teachers, students, community members, parents, coaches, and researchers. Only with a collaborative approach that capitalizes on each stakeholders' strengths and knowledge can we really make a difference for students. The time for such partnerships is now. Students deserve it.

Final Thoughts

As I reflect on my journey through the University of Delaware's graduate program and this ELP process, I am grateful to have worked with such dedicated scholars and educational leaders. The coursework and the ELP process have been challenging, but I know that because of this program I am better equipped to be an effective instructional specialist. With the knowledge and skills, I have built, I can purposefully pursue my passion for maximizing students' opportunities to engage with mathematics to build a deep understanding and appreciation for mathematics.

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Appendix A

ARTIFACT 1 – PDCE POLICY & PRACTICE CHANGE MAP

Policy is defined by Fowler (2012, p. 5) as "the dynamic and value-laden process through which a political system handles a public problem." Education policy, then, is a plan for addressing a problem in education and includes principles that guide both the definition of the problem and the decisions for addressing the problem. The four stages of the policy process are agenda setting, formulation and legitimation of goals and programs, implementation, and evaluation. The following map illustrates how I will instigate the policy and practice changes in PDCE, includes a policy practice timeline (historical and forward-looking), names the supports using systems-level policy thinking, and incorporates the study's findings.

Agenda Setting

Perception of a Problem

August 2021 I am assigned contracts to build the capacity of a new school-based coach and an experienced school-based coach to support ambitious teaching. I quickly realize supporting a school-based coach differs from supporting a math teacher and speak with my supervisor, who shares research on coaching coaches, which I then begin to read.

Fall 2021 I ask other PDCE math specialists assigned to support school-based coaches about their approaches. Each share that they need more guidance.

I continue to read research, talk with other PDCE math specialists and my supervisor, and ask

school-based coaches what they need to support their work. I keep

field notes on my strategies for supporting school-based coaches and find inconsistencies in my effectiveness in doing so.

Fall 2021 I look at the 2021-2022 contract spreadsheet and notice an increased number of contracts requiring math specialists to build the capacity of school-based coaches to support ambitious teaching.

Fall 2021 I share these findings with my supervisor, who informs me that school districts in Delaware are receiving weighted funding to support the state's most disadvantaged students (Office of Governor John Carney, nd.). One focus of this funding is building the capacity of school-based coaches to support the work of teachers as a means for system-wide changes in mathematics teaching and learning.

Definition of Problem

Winter 2022 Although the PDCE has tools, protocols, and supports for coaching teachers, we have not developed tools to specifically support the school-based coaches in their work with teachers. PDCE can build the capacity of school-based coaches to support ambitious mathematics teaching as a means of system-wide change by expanding our current PL model to include tools/protocols for facilitating deep, specific mathematics discussions about student thinking, pedagogy, and math concepts with school-based coaches.

Mobilization of Support for Including Problem on Agenda

Spring 2022 I discuss my problem definition with my supervisor, professors, and PDCE colleagues. I advocate for an expansion of our current PL model to include protocols/tools for facilitating deep, mathematical discussions with school-based coaches. My supervisor provides additional research and feedback to refine and advance my thinking and shares that including protocols for working with school-based coaches could be an important addition to PDCE's PL model.

Spring 2022 I meet with Seaford School District's Director of Instruction, Dr. Kelly Carvajal-Hageman to discuss my theory to build the capacity of school-based coaches and my desire to study my collaboration with Seaford Middle School's school-based coach. She supports the idea and agrees to be a member of my ELP committee. I then meet with Seaford Middle School's principal and school-based coach, who agree to participate in my study.

Formulation and Legitimation of Program and Goals

Information collection, analysis, dissemination

Spring 2022 I focus my semester project in EDUC836 on problem identification, the possibility of implementing a program to support school-based coaches, and an analysis of likely outcomes. I continue to read and synthesize research and discuss and analyze my thinking with Dr. Gibbons, a prominent researcher on potential high-leverage coaching practices that support ambitious teaching.

Summer 2022 I meet with Dr. Stein on Zoom, a prominent researcher who studies training school-based coaches to facilitate deep mathematical discussions with teachers and whose work influences my thinking. We discuss my idea of creating tools/protocols for math specialists to utilize to facilitate deep math discussions with school-based coaches, who in turn facilitate deep math discussions with teachers.

Advocacy and Coalition Building

Summer 2022 I continue to share with colleagues and supervisor the research I have been reading and the discussions I have had with Drs. Stein and Gibbons and how they are shaping my thinking about supporting school-based coaches. I ask about their experiences working with building coaches, and we discuss our successes and challenges.

Compromise, Negotiation, and Decision

Summer 2022 My supervisor asks me to create and facilitate PL on a possible PDCE coaching-the-coach model for PDCE math specialists.

Summer 2022 I facilitate Coaching-the-Coach PL, during which I share research findings and provide opportunities for specialists to brainstorm on what coaching a school-based coach entails. I explain that I am focusing my ELP on expanding PDCE's Theory of Change to include protocols/tools designed to support school-based coaches' uptake of the high-leverage coaching practice facilitating deep and specific pre-lesson mathematical discussions. I collect evidence of their

	thinking, and my supervisor and I debrief the PL and use colleague feedback to refine tools/protocols.
Fall 2022	I introduce draft tools/protocols to Seaford Middle School's school-based coach, and we use them to plan with teachers. We debrief afterward and together modify the layout of the tools to make them easier to use.
Spring 2023	I will present the findings of my ELP study and a potential adaptation to our Theory of Change to include building the capacity of school-based coaches to support ambitious teaching to PDCE's leadership team who will whether to adopt the adaptation and decide the language for any adaptation.

Program Implementation

Resource Acquisition

Summer 2023	Allocation of PDCE PL time Allocation of time to introduce partnering school districts to our coach-the-coach model

Planning

Summer 2023	I will create and facilitate two PLs on introducing and implementing tools/protocols to build the capacity of school-based coaches, one for district and school leadership and one for PDCE specialists.

Organizing

Summer 2023	PDCE's director will schedule time for a PL session on introducing and Implementing tools/protocols to build the capacity of school-based coaches to our PL model.

Providing

Services

Fall 2023 PDCE will implement coaching-the-coach protocols and tools.

Evaluation of Implementation, Performance, and Impacts

Fall 2023 PDCE specialists will collect data on fidelity of implementation, performance of school-based coaches, and impact on teaching using self-reporting PDCE coaching documents and field notes. These data will be analyzed quarterly.

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Appendix B

ARTIFACT 2 – LITERATURE REVIEW

The wide adoption of Common Core State Standards-Mathematics (CCSS-M) and rigorous college-and-career readiness standards requires a change in mathematics teaching from traditional teacher-centered, algorithmic-based practices (i.e., direct instruction, think: "I do-We do-You do") to teaching that is concept-building and responsive to student ideas, referred to in the literature as "ambitious mathematics teaching" (Lampert & Graziani, 2009, p.492). While researchers posit that ambitious teaching practices are effective in supporting students in developing a deep and flexible understanding of mathematics, shifting teaching practices is challenging (Lampert & Ghousseini, 2012). School district leaders realize that although adopting high-quality instructional materials (HQIM) and providing implementation training support ambitious teaching, these resources alone are insufficient.

Many school districts have created instructional coaching roles to support substantive changes in teaching practices, through which teachers can learn to implement ambitious practices that support students' developing conceptual understanding (Kraft & Hill, 2020; Russell et al., 2017, 2020). Routinely, these coaches are selected for their excellent teaching practices but may have limited knowledge of coaching practices. Therefore, school-based coaches need professional learning opportunities to acquire the necessary skills and knowledge to effectively implement coaching practices that support teachers' development of ambitious teaching practices (Chval et al., 2010; Kane &

Saclarides, 2022).

In this literature review, I discuss ambitious teaching using the National Council of Teachers of Mathematics (NCTM) framework to highlight the relationship among eight effective teaching practices (2014). I present mathematics coaching as professional learning that supports teachers' development of ambitious teaching practices. Finally, I discuss potential high-leverage coaching practices, including the role of deep and specific mathematics discussions among coaches and teachers when co-planning lessons and the ways coaches learn them.

Ambitious Mathematics Teaching

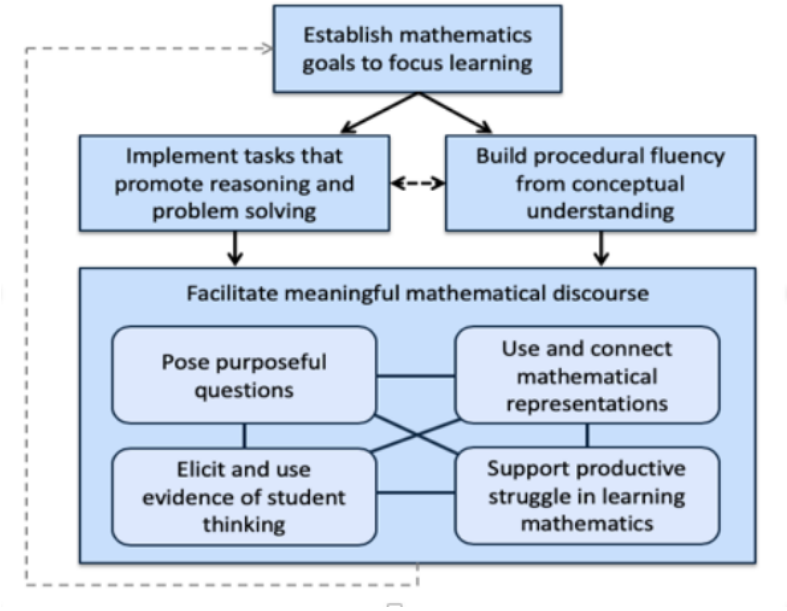
At the heart of ambitious teaching is a vision of all students as mathematics learners and doers. Teachers using ambitious teaching practices treat students as sense makers, maximizing opportunities for all students to engage in rigorous mathematical work (Lampert et al., 2013). Teachers create opportunities to make student thinking public (Lampert & Ghousseini, 2012; West & Staub, 2003) and hold students accountable for learning goals (Kazemi et al., 2009; Windschitl et al., 2012) while building mathematical knowledge, applying that knowledge to solve authentic problems, and explaining or constructing arguments about their solution paths (Lampert & Ghousseini, 2012).

To teach mathematics ambitiously, educators must plan cognitively challenging tasks (Jackson et al., 2013) that support specific mathematical goals (Hiebert et al., 2018), anticipate student thinking (Smith et al., 2008), and facilitate class discussions in ways that enable students to engage with each other's ideas as they develop a conceptual understanding (Franke et al., 2015). By using ambitious teaching strategies, teachers

support a broad range of students in various learning environments (Witherspoon et al., 2021) to develop deep, connected, and flexible conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive dispositions (Lampert & Graziani, 2009; Lampert et al., 2011; Kazemi et al., 2009).

The National Council of Teachers of Mathematics (NCTM) suggests a coherent and connected framework of eight mathematics teaching practices that support mathematics learning for all students (NCTM, 2014), including establishing mathematical goals, implementing tasks that promote reasoning and problem-solving, building procedural fluency from conceptual understanding, posing purposeful questions, using and connecting mathematical representations, eliciting and using student thinking, and supporting productive struggle. As shown below, in this framework, the goals of a lesson are the destination for students' mathematical learning, and the rich tasks are the vehicles through which students build reasoning and problem-solving skills and create a conceptual understanding of the goals. The classroom mathematical discourse is the forum through which students share and refine their thinking about the mathematical goals of a lesson. The following section discusses in more depth these ambitious mathematics teaching practices and the role intentional planning plays in their implementation.

Eight Mathematical Teaching Practices



(NCTM, 2014) A framework for mathematics teaching that highlights the relationship between and among the eight effective teaching practices.

Ambitious Teaching Practices

Establishing mathematics goals

Teachers' deep understanding of a lesson's mathematics goals is the central component of ambitious teaching upon which all other effective practices are built. By establishing specific mathematics goals, a teacher focuses on what students will understand by the lesson's end and possible effective teaching moves that will support students in building that understanding (Smith et al., 2017; Hiebert et al., 2007). When clearly understanding the mathematics goals, teachers can recognize how each lesson task supports students' understanding of the mathematical goal and what counts as evidence of students' learning (Hiebert et al., 2007; Leinhardt & Steele, 2005). Implementing ambitious teaching practices requires intentional lesson planning focused on math content (including clear mathematical goals), student thinking, and teaching practices to

maximize students' opportunities to learn meaningful mathematics (Lampert & Ghousseini, 2012).

Implementing tasks that promote reasoning and problem-solving

If the mathematical goals are the destination, the mathematical tasks are the conduits through which students move from their current mathematical understanding toward a deep understanding of the mathematical goals. Students cannot learn to think without access to rich, relevant things to think about (Resnick & Hall, 2000). Researchers suggest that students who regularly engage in high-level tasks show greater achievement gains than those who spend most of their time on procedural tasks (Stigler & Hiebert, 2004; Stein & Lane, 1996). Thus, implementing low-floor, high-ceiling tasks that every student can access and explore using various strategies provides opportunities for problem-solving and reasoning and move students toward a deeper understanding of the mathematical goals of the lesson. However, researchers submit that tasks with high cognitive demands are challenging to implement (Stein & Lane, 1996; Stigler & Hiebert, 2004). When planning, teachers must decide which aspects of a task support the mathematical goals of the lesson and plan possible strategies (i.e., asking advancing questions, providing tools, encouraging exploration) to advance student thinking without reducing the rigor of the task (NCTM, 2000).

Building Procedural Fluency from Conceptual Understanding

Conceptual understanding and procedural fluency are interwoven components of mathematics education in that teaching that first builds conceptual understanding supports students in effectively and efficiently using procedures and provides a basis for building new mathematical understanding (Smith et al., 2017). Hiebert and Grouws

(2007) suggest that students in concept-focused classrooms develop both conceptual understanding and procedural fluency. When students have opportunities to explore when and why to use a procedure, they make more appropriate decisions on how to apply procedures in novel situations than those who do not make connections between procedures and concepts (Fuson et al., 2005). When planning a lesson, teachers and coaches can discuss providing opportunities for students to use their own reasoning to solve tasks and connecting student strategies to algorithmic procedures as appropriate.

Facilitating Meaningful Mathematical Discourse

Mathematical discourse is the forum through which students advance their understanding of mathematical concepts. Meaningful mathematical discourse among students and their teachers builds on and honors students' contributions as they connect, clarify, and refine their thinking about mathematical ideas (NCTM, 2000). During conversations, teachers invite students to participate by asking probing questions and creating opportunities for students to engage in each other's thinking. Teachers can plan for and facilitate conversations that advance students' conceptual understanding of lesson goals by anticipating, monitoring, selecting, sequencing, and connecting student ideas (Stein et al., 2008; Smith & Stein, 2018).

Supporting Productive Struggle

Providing opportunities for students to engage in productive struggle is a key ambitious teaching practice (Hiebert & Grouws, 2007). Findings from several studies (Kapur, 2010; Warshauer, 2015; Smith, 2000) on productive struggle in middle school indicate that productive struggle is necessary for students to make sense of a challenging problem. Warshauer (2015) suggests teaching practices that support students to struggle

productively include asking questions, giving time, providing encouragement, and acknowledging student struggle. Teachers can support productive struggle by planning for and facilitating opportunities for students to discuss strategies with classmates, asking students to explain their thinking, and providing access to tools that support their thinking (Smith, 2000).

Elicit and Use Evidence of Student Thinking

To teach ambitiously, teachers need to gather evidence of student understanding and use that evidence to inform their instructional decisions. Eliciting and using student thinking enables teachers to determine students' current understanding of mathematical ideas, build on and extend their thinking (Jacobs et al., 2010; Smith et al., 2017), and adapt instruction to meet the needs of their students. These practices begin with a clear understanding of what constitutes an indicator of student thinking (Sherin & van Es, 2003) in relation to the mathematical goals of the lesson. Thoughtful lesson planning, during which teachers anticipate multiple student responses and create a systematic plan to elicit student thinking allows teachers to see how students are developing a conceptual understanding of the mathematical goals of the lesson (Sztajn et al., 2012).

Pose Purposeful Questions

Posing purposeful questions is an essential element of mathematical discourse. Teachers can use such questions to gather information, probe thinking, make mathematics visible, and encourage student reflection and justification (Boaler & Brodie, 2004; Chapin & O'Connor, 2007). When students respond to purposeful questions, they reveal their current thinking about a mathematical idea, explain and clarify their thinking, and reflect on and connect their thinking to that of their peers (Smith et al., 2017). When

lesson planning, teachers should create questions that support students' understanding of key mathematical ideas or choose them from the mathematics curriculum. This approach ensures that questions go beyond information gathering to building on and advancing students' thinking.

Complexity of Ambitious Teaching

Teaching mathematics ambitiously is a complex task. Teachers engaging in ambitious teaching treat students as sense makers and maximize opportunities for all students to engage in rigorous mathematical work (Lampert et al., 2013). They plan and facilitate goal-focused lessons that support students in developing conceptual understanding by purposefully noticing, building on, and extending students' thinking (Jacobs et al., 2010). While researchers posit that ambitious teaching practices are effective in supporting students in developing a deep and flexible understanding of mathematics, shifting teaching practices is challenging because of the content, and pedagogical knowledge teachers need to possess (Lampert & Ghousseini, 2012).

Ambitious teaching requires teachers to possess mathematical knowledge beyond rules and algorithms and engage every student in rigorous work and in-depth discussions that develop their understanding of both the what and the why of the mathematical concepts (Kazemi et al., 2009; Lampert & Ghousseini, 2012). To teach mathematics ambitiously, teachers must know mathematics content deeply in ways that make the knowledge useful for teaching (Ball & Forzani, 2010; Ball et al., 2008). They need to understand big math ideas (Silverman & Thompson, 2008) and possess the mathematical and pedagogical knowledge necessary for effective instruction, referred to as mathematical knowledge for teaching (MKT) (Ball et al., 2008). MKT includes

knowledge of how students learn mathematical content and knowledge to recognize, interpret, and remediate errors, evaluate various solution methods, analyze the affordances and constraints of representations, know the rationale behind procedures, and decompress mathematical knowledge (Ball et al., 2008).

Researchers posit that when teachers possess a deep conceptual understanding of specific math content, including the rationale behind procedures and multiple solution pathways, they are equipped to develop these skills in their students (Hill et al., 2005). To increase student achievement by improving the quality of mathematics instruction, school districts are hiring mathematics coaches to target teachers' understanding and actions (Campbell & Malkus, 2013) and support teachers' development of ambitious instructional practices (Kane & Saclarides, 2022).

Mathematics Coaching

Researchers describe mathematics coaching as job-embedded, ongoing professional development through which teachers advance their knowledge and implementation of practices that support student learning by working with more knowledgeable colleagues (Bengo, 2016; Campbell & Malkus, 2011; Coburn & Russell, 2008). While many mathematics coaching models share key components, there is no universal set of features or practices defining all coaching models. Russell and colleagues (2020) and Stein and colleagues (2021) models focus on one-on-one coaching cycles of planning, enacting, and reflecting on a specific lesson to build teachers' capacity to implement mathematics tasks that support student thinking and reasoning. Gibbons and colleagues (2017) envision mathematics coaching as supporting groups of teachers to examine standards, study student thinking and enact lessons together. A common

component shared by these models is to use lesson planning sessions to (1) plan effective instruction that supports students' understanding of key mathematical concepts and (2) develop teachers' capacity to teach mathematics ambitiously.

High-leverage Coaching Practices

To better understand the effects of mathematics coaching, researchers need to identify and explain coaching practices that support the development of ambitious teaching practices. Literature identifying high-leverage mathematics coaching practices is limited. Gibbons and Cobb (2017) conducted a conceptual analysis identifying potentially productive coaching activities supporting ambitious mathematics and science teaching practices. They examined teacher education literature and identified five characteristics of high-quality professional development that researchers appeared to agree on: intensive and ongoing; focuses on challenges of teachers' daily work; focuses on student thinking; fosters teacher communities to provide opportunities for professional discourse; and provides opportunities to explore and practice specific pedagogical routines (Desimone, 2009; Garet et al., 2001). Gibbons and Cobb used these characteristics to identify potentially productive *content*-focused coaching activities to use with groups of teachers. These activities are analyzing classroom videos, engaging in lesson study, engaging in the content, and examining student work.

While co-designing lessons met their criteria for high-quality professional development, Gibbons and Cobb concluded that "the description in the research of what teachers had opportunities to learn from [this activity] was insufficient to include in the final analysis" (p. 416). However, Russell and colleagues (2017, 2020) and Stein and colleagues (2021) suggest that engaging teachers in deep and specific lesson-planning

conversations around math content, student thinking, and pedagogy is a potential high-leverage coaching practice. In the next section, I will examine research focusing on deep and specific mathematics lesson-planning conversations as potential high-leverage coaching practice.

Deep and Specific Mathematics Discussions

Researchers at the University of Pittsburgh, in conjunction with professional development providers from the Institute for Learning, and the Tennessee Department of Education created a model to improve teaching practices that included "one-on-one coaching that targets planning, enacting, and reflecting on a specific lesson" (p. 442, Russell et al., 2020). In several studies (Russell et al., 2017; Russell et al., 2020; Stein et al., 2021), the researchers examined deep and specific mathematics discussions between a coach and a teacher to see whether these conversations predicted teaching improvement and how coaches learned to facilitate these conversations. These conversions centered around the mathematical ideas of the lesson (mathematical goals), pedagogy (advancing and assessing questions), and student thinking. The researchers posit that planning sessions should include in-depth discussions about the mathematical goals of the lesson, time to do each task in multiple ways, and discussion about the constraints and affordances of each solution pathway to prepare teachers to notice and interpret student thinking. When coaches push teachers to articulate the goals of the lessons clearly, teachers develop an understanding of how tasks support students' reasoning about the mathematical ideas of the lesson. Discussing multiple solution paths and identifying advancing questions prime teachers to monitor, select, and sequence student solution

paths and to recognize, build on, and extend student thinking during instruction (Hiebert et al., 2018).

Witherspoon and colleagues (2021) used a mix-methods, case-comparison design to study lesson planning conversations in which coaches and teachers explicitly discussed specific, ambitious teaching practices, when to use the practices, and why those practices might be effective during lesson planning. Their results suggest that when coaches and teachers discuss when and why certain practices should be used teachers continued to implement ambitious teaching practices in later lessons, suggesting that teachers developed adaptive reasoning. These findings add nuance to a vision of what deep and specific lesson planning as a high-leverage coaching practice looks like.

Researchers posit that growth in a coach's capacity to facilitate deep and specific lesson-planning conversations predicts teaching improvement in creating opportunities for students to engage in cognitive thinking (Russell et al., 2020; Stein et al., 2022), a vital component of ambitious teaching. To effectively implement this and other potential high-leverage coaching practices that support ambitious teaching, school-based coaches need professional development (Chval et al., 2010; Kane & Saclarides, 2022).

How Coaches Learn High-leverage Coaching Practices

What Coaches Should Know and Do

Mathematics coaching involves skills and knowledge that different from those for good teaching. In their Examining Mathematics Coaching (EMC) project, Sutton, Burroughs, and Yopp (2011) suggested and defined domains of mathematical knowledge for coaching including assessment, communication, leadership, relationships, student learning, teacher development, teacher learning, and teacher practice. In other words,

mathematics coaches must assess teachers' beliefs about students and teaching practices and their content and pedagogical knowledge. Coaches must communicate professionally and build relationships grounded in content as they support teachers learning to engage students in meaningful mathematics tasks. Coaches must differentiate coaching to meet the developmental and learning needs of each teacher.

How Coaches Learn to Implement High-leverage Coaching Practices

Some researchers suggest that coaches learn to implement high-leverage coaching practices through intensive professional training. For example, Campbell and Malkus (2011) conducted a large-scale study and found gains in student achievement when mathematics coaches participated in coursework concerning mathematics content, pedagogy, and how to coach in order to support teachers' instruction. Coaches in the TN Coaching project were trained in several workshops by means of direct instruction, simulations, collaborative analysis of videotaped coaching sessions and transcripts, and individualized written feedback (Russell et al., 2020, Stein et al., 2021). Facilitators used these activities to focus coaches' attention on the mathematical ideas (goals) of a lesson, possible student strategies to solve tasks that support lesson goals, and questions that assess and advance student thinking.

Some researchers posit that coaches may benefit from practice-embedded learning opportunities like those used with teachers, in which a facilitator establishes a purpose, presses for and listens to explanations and evidence, and maintains focus on the disciplinary content (van Es, et al., 2014). Olanoff, Masingila, and Kimani (2021), mathematics teacher educators (MTEs), formed a community of practice to study and improve their teaching practices. The two novice MTEs observed the experienced MTE's

class before teaching their own, and the experienced MTE observed their classes several times during the study. The MTEs mutually engage to improve their practices, form a repertoire of communal resources (language, routines, artifacts), and improve their mathematical knowledge for teaching teachers.

While researchers discuss possible high-leverage coaching practices and what coaches need to know to facilitate them, they have varying hypotheses of how coaches learn these practices. Informed by the studies mentioned above and in an attempt to fill the gap in the literature concerning how coaches learn to implement high-leverage practices, I examine whether and to what extent a school-based coach engaging in deep and specific mathematical discussion with an instructional specialist changed the ways in which she facilitated lesson planning sessions with a grade-level group of teachers.

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Appendix C

ARTIFACT 3 – SUITE OF TO TOOLS AND PROTOCOLS

Introduction to PDCE Suite of Planning and Reflections Tools and Protocols

Rigorous college-and-career readiness standards require a change in mathematics teaching from traditional teacher-centered, algorithmic-based practices (i.e., direct instruction, think: "I do-We do-You do") to teaching that is concept-building and responsive to student ideas. Teachers must create opportunities to make student thinking public (Lampert & Ghousseini, 2012; West & Staub, 2003) and hold students accountable for learning goals (Kazemi et al., 2009; Windschitl et al., 2012). Teachers need to support students to build mathematical knowledge, apply that knowledge to solve authentic problems, and their solution paths (Lampert & Ghousseini, 2012). Implementing such ambitious teaching requires intentional lesson planning focused on math content (including clear mathematical goals), student thinking, and pedagogy to maximize students' opportunities to learn meaningful mathematics (Lampert & Ghousseini, 2012). One high-leverage coaching practice to support ambitious teaching is facilitating deep, specific lesson planning discussions focused on the mathematical point of the lessons, student thinking, and ambitious teaching moves that elicit, build on and extend student thinking. Coaches can build their capacity to facilitate such discussions by engaging in deep, specific conversations intentionally designed to prepare them to advance teachers' mathematical knowledge for teaching.

PDCE has created a suite of tools and protocols for PDCE instructional specialists and school-based coaches to support teachers in planning goal-focused, student-responsive lessons. There will be eight tools in the suite--four for Instructional Specialists and four for School-based Coaches, including planning templates, discussion guides, data collection tools, and reflection tools.

Tools and Protocols

1. A planning template for school-based coaches to plan a discussion to focus on deep mathematical ideas with teachers.
2. A Discussion Guide for school-based coaches to guide the discussion with teachers.
3. A Data Collection tool to collect data on the impact of the school-based coach's discussions on teacher practice.
4. A tool to guide reflection on the impact of the discussion of the school-based coach on teacher practice.
5. A planning template for Instructional Specialists to plan a discussion to focus on deep mathematical ideas with the school-based coach.
6. A Discussion Guide for PDCE Instructional Specialists to guide the discussion with the school-based coaches.
7. A Data Collection tool to collect data on the impact of the specialist discussion on the school-based coach’s practice.
8. A tool to guide reflection on the impact of the discussion of Instructional Specialist on the school-based coach’s practice.

Coaching Through Lesson Planning Tool

Unit:	**Lesson:** **Date:**	**Teacher:**	
Standards	**Building on:** **Addressing:**	**Record possible questions/strategies to explicitly address content, student thinking, & possible teaching strategies.**	
Lesson Section	**Guiding Questions to Consider**	**Coach moves/questions**	**Teachers' Thinking/Input**
Read Lesson Narrative and Synthesis	What is the purpose of this lesson (the big math ideas)? How will students build knowledge toward this purpose?		
Lesson Goals	What should students **know** and be able to **do** at the end of the lesson?		
Cool-Down **(Do the math)**	How can students show understanding of the learning goal? What might incomplete understanding/ misconception look like? Where can you address them in the lesson?		
Warm-Up Do the math to anticipate how to support **students' understanding**	What is the task's purpose & connection to goals? What do you expect to see/hear that indicates student understanding? What strategies & questions will you use to make the key ideas stand out?		
Activity 2 Do the math to anticipate how to support **students' understanding**	What is the task's purpose & connection to goals? What do you expect to see/hear that indicates student understanding? What strategies & questions will you use to make the key ideas stand out?		
Activity 3 Do the math to anticipate how to support **students' understanding**	What is the task's purpose & connection to goals? What do you expect to see/hear that indicates student understanding? What strategies & questions will you use to make the key ideas stand out?		
Lesson Synthesis	How will you support **students** to **generalize/connect their understanding** of the lesson concepts? of the unit concepts?		
Previous Next Steps: Check-In on Progress			

Collect Data On:			

School-based Coach Discussion Guide

Lesson Planning Duration: 20 minutes 1 to 2 days before teaching the lesson
Attendants: School-based coach and grade level group of teachers or individual teacher

1. **Before the lesson planning session,** the teacher(s) and coach read the lesson (including narrative, syntheses, and goals), clearly articulate the mathematical idea(s) of the lesson, and complete the math tasks in multiple ways to anticipate student thinking.
2. Coach and teacher engage in deep and specific discussion of the math goals, anticipated student thinking, and teaching moves to support student learning. Specifically, teachers and coach:
    1. Identify the specific mathematical concepts addressed and what students should know and be able to do by the end of the lesson. The purpose of the discussion is to ensure everyone has a clear understanding of the mathematical point of the lesson.
    2. Discuss multiple solution paths students might use to solve tasks, identifying possible misconceptions and ways to address them. Preliminarily decide which solution paths to elicit and build on to support the lesson goals.
    3. Discuss questions the teacher plans to use to advance student thinking toward the lesson's goals, explicitly **focusing on why** the teacher chose those questions **and when** to ask them.
        1. Questions that encourage students to clarify their thinking
        2. Questions that encourage students to connect their thinking with others

3. Questions that encourage students to evaluate their own and others' thinking

Questions may be chosen from the curricular materials or created by the teacher/coach. It is suggested that teachers have these questions ready during the lesson.

3. The coach will use open-ended probing and advancing questions to facilitate discussion. Questions will be both pre-planned and in response to the teachers' thinking and focus teachers' attention on the mathematical purpose of the lesson and student thinking. When needed, the coach may follow up questions with direct suggestions/ideas and reasons for them.

4. The coach will keep a written artifact of the conversation using the PDCE coaching tool to refer to when observing teachers, planning debriefing sessions, and planning their next steps for supporting teachers.

School-based Coach Reflection Tool
Lesson: Date:
Lesson goal(s):

1. Reflect on moments in the planning session where you fostered teachers' discussion on the following. Include questions you asked/moves you made (doing a task together, etc.) that elicited, built on, and/or extended *teachers'* thinking about content, student thinking, or teaching moves (pedagogy) that support student reasoning.

    a. The big mathematical ideas of the lesson and how each task supports students' understanding of them

    b. Anticipated student thinking about the mathematical ideas

    c. Specific teaching moves/questions to elicit, build on, and/or extend student thinking and WHY teachers chose them

    d. Specific teaching moves/questions to help students synthesize their learning and WHY teachers chose them

2. In what ways did the planning tool and/or discussion with the PDCE specialist prepare you for deep, specific mathematics conversations with teachers?

Data Collection Tool: Teacher Lesson Planning Practice

Teacher(s):_____ Date:_____ Lesson:_____

During the lesson planning session, the teachers discussed the big math ideas, including the learning goals and how each task supports students' understanding of the goals.
Observational data:

The teachers discussed specific anticipated student thinking about the big mathematics ideas of the lesson, including multiple solution pathways and possible misconceptions.
Observational data:

The teachers discussed teaching strategies and questions that could elicit, build on, and extend student thinking about the big math ideas of the lesson and WHY they chose them.
Observational data:

PDCE Specialist Reflection Tool

School-based Coach: Lesson:

Date:

Lesson goal(s):

Reflect on moments in the planning session with the school-based coach where the questions you asked/ moves you made prepared the school-based coach to facilitate deep and specific discussions with teachers.

a. The Specialist and school-based coach discussed (1) the big mathematical ideas of the lesson, (2) anticipated possible student thinking about those ideas, and (3) strategies teachers might use to elicit, build on, and extend student thinking

b. The specialist and school-based coach discuss specific moves/questions the coach might use to elicit, build on and extend the *teachers' thinking* about the mathematical ideas in the lesson AND why/when the coach would use them in their planning with teachers.

c. The specialist and school-base coach discussed specific moves/questions the coach might use to support teachers to plan for student synthesis of their learning of the mathematical ideas of the lesson

PDCE Specialist Data Collection Tool: Coaching Practice
Coach:_____ Date:_____ Lesson:_____

The coach facilitated discussion around the learning goals, connecting tasks and teaching strategies to the learning goals.
Observational data:

The coach facilitated discussion on the mathematical concepts in the lesson, addressing any misconceptions held by teachers.
Observational data:

The coach facilitated a discussion of multiple anticipated student strategies to identify partial understanding/misconceptions and design questions that elicit, build on, and/or extend student thinking.
Observational data:

Coach/teacher(s) share, critique, and connect/ build on each other's ideas/strategies to support /encourage student math discourse.
Observational data:

Coach facilitated discussion that prepared teachers to support students in synthesizing their understanding of the lesson goals.

Observational data:

PDCE Instructional Specialist Discussion Guide
Lesson Planning Duration: 20 minutes 1 to 2 days before the school-based coach's planning session with teacher(s).
Attendants: Instructional Specialist and School-based coach

1. **Before the coach planning session,** the specialist and coach read the lesson (including narrative, syntheses, and goals), clearly articulate the mathematical idea(s) of the lesson and complete the math tasks to anticipate and build-on student thinking.
2. Coach and Specialist engage in deep and specific discussion of the math goals, anticipated teacher and student thinking, and questions/moves to support teachers' thinking. Specifically, Specialist and Coach:
    1. Identify lesson goals, including specific mathematical concepts addressed and what students should know and be able to do by the end of the lesson. The purpose of the discussion is to ensure everyone has a clear understanding of the mathematical point of the lesson.
        1. Plan questions the coach may ask to support teachers' thinking around the mathematical concepts and how students need to know them (identify, apply, justify, etc.).
    2. Discuss multiple solution paths students might use to solve tasks, identifying possible misconceptions and ways to address them.
        1. Plan questions the coach may ask teachers as they anticipate student thinking.

3. Discuss questions the coach will ask to help teachers advance student thinking toward the goals of the lesson, explicitly **focusing on why** the coach chose those questions **and when** to ask them. Specifically:
    1. Questions that encourage teachers to recognize student thinking (including incomplete thinking) and build on it.
    2. Questions that focus teachers' attention on ways to help students compare and connect their thinking with other students
    3. Questions that encourage teachers to plan synthesis questions
    4. Questions that encourage teachers to reflect on and evaluate the effectiveness of their intended teaching moves
3. The Specialist will use open-ended questions to facilitate discussion. Questions will be both pre-planned and in response to the coach's thinking and focus the coach's attention on the mathematical purpose of the lesson, teachers' MKT, and student thinking. When needed, the Specialist may follow up questions with direct suggestions/ideas and reasons for them.
4. The Specialist will keep a written artifact of the conversation using the PDCE Specialist planning tool to refer to when planning debriefing sessions and planning their next steps for building the capacity of the school-based coach to facilitate deep and specific mathematical discussions when planning with teachers.

Coaching the Coach Through Lesson Planning Tool

Unit:	**Lesson:** **Date:**	**Coach:**	
Standards	**Building on:** **Addressing:**	**Record possible questions/strategies to explicitly address coaching strategies to support specific discussion on math content, student thinking, & possible teaching strategies.**	
Lesson Section	**Guiding Questions to Consider**	**Specialist thinking/input**	**School-based Coach's Thinking/Input**
Read Lesson Narrative and Synthesis	What is the purpose of this lesson (the big math ideas)? How will students build knowledge toward this purpose?		
Lesson Goals	What should students **know** and be able to **do** at the end of the lesson?		
Cool-Down **(Do the math)**	How can students show understanding of the learning goal? What might incomplete understanding/ misconception look like? Where can teachers address them in the lesson?		
Warm-Up Do the math to anticipate how to support **students' understanding**	What is the task's purpose & connection to goals? What do you expect teachers to see/hear that indicates student understanding? What strategies &questions might teachers use to make the key ideas stand out? What questions will you ask to elicit, build on, and extend teachers' thinking on ways to support **students'** understanding of key ideas?		
Activity 2 Do the math to anticipate how to support **students' understanding**	What is the task's purpose & connection to goals? What do you expect teachers to see/hear that indicates student understanding? What strategies &questions might teachers use to make the key ideas stand out? What questions will you ask to elicit, build on, and extend teachers' thinking on ways to support **students'** understanding of key ideas?		
Activity 3 Do the math to anticipate how to support **students' understanding**	What is the task's purpose & connection to goals? What do you expect teachers to see/hear that indicates student understanding? What strategies &questions might teachers use to make the key ideas stand out? What questions will you ask to elicit, build on, and extend teachers' thinking on ways to support **students'** understanding of key ideas?		

Lesson Synthesis	What questions will you ask to elicit, build on, and extend teachers' thinking on ways to support **students** to **generalize/connect their understanding** of the lesson concepts? of the unit concepts?		

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Appendix D

ARTIFACT 4 - METHODOLOGICAL MEMOS

6/30
Yesterday I zoomed with Amber after contacting her by email with several questions I had about her work with SMS before my coaching there. She came to the meeting with a document with answers to the questions that she shared with me. This is indicative of the way she has always worked with me. We had an open & honest conversation about the way our partnership began (rather rocky) and how it grew.

Amber has a great deal of knowledge about math content, and Seaford School District (students, community, politics, etc.). She has agreed to read and edit my writing. I consider her a valued thought and writing partner.

8/26
I facilitated PL for SMS teachers on 8/22 on building thinking classrooms and equitable instructional practices. We spent time planning initial lessons by grade in the afternoon with a focus on practices explored in the PL. Throughout the PL and planning, teachers referenced SBAC and DBI testing often. Several commented that they liked IM, but they needed to do things that directly taught to the items on DBI/SBAC. 8th-grade teachers wanted to combine the first 2 lessons of unit 1 because they were worried about covering material for SBAC/DBI

Last May, Amber, Jim, and I sat down and planned 3-day coaching cycles in which teachers would plan with me on day 1 (20 min), I would observe on day 2 (20 min), and we would debrief on day 3 (15 min). Either the debrief or the planning day would be at PLC time, and they would have the remainder of the period free. On 8/22, I found out that the school had planned PLC agendas for nearly every week, making our plan impossible. We have to brainstorm ways to get 3-day cycles in.
Three-day cycles provided time for the coach and specialist to discuss upcoming planning sessions during which they could clarify their understanding of the mathematical point of the lesson, how the tasks support that point, possible student strategies, and moves teachers can make to support student thinking. With this preparation, the coach was primed to have deep, specific mathematics conversations with teachers while planning. The hypothesis was if teachers engaged in deep, specific mathematics conversations, they would be prepared to hold similar conversations with their students.
9/20
6th grade 6.1.10
This is Amber's filled-out tool for planning with 6th grade teachers. It was our initial run of the tool with 6th-grade teachers. We had discussed it the morning, and Amber edited

the tool to make it more user-friendly (colors, columns) but did not change the essence of the tool.
10/11
Yesterday Amber and I used the coach planning tool to preplan to facilitate deep math discussions while planning with teachers. (I filled it out ahead of time, and she added to it). We then planned with each grade, focusing on the math goals, student thinking, and teaching moves to support the two. 6th grade 6.2.3 10/11;
After each planning session, we debriefed on refining our conversations with teachers and/or the tool. I realized that I am not focusing attention enough on student thinking, so did a better job in the next planning session.

After discussion, we know that I need to take less time to plan with teachers. We are thinking of ways to streamline discussions with teachers.

Today our first visit: Class was student focused. Students talking with each other Teacher set up time and expectations for that, including student movement around the room.

10/23
Completed the set of planning tools this morning. I looked at versions of tools PDCE currently uses as well as read literature about important components of planning effective math lessons and created an IM-specific tool for planning, reflection tools, data collection tools, and guides for using the planning tools to facilitate deep and specific mathematical discussions on the big math ideas of the lesson, student thinking about the ideas, and teaching strategies that support students to build conceptual understanding of the mathematical concepts.

This morning I planned 3 upcoming lessons for 6,7,8 grades at Seaford that we will plan with teachers tomorrow. Amber has already used the coach planning tool/guide to plan for these discussions. I used the Specialist tool and the guide to plan my discussions with Amber before our planning sessions with teachers. I anticipate that Amber will lead the discussions tomorrow, and I will audiotape them for analysis later. I need to use a timer to keep the discussions to 20 minutes. (this has been a problem for me this year, and I have taken too much teacher time!)
Tools:
Planning templates
Gr 6 coach planning 10/24
6th 6.2.10 (10/24)
Transcripts
transcript 10/26 teachers
10/26 Boyce/Brown planning

10/29
I spent Monday, Tuesday, and Wednesday at SMS this week. Amber and I recorded our planning discussion for lesson planning with 6th-grade teachers Smith, Rodsan, Tyler (Tiffany, Brandis) on lesson 6.2.10. Amber came to the meeting with the coach planning tool completed, tools:

Gr 6 coach planning 10/24 the math tasks of the lesson completed in multiple ways, and the TE lesson annotated. I used the questions on the specialist planning tool to discover her thinking about the major math of the lesson and questions she could pose to help teachers see the big math ideas and the moments in the lesson where they should linger, so students develop an understanding and connect the representations within the lesson (double # lines, tables, unit rate). Her planning tool indicates that initially, Amber thought the unit rate was a major lesson point. Through discussion and questioning, we came to an agreement that although the unit rate is a feasible strategy, this lesson was meant to prompt students to use other methods to compare ratios to find equivalence, encountered as same rate (cost of tickets) or same taste (recipes)

In the teacher planning meeting, teachers were fixed on unit rate as the main strategy to focus on because the previous lessons did. However, we pointed out that IM chose numbers that were not friendly to unit rate so students would naturally use other strategies. (note: in debrief, teachers were excited when students used unit rate) Teachers did discuss misconceptions students might have about double # lines. Amber asked questions to prompt teachers to think about student possible strategies and how to connect their thinking (6th 6.2.10 (10/26))

11/15

A 3-day visit to SMS began yesterday. Amber and I each came prepared with 3 lessons completed using our specific tool. That is, I used the specialist tool, and she used the coach tool. (This time, Amber did not have the lessons printed showing all the math.) However, 7th-grade teachers changed their lesson, so we each independently went through the lesson and then discussed it afterward to keep our data collection the same. Amber and I discussed each lesson from the lens of working with teachers to understand and highlight the mathematical point of the lesson (lesson goals, and how students are to know those goals). We recorded our planning session for 6th-grade teachers and the planning session with 6th-grade teachers (Rodsan, Smith, Tyler, Tiffany, and Brandis) by recording a Zoom meeting. In every instance, we met in person, but I recorded the discussions by placing the computer at the center of the table. Only audio was recorded. This time Amber took more of the lead with the teachers, and I tried to say less in the session. We went over by 3 minutes.

We began with the lesson's goals and how students were expected to engage with the goals (describe, draw, choose, etc.). We then discussed the cooldown and what part of the lesson it addresses (finding answers using rate per one). After discussion, we concluded that this lesson focuses on the usefulness of using per-1 thinking when trying to solve unfamiliar context problems (washing windows of the Burj Kalifa). Teachers thought most students would use either arithmetic (division to find the rate per window, then multiplication to find the time to wash all windows) or tables. We discussed using student work to compare the two representations. Amber discussed the possibility of annotating the synthesis questions to focus student attention on the usefulness of finding per one. Rodsan is a little behind, so she chose not to do the lesson on 11/15 but will do it on 11/16.

On 11/15, we observed each class and collected data requested by the teachers. We brought paper to jot down a few notes. I did a little real-time coaching by making

suggestions (like using turn and talk or collecting student data and reporting it to the teacher to aid in the discussion). Amber did the same.

11/23
This week, I downloaded the Zoom transcripts and cleaned them by hand. I listened to the recordings repeatedly, naming each participant and editing words/phrases that were transcribed by Zoom incorrectly. I chose to leave the "ums" and repeated phrases or dropped thoughts in the cleaned transcriptions to help capture the true flow of the discussions and indicators of thinking/processing. I also noted extended pauses and the cause. For example, during one recording, there was a long interruption due to school-wide announcements.

11/23
Today I decided to use the coding scheme included in Stein et al. (2022) with minimal adaptations to code the coach-teacher discussions I have transcribed and more adaptations to code to fit the specialist-coach discussions. These researchers have worked in the TN project over a number of years and the codes have been shown to be reliable and capture what I am studying. I will also include open coding if I find interesting data that does not fit in the Stein coding scheme. My unit of measure will be a phrase. I will train my advisor to use these codes.
I created a coding scheme document so that I can train my supervisor/advisor to code to increase the validity of my findings.

School-based Coach and Teacher Lesson Planning Rubric
Rubric adapted from Coach Learning to Help Teachers Learn to Enact Conceptually Rich, Student-focused Mathematics Lesson (Stein et al., 2022)

Component	**Rubric**
STUDENT THINKING Multiple Solution Strategies Discussed Definition: Coach and teacher identify multiple solutions paths for the task	0—No solution paths mentioned or discussed 1—All discussed in superficial ways 2—One discussed in more than superficial way 3—At least two discussed in more than superficial ways
PEDAGOGY Advancing Questions Identified Definition: Advancing questions asked by the teacher to challenge students or move students beyond their current thinking	0—Not named 1—One or more named but not discussed (e.g., when to use, potential teacher or student responses that are procedural or logistical in nature) 2—Discussed with depth (e.g., likely student answers and potential teacher responses as long as responses are related to probing student thinking and go deeper into the math idea)
MATHEMATICAL CONTENT Mathematical goal is discussed with specificity Definition: The discussion of the mathematical goal went beyond broad topics (e.g., fractions) to include identification of specific mathematical concepts or principles that are the goal for student learning	0—No goal named 1—Broad topics named 2—Gives a mathematical definition or a procedure as the goal 3—Discussion of students acquisition of the underlying meaning of a concept

PDCE Math Specialist and School-based Coach Pre-Lesson Planning Discussion Rubric
Rubric adapted from Coach Learning to Help Teachers Learn to Enact Conceptually Rich, Student-focused Mathematics Lesson (Stein et al., 2022)

Component	Rubric
STUDENT THINKING Multiple Solution Strategies Discussed Definition: Instructional specialist and school-based coach identify multiple solutions paths for the task	0—No solution paths mentioned or discussed 1—All discussed in superficial ways 2—One discussed in more than superficial way 3—At least two discussed in more than superficial ways
PEDAGOGY Advancing Questions Identified Definition: ~~Advancing questions asked by the school-based coach to guide teachers to ask questions to challenge students or move students beyond their current thinking~~Advancing questions asked by the math specialist to challenge the school-based coach to move teachers' beyond their current thinking	0—Coach does not ask advancing questions 1—One or more asked but not discussed (e.g., when to use, potential teacher responses that are procedural or logistical in nature) 2—One or more asked and discussed with depth (e.g., potential teacher responses as long as responses are related to probing student thinking and go deeper into the math idea)
MATHEMATICAL CONTENT Mathematical goal is discussed with specificity Definition: The discussion of the mathematical goal went beyond broad topics (e.g., fractions) to include identification of specific mathematical concepts or principles that are the goal for student learning	0—No goal named 1—Broad topics named 2—Gives a mathematical definition or a procedure as the goal 3—Discussion of students acquisition of the underlying meaning of a concept

11/26

Today I revised the lesson planning guidelines to clearly articulate the goals of the planning sessions and how to facilitate deep mathematical discussions during planning.

11/30

After coding several conversations, I realize that I am not using any open coding and so have decided to eliminate open coding from my coding scheme.

12/3

As I have begun analyzing my coding, I realized that a nuanced understanding of pedagogy wasn't being captured by my coding. As an example, in my conversations with the building coach, we began discussing when teachers might use a question to advance student thinking and the importance of the teachers knowing why it was a good time to use it.. At first, I thought it was a new code, but after creating it and discussing it with my advisor, we concluded that I needed one more level of coding within my current pedagogy code. This new level captures the times when the what, when, how, and why

advancing questions are used. This is in line with the research of Witherspoon et al.(2020).

The revised rubrics:

School-based Coach and Teacher Lesson Planning Rubric

Rubric adapted from Coach Learning to Help Teachers Learn to Enact Conceptually Rich, Student-focused Mathematics Lesson (Stein et al., 2022)

Component	Rubric
STUDENT THINKING Multiple Solution Strategies Discussed Definition: Coach and teacher identify multiple solutions paths for the task	0—No solution paths mentioned or discussed 1—All discussed in superficial ways 2—One discussed in more than superficial way 3—At least two discussed in more than superficial ways
PEDAGOGY Advancing Questions Identified Definition: Advancing questions to be asked by the teacher to challenge students or move students beyond their current thinking	0—Not named 1—One or more named but not discussed (e.g., when to use, potential teacher or student responses that are procedural or logistical in nature) 2—Discussed with depth (e.g., likely student answers and potential teacher responses as long as responses are related to probing student thinking and/or go deeper into the math idea) 3-Meta discussions of the *what, when, why, and how* of the specific teaching situation to support teachers' capacity to plan advancing questions in the future.
MATHEMATICAL CONTENT Mathematical goal is discussed with specificity Definition: The discussion of the mathematical goal went beyond broad topics (e.g., fractions) to include identification of specific mathematical concepts or principles that are the goal for student learning	0—No goal named 1—Broad topics named 2—Gives a mathematical definition or a procedure as the goal 3—Discussion of students acquisition of the underlying meaning of a concept

Math Specialist and School-based Coach Pre-Lesson Planning Rubric

Rubric adapted from Coach Learning to Help Teachers Learn to Enact Conceptually Rich, Student-focused Mathematics Lesson (Stein et al., 2022)

Component	Rubric
STUDENT THINKING Multiple Solution Strategies Discussed Definition: Instructional specialist and school-based coach identify multiple solutions paths for the task	0—No solution paths mentioned or discussed 1—All discussed in superficial ways 2—One discussed in more than superficial way 3—At least two discussed in more than superficial ways
PEDAGOGY Advancing Questions Identified Definition: Advancing questions to be asked by the coach to challenge teachers or move teachers beyond their current thinking.	0—Not named 1—One or more named but not discussed (e.g., when to use, potential teacher or student responses that are procedural or logistical in nature) 2—Discussed with depth (e.g., likely student answers and potential teacher responses as long as responses are related to probing student thinking and/or go deeper into the math idea) 3-Meta discussions of the *what, why, when, and how* of the specific teaching situation to support teachers' capacity to plan advancing questions in the future
MATHEMATICAL CONTENT Mathematical goal is discussed with specificity Definition: The discussion of the mathematical goal went beyond broad topics (e.g., fractions) to include identification of specific mathematical concepts or principles that are the goal for student learning	0—No goal named 1—Broad topics named 2—Gives a mathematical definition or a procedure as the goal 3—Discussion of students acquisition of the underlying meaning of a concept

12/5

Today, after having a deep discussion with Ms. Boyce concerning facilitating deep math discussions w/ teachers during planning, she facilitated the 6th- planning session with no input from me. This decision was to see be able to compare how the school-based coach facilitated alone with how the planning session progressed when I was also working with teachers. I will transcribe the audio recording, and code it. I am interested seeing whether there are changes in coaching practices.

12/8

As I am coding, I am noticing interesting data. Ms. Boyce is intentionally designing her lesson planning time to address the needs of her teachers, deciding on a specific goal for

each session. For example, on 12/5 she discussed with me in our pre-conference that she wanted to extend the 6th-grade teachers' goal to have students record/edit their work in their workbook after the task synthesis to hold them accountable for the day's learning. She decides to elevate their practice by building off their goal and extending it to include the synthesis of each task and the lesson synthesis. Instead of students merely copying what is on the board, how can teachers be sure students are synthesizing the important math ideas of the lesson/task? While Ms. Boyce had some logistical ideas, she states in our conversation that she hopes teachers will have ideas. During planning, Ms. Boyce introduces this idea of building off the routine they have established of completing/editing their work after discussion to include ways for students to use that time to synthesize the task/lesson. Teachers appear eager to include this.

12/15

Over the last two days, I have re-examined my transcripts to compare codes between specialist-coach conversations and coach-teacher conversations to look for patterns among codes. Specifically, I want to examine codes to see whether the depth with which Ms. Boyce and I discussed student thinking, pedagogy, and math content was similar to the depth of discussions held with teachers. To do this, I re-read the transcripts for the coach-teacher conversation for 10/26 and made clarifying comments on my copy where I recorded my initial coding. For example, I added a note to lines 92-95 clarifying that this section of the discussion was related to data collection/sequencing and using data to probe or advance student thinking. (Ms. Boyce asks, "How are you going to collect data while they're working, and then, once you have collected it, what order will you sequence these in to share out?"). I then edited the written transcript with arrows highlighting the teacher's response and sequence and how I related it to the sequence found in IM curriculum (lines 99-105). These data capture the question Ms. Boyce asked, the teacher's response, and the connection I expressed during the discussion to the usefulness of the IM curriculum to support sequencing student responses.

Next, I created a new table that compares the codes for the teacher-coach conversations and the specialist-coach conversations. I intend to examine the data to see whether any relationship between the levels of conversations appear.

12/16

This morning I realized that I need to change the unit of measure from a phrase (my original unit of measure) to more clearly capture the relevant moments in the conversations. To complete the tables (see 12/15) that compare codes in conversations, I located relevant moments by recording line-numbered transcripts of specialist/coach talk and coach/teacher talk, marking episode boundaries by shifts in topic and/or participation structure and recording them in the tables. Each relevant moment is coded with a level and the transcript lines. This approach allowed me to include context in the moments and show when student thinking, pedagogy or goals were not further discussed. This coding is similar to coding used by Horn and Little (2010). I modified the transcripts slightly by removing "ums", repetitive words (ex. Students, the students, the students, um, they might…).

12/18

In my study, the coach prepared for coaching conversations during lesson planning by discussing with me the goals, student thinking, and pedagogy related to an upcoming lesson they will plan with teachers. After each coach/teacher coaching session, the specialist and coach engaged in a reflective conversation concerning the depth of conversations during planning and areas we need to attend to improve the facilitation of planning. Initially, those conversations concerned the planning tools and whether they supported the conversations and suggestions for modifications. Later, we discussed teachers' engagement in discussions and how to increase engagement and/or make space for every voice.

12/19
I have completed the first two columns of my comparison table for 10/26 conversations. Interestingly, the depth of conversation between teachers and coaches never exceeded the depth of conversation between coach and specialist. I will begin to compare 11/14 conversations today to see if this pattern holds true. The table can be found here: Coding Analysis Draft

12/20
As I think about the data I have collected and the research I have read, I am trying to make sense of what my work contributes to the field. Here are some thoughts:

1. In my study, we have 20 minutes to plan with teachers. I have not read any research in which the planning sessions were as short as 20 minutes, and yet that is what works in the teachers' schedules, so it seemed prudent to use that time frame to plan.
2. The set of tools that I created, and Ms. Boyce helped me edit have helped to guide our thinking about planning goal-focused, student-centered lessons. I believe that the act of creating, using, editing, and using the edited version was also instrumental in shaping our thinking around planning with teachers.
3. I have made assumptions in this process:
    1. Everyone involved wanted to maximize opportunities for student learning
    2. The planning sessions have two objectives: to maximize opportunities for student learning and to support the professional development of everyone involved. (In other words, to use the act of planning lessons to improve our practice, whether coach, specialist, or teacher.
    3. The data would reveal some hidden component of coaching that would refine our work at PDCE. (Instead, I think that as I reflect on the ELP process, I see that the coaching being refined is my own, and I am unsure if it has merit in the larger coaching community.)
4. There appear to be parallels between the conversations I have with the school-based coach and the conversations we have with teachers, including similar depth of conversation. At first, I thought that this was important, but now it seems a logical progression. One cannot expect to extend the thinking of others if one doesn't already possess the depth of thought.
5. PDCE PL ideas
    1. I want to have specialists interact with the curriculum, the planning tool, and some data to spark their thinking around intentional planning.

12/21
TRANSCRIPTS (uncoded):

- Transcript: 10/26 6th grade planning
- Transcript 10/26 Boyce/Brown planning
- Transcript 11/14 6th grade planning
- Transcript 11/14 Boyce/Brown planning
- Transcript 12/5 6th grade planning
- Transcript AB:AB 12/5

CODING TABLES OF TRANSCRIPTS

- Oct 26 Coding Analysis
- Nov 14 coding analysis
- Dec 5 Coding Analysis

Specialist planning tools:

- Gr 6 coach planning 10/24
- 11/14 6th grade Specialist IM Lesson Planning Tool Template
- 12/5 AB:AB grade 6

School-based coach planning tools:

- 6th 6.2.10 (10/26)
- 6th Grade 6.3.1 (11/15/22)
- 6th Grade 6.3.10 (12/6)

12/23

As I continue to analyze the planning tools and coded conversations, I note that Ms. Boyce articulates a focus on advancing teachers' practice. For example, in our 12/5 conversation, Ms. Boyce shares that she wants to elevate the norm that teachers have created of having students complete or edit their thinking after class discussions to include having students summarize and synthesize their thinking. I ask Ms. Boyce (lines 129-135) what approach she will use to extend teachers' thinking to the importance of synthesis. She explains that copying answers/strategies from the slides is not enough. She decides to ask " "What can we do to build a synthesis piece and how will students engage with it? And as the teacher, what should come out of it and where can students find that information? This is to draw teachers' attention back to the task and lesson syntheses. In line 189 she states that it will be her goal for the planning session. In this way, Ms. Boyce uses the planning session to (1) help teachers plan an ambitious, goal-focused, student-centered lesson and (2) build teachers' mathematical knowledge for teaching. (She connects the mathematical goals with pedagogical moves that will advance student thinking.) When she plans with teachers, Ms. Boyce introduces this idea by asking the teachers how can we take (student editing/completing their thinking) this further? Smith responds that the teachers can get students to explain what we just did and verbalize it. Boyce asks, "How does that take it from the habit in place to elevating it to where now, as the teacher, you can say, "Yeah, I know these guys understand it" A discussion follows (see 12/5 coding analysis) in which the teachers discuss student thinking/strategies and making connections among them, the understanding that needs to come out of the task, how a student might interact with each other's thinking, etc. Boyce asks, "So what are you going to ask them to do that would show you their synthesis of activity one?" A bit later she explains that the TE is a great resource for teachers to look to see what the big

learning student is should take away. She has them take a minute and read the task synthesis in TE and asks, “How would you structure this synthesis of task one? This opens another discussion among teachers about student strategies and what they might tell about student thinking. For example, Smith says that he realizes (from reading) that students might see a pattern like 60 dimes is 60% without realizing they are scaling up. Boyce asks how he could help pull out that idea, and Tyler explains how they can use various coins and connect it back to scaling up which students have prior experience with. Boyce suggests maybe using the double number line when asking synthesizing questions to connect strategies.

12/27

Today I am comparing the coding analysis pages with the completed planning tools to look for any connections between what the school-based coach planned, what she discussed with the specialist, and what was discussed with teachers. I am looking to see whether and in what ways Ms. Boyce’s conversations with teachers reflect her planning and conversations with the specialist. I am also looking to see whether there are changes in the depth and specificity of any of these discussions.

Findings: (in no particular order)

We are confined to 20 minutes for these planning conversations, although we went a few minutes past that on 2 occasions. Because of this time constraint, we have found it impossible to “do the math” together. Each person involved is to come having completed each task in multiple ways, prepared to discuss student strategies. Multiple teachers have complied with this expectation, which is evidenced by the number of solution strategies we discuss.

I spoke too often in the early planning sessions. I was not intentionally modelling how to facilitate a deep and specific conversation; I was unaware of how much I was actually making statements instead of asking advancing questions. As I listened to the transcripts in order to clean them, I became aware of this and began to make changes in the way I planned with Ms. Boyce and teachers. I began to plan and ask more advancing and clarifying questions.. For example, in the 12/5 discussion on goals, I ask Ms. Boyce, “What is your approach to get them to kind of extend their thinking to the importance of those syntheses?” This question opens a space for Ms. Boyce to continue to refine her ideas about moving her teachers’ practice from recording edited work to synthesizing each task.
In another example, on 11/14:
Amy Brown: Do you think it's possible that teacher could teach this, and never really get to the goals?
Boyce: yes, I do. Because it’s just going to be about the calculation
Amy Brown: So, what kinds of things can we do in the meeting with them to get them, push them past that?
In this part of the planning session, I am providing Ms. Boyce with an opportunity to plan questions so teachers create a vision of the lesson. In this way, Ms. Boyce’s reason for planning is not to facilitate the lesson to students, but to

support teachers to do that work. She plans the lesson thinking about eliciting, building on and extending student thinking AND eliciting, building on and extending teacher thinking.

During the 12/5 specialist/coach planning meeting, Ms. Boyce discusses her idea of purposefully planning to expand student editing norms to include summary/synthesis norms. She explains her idea, concluding with the lines below

Boyce: We've now protected that time. How do you then hold students accountable for actually summarizing whatever it is you wanted them to take time to edit?
I state that she is using the planning conversation with teachers to plan the lesson and at the same time to build their MKT. Amy Brown: I think that's a great next step. So, I think this lesson is a good way to start that conversation so that we can use this planning conversation, both as planning this topic, but moving their practice.

Ms. Boyce's facilitation of discussions increased in depth over the course of the study (but I cannot say with certainty whether this was due to the intervention).

- Example:

  10/26 Boyce: All right. So then, the lesson synthesis, IM gives you these four questions,: and I know on your slides, it looks like, and I know you guys are really good about making sure you put these in here. Thoughts on how you're going to debrief it?
  11/14 Boyce:

  - So, what about the lesson synthesis, thinking about the lesson goals? So, I'm just because I questioned this earlier. When we're doing, and I'm just curious of your thoughts on it. So, I'm going to read the two goals to you again and keep these lessons in these questions. So, evaluate the usefulness of calculating a rate for one when solving problems involving unfamiliar rates, and explain orally or in writing, and through other representations, how to solve a problem involving rates in less familiar context. And the lesson goals are actually about the usefulness of calculating which I think are two different things.

To summarize above, on 10/26 she had them think about how they would debrief the questions given in IM. On 11/15 she had them decide if the given questions truly supported the lesson goals and how to modify them to focus students' attention on the goals.

On 12/15 the coach asks teachers a question about synthesis. After one teacher shares his thinking, she directs them to look at the IM curriculum as she reminds them that they do not have to create synthesis questions but can use the ones in the curriculum. In a subtle way, she is indicating the importance of using the TE to guide their thinking. This

generalizes the routine of using the curriculum materials to plan lessons. It builds on the work of the 11/15, in which teachers closely examined the questions and modified where necessary. Teachers are beginning to see that the curriculum provides useful synthesis questions, but teachers ultimately need to examine them carefully. (Note: This point needs to be re-examined and explicitly discussed in future planning sessions.)

12/29: here are thoughts for a paragraph I might be able to use in my ELP

While researchers discuss possible high-leverage coaching practices and what coaches need to know in order to facilitate them, they have not painted a clear picture of how coaches learn these practices. To fill this gap in the literature, I focus on one potential high-leverage coaching practice-deep and specific mathematics discussions- and how school-based coaches learn to facilitate them. I model my study after the work Russell and colleagues (2018, 2020) and Stein and colleagues (2022) did on deep and specific mathematics discussion during lesson planning. I also draw from the work of Olanoff, Masingila, and Kimani (2021), mathematics teacher educators (MTEs) who studied formed a community of practice to study and improve their teaching practices. Throughout the study the authors, two of whom were novice MTEs and the third an experienced MTE who served as mentor, mutually engage to improve their practices, form a repertoire of communal resources (language, routines, artifacts), and improve their mathematical knowledge for teaching teachers. The novice MTEs observed the mentor's class before teaching their own; the mentor observed their classes several times during the study. The authors briefly discussed their lesson plans and observations each week. Similarly, Ms. Boyce and I formed a community of practice in which we engaged to improve our practices, and over time formed a repertoire of resources and improved our knowledge for coaching teachers.

12/31 More Analysis

On 12/15 the teachers begin building off each other's ideas and asking their thoughts as they discuss questions that will advance student thinking. This is an example of building the collective capacity of the teachers. together, the 6th grade teachers built a common understanding of the lesson goals, student thinking around those goals, and possible moves to support students. This type of planning allows for the possibility for all students to have equitable access to ambitious instruction.

1/1/23

As I analyze and synthesize the findings of my case study, I think back on the partnership I have with Seaford Middle School. When I began the partnership in Aug 2021, many of the teachers had not attended formal Illustrative mathematics training. This was the result of teacher turn over. The teachers and coach focused grade-level optional common planning time on creating presentation slides. Their aim was to make the slides more inviting than those supplied by Kendall Hunt and to include tools such as timers to assist teacher facilitation. Since students did not have workbooks, they also spent time creating and copying handouts for students. In an effort to create coherence

between the slides and handouts, they sometimes changed the focus of tasks by changing the wording of tasks or advancing questions but were unaware of the way such changes impacted students' learning. For example, changing a task from "Create a scaled copy of the following figure" to " Circle the diagrams that illustrate a pair of scaled copies?" do not require the same skill set, nor do they provide the same evidence of student understanding. While teachers had access to the Kendall Hunt TE online, the norm was for teachers to plan from a copy of the student workbook. This meant that they based lessons on the student facing goals and did not read the lesson notes that explained the launch, focus, possible student strategies, etc.

In the spring of 2021, Ms. Boyce and I realized that we needed to focus on shifting lesson planning practices. We approached the principal with the idea of using 12 three-day coaching cycle that consisted of grade-level collaborative planning sessions, classroom observations, and debriefing meetings. It was at this time that Ms. Boyce agreed to participate in my ELP case study concerning building the capacity of school-based coaches to facilitate deep and specific lesson planning sessions. We had an idea that increasing the depth and specificity of planning sessions would result in student-centered, goal-focused learning experiences for students that would result in gains in student achievement.

Throughout the course of this study, teachers have shifted their collaborative planning routines. Teachers in the second and third sessions came having read the TE and completed the problems in multiple ways. This preparation enabled them to discuss student thinking and build off that thinking by designing possible advancing questions. Although not mandatory in the study, one teacher began using the lesson planning template and another used the guiding questions in the template to plan and recorded his thinking using his own lesson planner.

1/3/23

Classroom routines have changed over the course of the study.

1. Teachers used to have the student-facing goals written and go over them at the beginning of the lesson. Teachers are now returning to lesson goals several times during the lesson. They expand the way they discuss them.
2. Teachers are creating opportunities for students to work independently and are using that time not to help individual students, but to collect data of student understanding. They are using this information to inform their work with small group/whole group discussions.
3. Teachers are using routines such as think-pair-share and turn-and-talk to invite students to share their ideas prior to whole group discussions. The number of students actively participating in these discussions is increasing.
4. Teachers are holding students accountable for editing their work after the class discussion of a task.

1/4/23

School-based coach led grade-level lesson planning has changed over the course of the study:

1. Prior to the intervention, the norm set for lesson planning sessions was to do all planning within the 20-minute time frame. Conversation revolved around slides

and handouts to be used. During the intervention, the norm was set to arrive to the planning session having read the TE narrative and completed the tasks in multiple ways to prepare to discuss goals, student thinking and pedagogy. For the second and third planning sessions in the intervention, the three regular 6th-grade teachers arrived at the planning sessions having read the lesson narratives and completed the tasks in multiple ways. (The special education teachers had not completed the tasks.)

2. Engaging the special education teachers in depth conversations about student thinking, goals and teaching strategies has proved challenging. I think this should be a focus for future study.
3. The coach's preparation changed over the course of the study. Note changes in planning template. Additionally, the coach arrived at the 2nd and 3rd session with the tasks solved in multiple ways on paper. She referred to these during the planning session.
4. Over the course of the study, the school-based coach used her planning template less as a step-by-step guide and more to (1) focus attention on the big math ideas, how students were expected to interact with those ideas, and teaching moves that supported students to build conceptual understanding of those math ideas (2) focus her thinking on how to support teachers to facilitate a student-centered lesson using ambitious teaching.

1/4/23

- When discussing the telescoping tools with a colleague, I came to the realization that the coach the coach tool needs a next steps portion as well. This section of the coach tool was originally designed by Amber Boyce. I think including a next steps section on the specialist tool will help focus specialists on their next steps when working to build the capacity of coaches to support teachers to teach ambitiously.

1/15

Thoughts for ELP 3

Vision for Improvement of Practice

For my study, I situate mathematics coaching as sustained, content-focused, active, and collaborative professional development (Joyce & Showers, 2002; Desimone, 2009; Desimone & Pak, 2016) that is embedded in teachers' daily work (Putnam & Borko, 2000; Stein et al., 2022; Kazemi & Franke, 2004) and helps teachers look for, see, and build-on evidence of student thinking (Kazemi & Franke, 2004). From this perspective, teachers and coaches collaboratively plan for instruction (Gibbons et al., 2016). I focus on one potential high-leverage coaching practice, deep and specific mathematics discussions when planning a lesson with teachers, and whether and in what ways engaging in deep and specific mathematics discussions with an instructional specialist prior to planning with teachers changes the school-based coach's capacity to facilitate them.

I model my study after the work of Russell and colleagues (2017, 2020) and Stein and colleagues (2022) on deep and specific mathematics discussion during lesson planning. I also draw from the work of Olanoff, Masingila, and Kimani (2021),

mathematics teacher educators (MTEs) who created a community of practice to study and improve their teaching practices. Throughout the study the authors, two of whom were novice MTEs and the third an experienced MTE who served as mentor, collaborated to improve their practices, formed a repertoire of communal resources (language, routines, artifacts), and improved their mathematical knowledge for teaching teachers. Similarly, Ms. Boyce and I formed a community of practice in which we shared a common goal of improving our coaching practices.

1/22
Thoughts
Because we had 20 minutes in which to meet, each teacher, Ms. Boyce, and I committed to planning the upcoming lesson, including completing each math task multiple ways, prior to our planning meeting. This enabled us to focus on deep, specific discussions about the mathematical goals, various thinking and strategies students might employ when interacting with the mathematics, and teaching moves teachers might use to support students to build conceptual understanding of the mathematics.
2/4
The ELP process has made me aware that I need to organize information/data/reflections better. I need to search through my files to find the documentation I am looking for. I will discuss this with my advisor
2/8
Today I am adding my artifacts to the ELP. Again, I am faced with my lack of organization and the need to find ways to streamline artifacts, data, reflections, etc.

Appendix E

ARTIFACT 5 - WHITE PAPER

Deep, Specific Mathematics Discussions: Supporting Ambitious Mathematics Teaching by Supporting School-Based Coaches

Overview

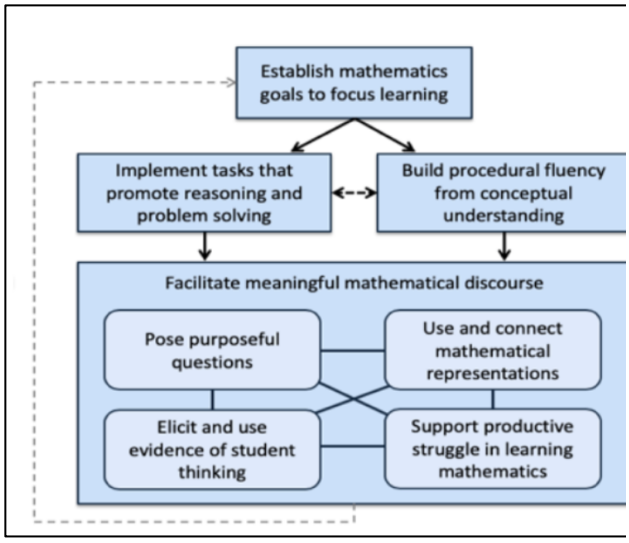
Researchers suggest that growth in a coaches' capacity to facilitate deep and specific lesson-planning conversations predicts teaching improvement in creating opportunities for students to engage in cognitive thinking (Russell et al., 2020; Stein et al., 2021). Focusing on building the capacity of school-based mathematics coaches to support teachers' development of ambitious teaching may be a way to amplify teachers' professional development and capitalize on local expertise.

A Call for Change

The wide adoption of college and career-ready standards calls for a change in mathematics teaching from traditional teacher-centered, algorithmic-based practices (i.e., direct instruction, think: "I do-We do-You do") to teaching that is concept-building and responsive to student ideas known as ambitious teaching. At the heart of ambitious teaching is a vision of all students as mathematics learners and doers. Teaching ambitiously includes creating opportunities for all students to engage in rigorous math work (Lampert et al., 2013) and make their thinking public (Lampert & Ghousseini, 2012; West & Staub, 2003) so they can build conceptual understanding of big math ideas. Ambitious teaching maximizes opportunities for all students to develop deep, connected, and flexible conceptual understanding and procedural fluency (Lampert & Graziani, 2009; Kazemi et al., 2009).

The National Council of Teachers of Mathematics' (NCTM) coherent and connected framework of eight mathematics teaching practices illustrates how to support all students to successfully engage in rigorous mathematical work that promotes conceptual understanding and procedural fluency necessary to meet ambitious standards (Figure 1). Establishing mathematical goals focuses teachers' and students' attention on the mathematical point of the lesson. Implementing rich tasks enables students to create a conceptual understanding of the mathematical goals while building procedural fluency. Successfully facilitating mathematical discourse creates a forum where students test and refine their thinking about the mathematical goals when comparing and connecting their strategies. (For more information, see *Principles to Actions*. National Council of Teachers of Mathematics, 2014).

Figure E.1 Framework for Eight Mathematical Teaching Practices (NCTM).



(NCTM, 2014) This diagram summarizes the connections among the eight mathematical teaching practices.

The Challenge

Teaching mathematics ambitiously is a complex task requiring teachers to possess mathematical knowledge to evaluate various solution methods, understand how students learn mathematics content, and develop strategies to support their learning (Ball et al., 2008). Although the adoption of high-quality instructional materials (HQIM) and implementation training can support ambitious teaching, these resources alone are insufficient. Many school districts have created mathematics coaching roles to provide job-embedded, ongoing professional development through which teachers advance their knowledge and implementation of ambitious teaching practices by working with more knowledgeable colleagues (Bengo, 2016; Campbell & Malkus, 2011; Coburn & Russell, 2008). Coaches use a variety of practices to support improvements in instruction. One potential high-leverage coaching practice to support ambitious, student-centered instruction is deep and specific mathematics discussions when lesson-planning.

Building Teachers' Capacity to Plan Ambitious Mathematics Lessons

To teach mathematics ambitiously, teachers must plan cognitively challenging tasks (Jackson et al., 2013) that support specific mathematical goals (Hiebert et al., 2018). They must anticipate student thinking (Smith et al., 2008), and prepare to facilitate class discussions that enable students to engage with each other's ideas as they develop conceptual understanding (Franke et al., 2015).

An effective way to build teachers' capacity to plan ambitious lessons is to adopt a coaching model that includes deep and specific mathematics discussion during lesson planning. With the guidance of PDCE Instructional Specialists, teachers and coaches focus on key mathematical ideas, student thinking about those ideas, and teaching moves (i.e., advancing questions) that guide student thinking toward conceptual understanding (Coburn & Russell, 2008; Stein et al., 2021). When teachers possess a deep conceptual understanding of specific math content, including the rationale behind procedures and multiple solution strategies, they are equipped to develop these skills in their students (Hill et al., 2005).

Building Coaches' Capacity to Support Teachers to Plan Ambitious Mathematics Lessons

Researchers suggest that growth in a coach's capacity to facilitate deep and specific mathematics conversations with teachers when lesson-planning predicts teaching improvement in creating opportunities for students to engage in cognitive thinking (Russell et al, 2020; Stein et al., 2021). One approach to building school-based mathematics coaches' capacity to facilitate deep and specific mathematics discussions with teachers is for school-based

coaches to engage in deep and specific mathematics discussions with an instructional specialist prior to planning with teachers.

A Case Study

In a recent case study in a Delaware middle school, a school-based mathematics coach and PDCE instructional specialist worked with teachers in three-day coaching cycles that included 20-minute grade-level planning sessions, 20-minute observations, and 15-minute debriefing sessions. Deep, specific mathematics discussion between the coach and specialist prefaced the planning sessions with teachers. The aim was to shift teaching practices to become more goal-focused, student-responsive (ambitious) by building the capacity of the school-based coach to facilitate deep, specific mathematics discussions with teachers during collaborative lesson planning.

A System-wide Approach

Planning and Commitment

Prior to beginning the coaching cycles, district leaders, school-based coach, school administrators, PDCE instructional specialist, and teachers met to discuss expectations and responsibilities, how to orchestrate the coaching cycle days, and the supports needed. Administrators scheduled common planning time and time for the coach, administrators, and instructional specialist to reflect on and discuss data trends and refine the process. The school-based coach and instructional specialist agreed to engage in deep, specific mathematics discussions prior to meeting with teachers. The teachers committed to intentionally planning student-centered lessons prior to meeting with the school-based coach and instructional specialist. PDCE provided planning tools and guidelines to support teachers, the coach, and the instructional specialist to plan for and engage in deep, specific mathematics discussions. (While the specialist and coach used PDCE tools in each cycle, teachers had a choice of planning tools, including PDCE's teacher planning tool.)

Building Coaching Capacity

Coaches benefit from practice-embedded learning opportunities in which the facilitator establishes a purpose, presses for and listens to explanations, and maintains focus on the content (van Es, et al., 2014). By meeting with the school-based coach before each teacher planning session, the PDCE instructional specialist intentionally supported them to build their capacity to facilitate deep, specific mathematics discussions with teachers.

Through deep and specific mathematics conversations, the specialist and coach addressed any lingering mathematical misconceptions and developed a clear understanding of the mathematical point (goals) of the lesson. The specialist supported the coach in choosing questions that would advance teachers' thinking about content, student thinking, and ambitious teaching strategies. By pushing the coach to justify why these questions, how they advanced thinking, and when to ask them, the specialist provided job-embedded professional development to support ambitious teaching.

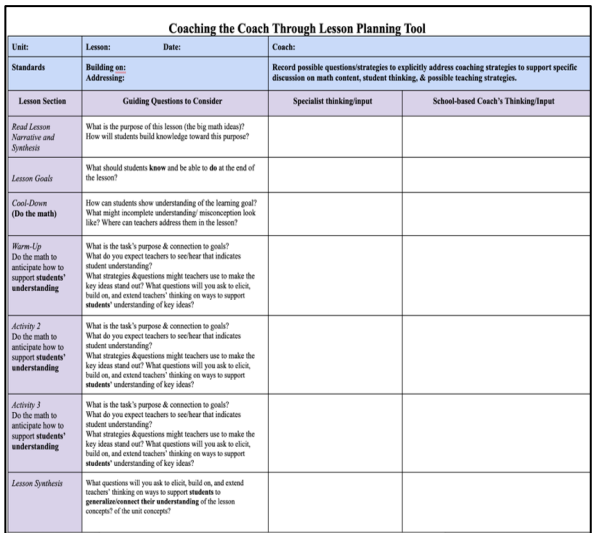
Planning Tools

The instructional specialist tool (Figure E.2) is designed to support the specialist in preparing the coach to facilitate a deep and specific mathematics conversation with teachers. The specialist uses the tool to plan for and facilitate deep, specific mathematics conversation with the school-based coach about the big math ideas of the lesson, student thinking, and pedagogy. It includes questions the specialist can ask the coach to

prepare them to support teachers as they plan ambitious lessons.

The coach tool (Figure E.3) is designed to support the coach in preparing teachers to facilitate deep and specific mathematics discussions with students by including questions the coach can ask teachers to support their capacity to notice, build on, and advance student thinking about the mathematical lesson goals. These tools provide artifacts of planning sessions and can be used to show changes in the focus and depth of mathematics conversations to inform choices on areas of focus for future planning sessions.

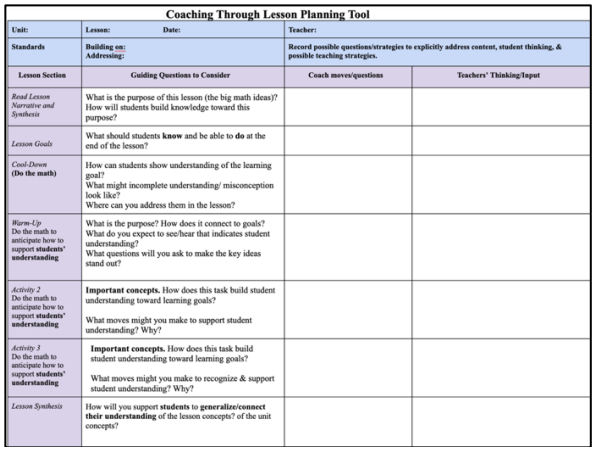
Figure E.2. Specialist Tool



Coaching the Coach Through Lesson Planning Tool

Unit:	Lesson: Date:	Coach:	
Standards	**Building on:** **Addressing:**	**Record possible questions/strategies to explicitly address coaching strategies to support specific discussion on math content, student thinking, & possible teaching strategies.**	
Lesson Section	**Guiding Questions to Consider**	**Specialist thinking/input**	**School-based Coach's Thinking/Input**
Read Lesson Narrative and Synthesis	What is the purpose of this lesson (the big math ideas)? How will students build knowledge toward this purpose?		
Lesson Goals	What should students **know** and be able to **do** at the end of the lesson?		
Cool-Down **(Do the math)**	How can students show understanding of the learning goal? What might incomplete understanding/ misconception look like? Where can teachers address them in the lesson?		
Warm-Up Do the math to anticipate how to support **students' understanding**	What is the task's purpose & connection to goals? What do you expect teachers to see/hear that indicates student understanding? What strategies &questions might teachers use to make the key ideas stand out? What questions will you ask to elicit, build on, and extend teachers' thinking on ways to support **students'** understanding of key ideas?		
Activity 2 Do the math to anticipate how to support **students' understanding**	What is the task's purpose & connection to goals? What do you expect teachers to see/hear that indicates student understanding? What strategies &questions might teachers use to make the key ideas stand out? What questions will you ask to elicit, build on, and extend teachers' thinking on ways to support **students'** understanding of key ideas?		
Activity 3 Do the math to anticipate how to support **students' understanding**	What is the task's purpose & connection to goals? What do you expect teachers to see/hear that indicates student understanding? What strategies &questions might teachers use to make the key ideas stand out? What questions will you ask to elicit, build on, and extend teachers' thinking on ways to support **students'** understanding of key ideas?		
Lesson Synthesis	What questions will you ask to elicit, build on, and extend teachers' thinking on ways to support **students** to **generalize/connect their understanding** of the lesson concepts? of the unit concepts?		

Figure E.3. Coach Tool



Coaching Through Lesson Planning Tool

Unit:	Lesson: Date:	Teacher:	
Standards	**Building on:** **Addressing:**	**Record possible questions/strategies to explicitly address content, student thinking, & possible teaching strategies.**	
Lesson Section	**Guiding Questions to Consider**	**Coach moves/questions**	**Teachers' Thinking/Input**
Read Lesson Narrative and Synthesis	What is the purpose of this lesson (the big math ideas)? How will students build knowledge toward this purpose?		
Lesson Goals	What should students **know** and be able to **do** at the end of the lesson?		
Cool-Down **(Do the math)**	How can students show understanding of the learning goal? What might incomplete understanding/ misconception look like? Where can you address them in the lesson?		
Warm-Up Do the math to anticipate how to support **students' understanding**	What is the purpose? How does it connect to goals? What do you expect to see/hear that indicates student understanding? What questions will you ask to make the key ideas stand out?		
Activity 2 Do the math to anticipate how to support **students' understanding**	**Important concepts.** How does this task build student understanding toward learning goals? What moves might you make to support student understanding? Why?		
Activity 3 Do the math to anticipate how to support **students' understanding**	**Important concepts.** How does this task build student understanding toward learning goals? What moves might you make to recognize & support student understanding? Why?		
Lesson Synthesis	How will you support **students** to **generalize/connect their understanding** of the lesson concepts? of the unit concepts?		

Findings

Over the course of three months, the school-based coach and teachers created a norm of using common planning time to discuss lessons, focusing on math content, student thinking and strategies that support student learning. They addressed any mathematical misconceptions and pushed each other's understanding of what ambitious teaching can look like and sound like in their classrooms. They built a common understanding of lesson goals, student thinking, and strategies that elicit and build on students' conceptual understanding. Teachers' conversations focused on ways they could support *all students* to engage in rigorous mathematical work. Deficit talk about student ability was replaced by discussions on how to harness students' prior knowledge and current thinking to support their understanding of the big math ideas.

Strategy 1: Deep, specific mathematics discussions between coach and specialist

Provide opportunities for school-based coaches to engage in deep, specific mathematics discussions with an instructional specialist prior to planning with teachers. During these discussions, school-based coaches and instructional specialists

address any possible misconceptions about content or misunderstandings about the mathematical goals prior to planning with teachers. With guidance from the instructional specialists, the school-based coach plans questions that elicit and build on teachers' understanding of the lesson's mathematical goals and how students need to know them (i.e., identify, justify, apply, etc.). The instructional specialist explicitly focuses the discussion on why the coach chose advancing questions and when to ask them.

To prepare for deep, specific mathematics discussions with teachers, coach & specialist discuss

- Questions that encourage teachers to recognize student thinking (including incomplete thinking) and build on it
- Questions that focus teacher's attention on ways to help students compare and connect their thinking
- Questions that support teachers to plan synthesis questions
- Questions that encourage teachers to reflect on and evaluate the effectiveness of their intended teaching strategies.

Strategy 2: Establish Planning Session Expectations

Create an expectation that teacher(s) and coach will prepare for and engage in collaborative planning sessions. Because planning sessions are 20 minutes long, all participants need to arrive fully prepared to discuss the mathematical content, student thinking, and teaching moves to support student thinking. All participants read the lesson (including narrative, syntheses, and goals), clearly articulate the mathematical idea(s), and complete the math tasks in multiple ways to anticipate student thinking prior to engaging in deep, specific mathematics discussions about the lesson.

Strategy 3: Deep, specific mathematics discussions between coach and teachers

Collaborative lesson planning revolves around deep and specific mathematics discussion through which coach and teachers create a collective understanding of the big math ideas and effective strategies (i.e., math and language routines, advancing questions) that support students' conceptual understanding of the big ideas. With guidance from the school-based coach, teachers plan advancing questions that elicit and build on students' understanding of the mathematical goals and how they need to know them (i.e., identify, justify, apply, etc.). The coach explicitly focuses on discussing with teachers why they chose their advancing questions and when to ask them.

To prepare for deep, specific mathematics discussions with students, teachers & coach discuss

- Questions that encourage students to clarify their thinking
- Questions that encourage students to connect their thinking with that of other students
- Questions that encourage teachers to reflect on and evaluate their own and others thinking
- Questions that support students to synthesize the big math ideas

Shifting mathematics teaching practices in ways that enable every student to develop deep conceptual understanding of key mathematical ideas requires a system-wide investment and commitment to effective, ongoing professional development of *mathematics teachers* and *mathematics coaches.* Implementing ambitious teaching

practices requires intentional lesson planning focused on math content (including clear mathematical goals), student thinking, and teaching practices. Deep, specific mathematics conversations with an instructional specialist can build coaches' capacity to engage teachers in deep and specific mathematics discussions that promote and develop ambitious teaching practices.

Deep, specific mathematic discussions that focus about mathematical content and student thinking prepare teachers to identify and build on student thinking during instruction. By using ambitious teaching strategies, teachers support all students to develop deep, connected, and flexible conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive dispositions (Lampert & Graziani, 2009; Lampert et al., 2010; Kazemi et al., 2009).

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Appendix F

ARTIFACT 6 - FINAL VERSION OF DISTRICT TOOL

Assessing School-based Mathematics Coaching Through Teacher Practices

This tool is designed to gather data on the capacity of school-based coaches to determine whether and how coach-led planning sessions focused on mathematical goals, classroom discourse, and student thinking have impacted teacher practice and student learning (Adapted from NCSM Essential Actions: Instructional Leadership in Mathematics Education © NCSM 2019.)

Establish Mathematics Goals to Focus Learning

Teacher-Centered	**Making Progress**	**Student-Centered**
Teacher states or displays the learning goals during the lesson and perhaps even reads (or has students read) the goals aloud. However, the teacher does not make connections to the learning goals throughout the lesson and does not use the learning goal to assess student understanding.	Mathematics goals of the lesson are clear and connected to the learning progression or become clear and connected to the learning progression. Teacher explains how tasks relate to the mathematics goals and uses the goals to assess student understanding. Mathematics goals drive the summary and synthesis of the lesson.	Mathematics goals of the lesson are clear and connected to the learning progression or become clear and connected to the learning progression. Students can explain why they are doing a mathematical task, how it relates to other areas of math, and possibly some important uses (real-world connections). Mathematics goals drive the student-led summary and synthesis as they reflect on their own progress toward the goals.
Observations:		

Elicit and Use Evidence of Student Thinking

Teacher-Centered	Making Progress	Student-Centered
Teacher invites students to give one-word or short answers, often relying on a small group of volunteers. The focus is on the answers and not on the thinking behind the answers. Students look to the teacher or text to validate correctness.	Teacher gathers data during investigation but appears to rely on volunteers (does not purposefully select and sequence shares) to build the mathematics of the lesson from student contributions. The teacher notes common student misconceptions but misses opportunities to address them in ways that support understanding of the mathematical concepts. Students focus on procedures ("I solved this by…", "How do I solve…"), but not the "why" ("I chose a tape diagram because…", "Why did you…"). Students look to the teacher or text to validate correctness.	Teacher gathers data during investigation and appears to purposefully select and sequence shares to build the mathematics of the lesson from student contributions. Teacher notes and addresses common student misconceptions in ways that support understanding of the mathematical concepts. Students focus on both the "how" and "why" of their thinking. Students argue the validity of a mathematical statement or solution (theirs or a classmate's) through reasoning and justifying.
Observations:		

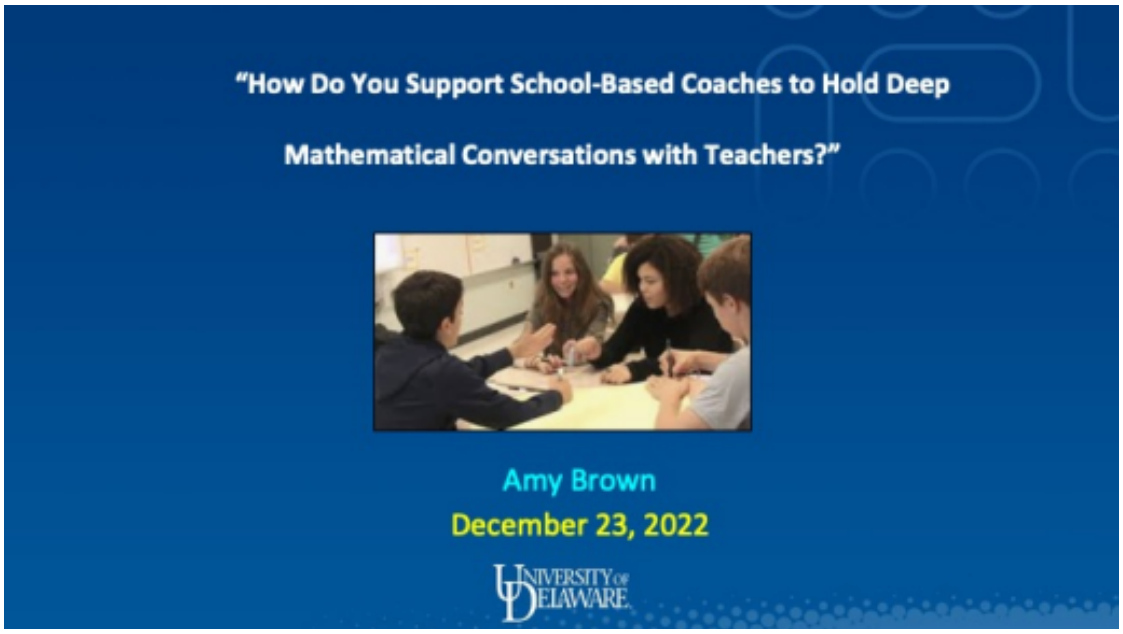
Facilitating Meaningful Mathematical Discourse

Teacher-Centered	Making Progress	Student-Centered
Lecture prevails rather than interactive discussions. Minimal (or no) opportunities for collaboration are provided. The teacher does not check in with students to evaluate their progress toward a learning goal.	Discourse is mostly teacher talk but may be guided by some of the students' ideas. Opportunities for collaboration are provided, but there is minimal engagement among group members. Students' discussions are focused on what they did but not necessarily on why they did what they did. Teacher asks questions to evaluate students' progress toward a learning goal (conceptual and procedural).	Discussion (led by student ideas) extends or solidifies the key mathematical ideas, concepts, and connections to the learning goals of the lesson. Student discussions are focused on both how and why they did what they did. Students listen to, comment on, and question classmates' contributions, using examples to support or counterexamples to refute arguments. Teacher asks questions that probe and advance student thinking. Students reflect on and justify their reasoning.
Observations:		

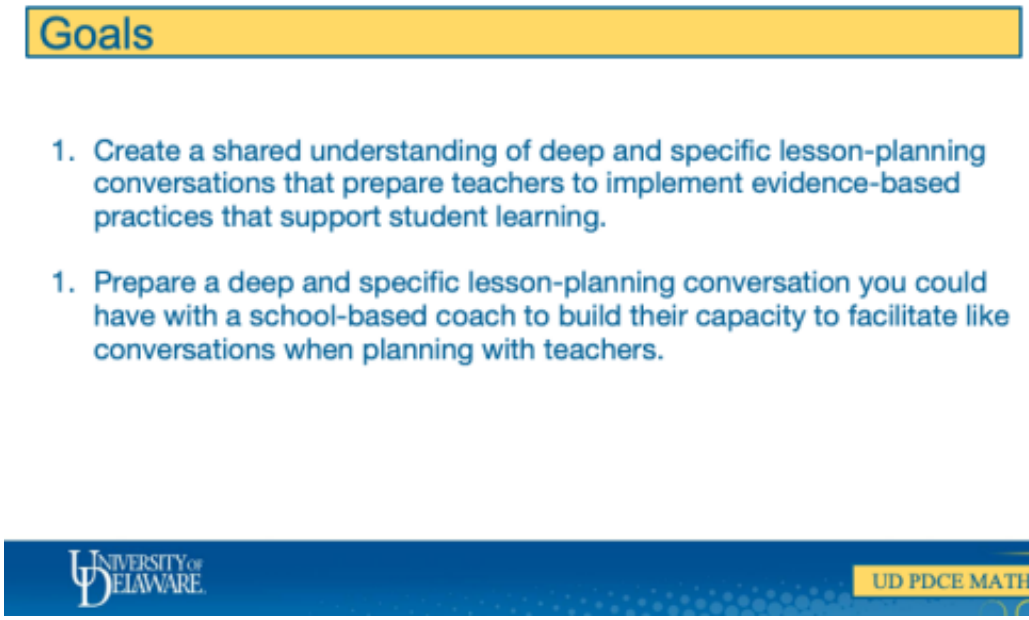
Adapted from NCSM (2019), NCTM (2014), and PDCE IC Tool

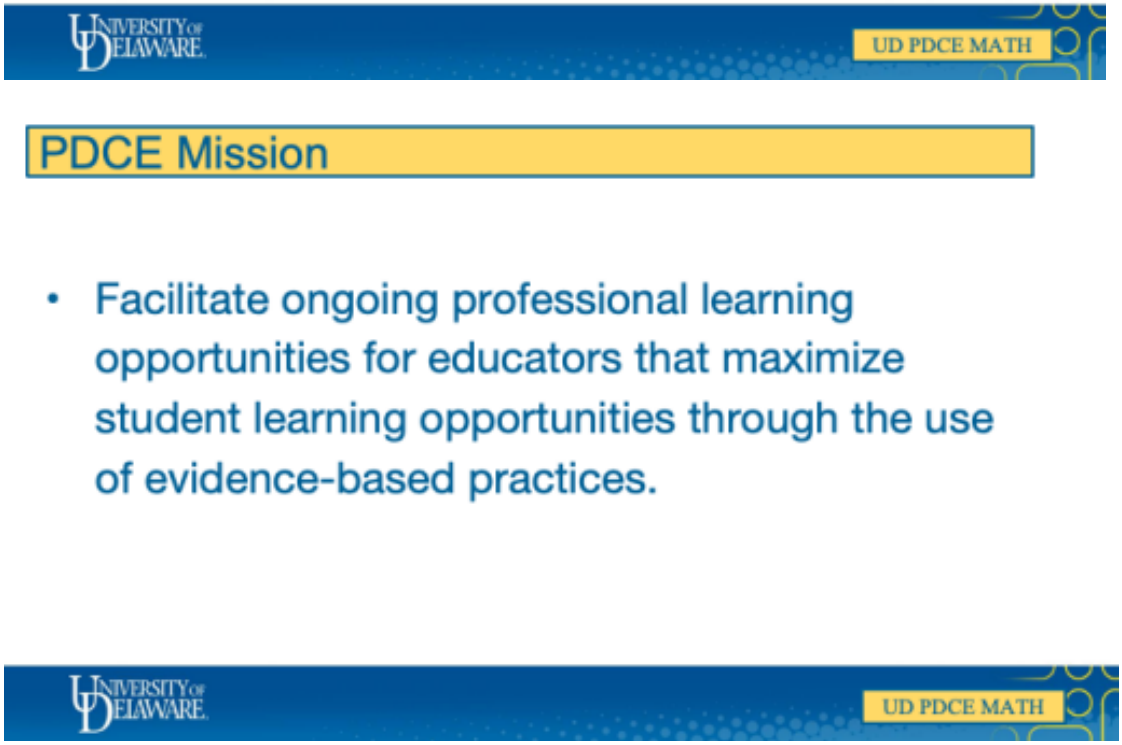
Appendix G

ARTIFACT 7 - COACHING THE COACH PL



The purpose of this PL session is to dive deeply into how we can hold deep conversations with teachers during lesson planning and build the capacity of school-based coaches to so as well. It provides opportunities for participants to read, discuss and synthesize current research on the "how" and "why" of deep and specific lesson planning discussions as a form of PL.



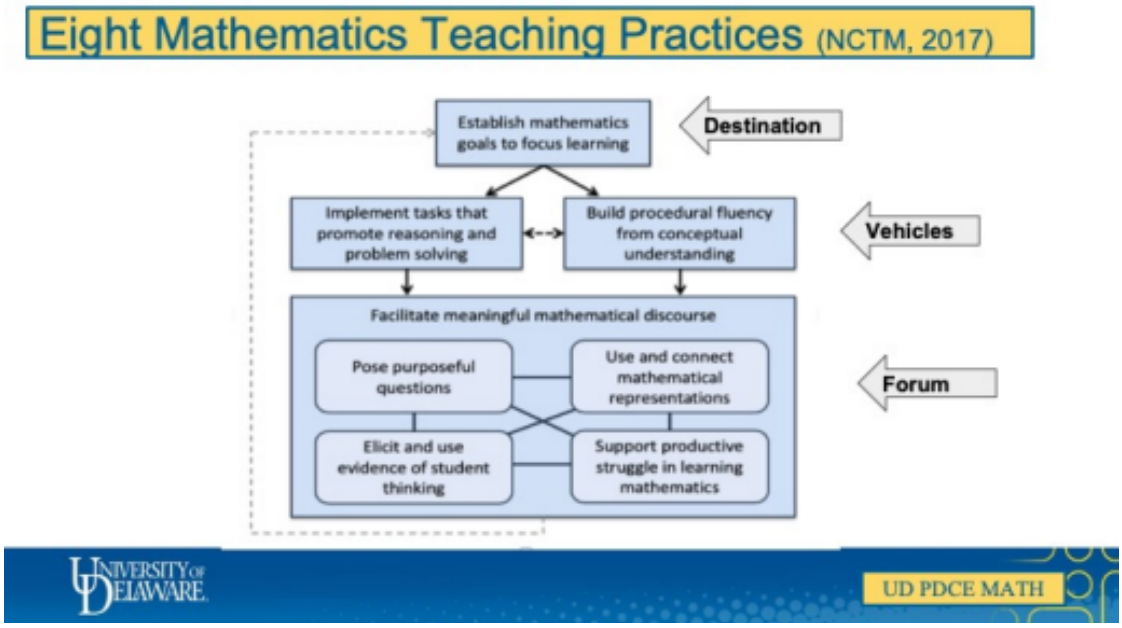


Time: 15 minutes
Facilitator: Begin with PDCE's mission statement to situate the PL in the participants work as they create a shared understanding of deep and specific lesson-planning conversations. It is important to discuss what evidence-based and research-based practices are to prepare participants for their work with research during the PL and beyond. Say: "Take 3 minute to think about this mission statement found on PDCE website. What are the learning opportunities

we want to maximize? What is ongoing professional development for educators and how does it maximize student learning opportunities? What are evidence based/research-based practices and why are they important?"
Give participants 5 minutes to discuss the questions above, followed by 5-minute whole group discussion.

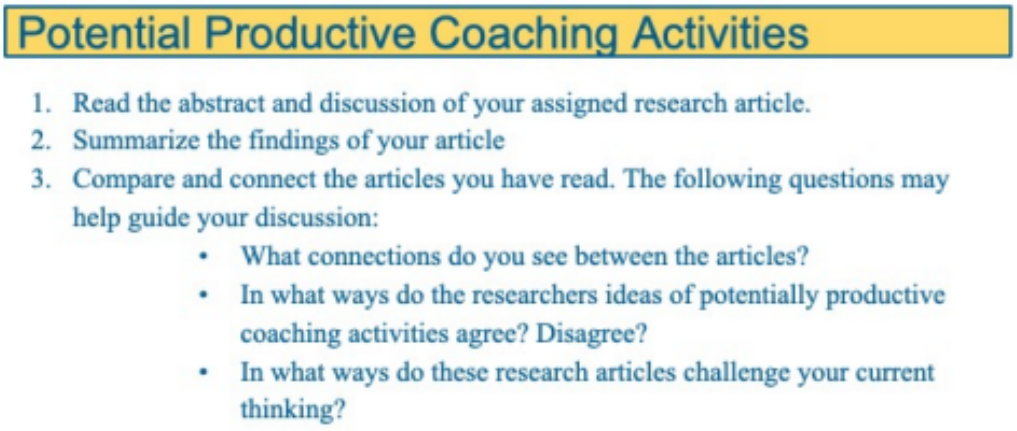
In whole group discussion focus attention on:
● Defining evidence-based and research-based practices and where to find them. research-based supported by research evidence-based as approaches supported by high-quality experimental research, where to find: What Works Clearing House, Shared Drive
● Ongoing PL means the ½ day or full day sessions followed by coaching cycles that embed the learning from these sessions into teachers' daily practice.

Maximizing opportunities for all students to
engage in rigorous mathematical work (Lampert et al., 2013)
make their thinking public (Lampert & Ghousseini, 2012; NCTM, 2010)
Be accountable to learning goals (Kazemi et al., 2009; Windschitl et al., 2012).



Time: 15 minutes (5 minutes individual time, then table discussion.)
The purpose of this slide is to review the characteristics of ambitious mathematics teaching and the 8 teaching practices that support such teaching. This discussion builds understanding of ambitious learning and teaching strategies that support it. IT leads into the next section: Mathematics coaching as a means of professional development, specifically deep and specific planning discussions.

Facilitator notes: Participants read handout (p. 1-4 Smith, M. S., Steele, M. D., & Raith, M. L. (2017). *Taking action: Implementing effective mathematics teaching practices in grades 6-8*. Reston, VA: National Council of teachers of Mathematics.) Then they will discuss how the mathematics teaching practices support teachers to acquire/refine practices that support student learning.
Note: the vignette on pg. 1 in Smith et al. does not include the lesson goals. Point this out and make explicit that establishing the goals is central to 8 teaching practices.



Time: 35 minutes (10 for independent work, 15 for table discussion,10 min whole group)
This activity supports goal 1 by having participants engage with research concerning

Facilitator notes: Briefly discuss how we will read these research articles (abstract and discussion/conclusion only), looking at headings to guide our reading. Note that closer examination of research articles would include a thorough read of the methods section.
1. Assign each person at the table one article to read the abstract and discussion/conclusion of the following:
● Russell, J. L., Correnti, R., Stein, M. K., Thomas, A., Bill, V., & Speranzo, L. (2020). Mathematics coaching for conceptual understanding: Promising evidence regarding the Tennessee math coaching model. *Educational Evaluation and Policy Analysis*, 42(3), 439-466.
● Gibbons, L. K., & Cobb, P. (2017). Focusing on teacher learning opportunities to identify potentially productive coaching activities. *Journal of teacher education*, *68*(4), 411-425.

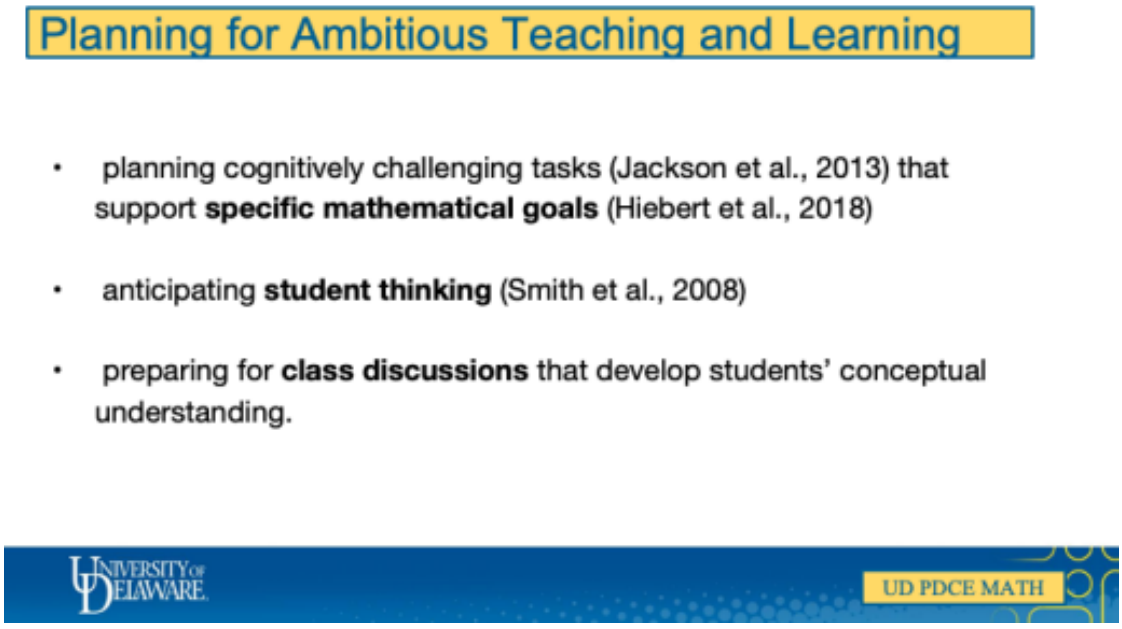
● Witherspoon, E. B., Ferrer, N. B., Correnti, R. R., Stein, M. K., & Schunn, C. D. (2021). Coaching that supports teachers' learning to enact ambitious instruction. *Instructional Science*, *49*(6), 877-898.

While groups are discussing, listen for the following to be shared during whole group discussion:

● Lesson planning (co designing) is suggested as a potential way to support teachers in ambitious teaching (Note: Gibbons & Cobb acknowledge that there is limited research on co-designing deposit the fact that it met their criteria for potentially productive coaching practice)

● Russell discusses the "what" of conversation– math content, pedagogy and student thinking. Witherspoon expands on the "what" and focuses on the "when" and "why" of certain practices.

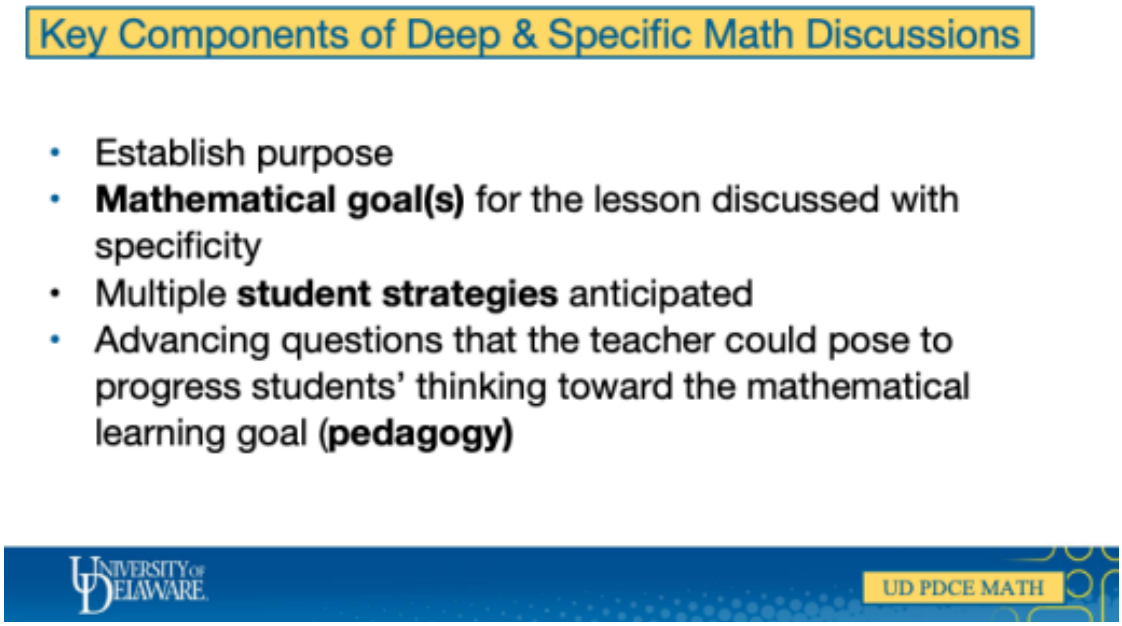
Be sure to create space for participants to express in what ways the research challenges their thinking about coaching, research, theory vs. practice, etc.



5 minutes

The purpose of this slide is to introduce participants to what researchers say about planning for ambitious teaching and learning. It primes the pump for the discussion on deep and specific lesson planning discussion as a potential high-leverage coaching activity.

Facilitator: This is a foreshadowing to the components of planning for deep and specific lesson planning conversations.



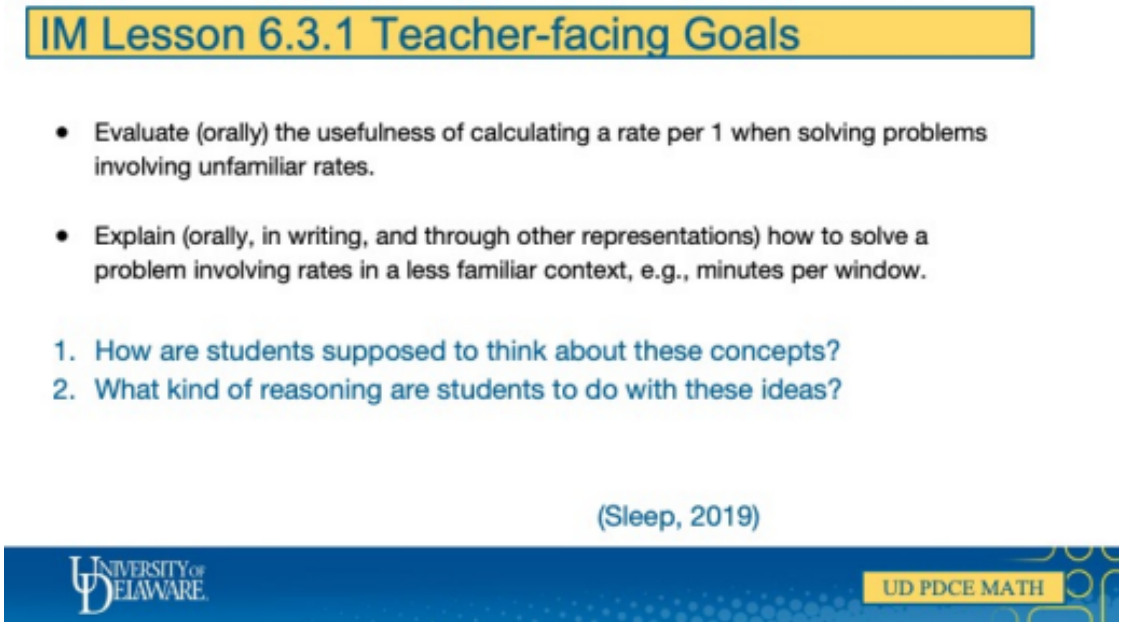
Time: 20 min

Facilitator notes: Have participants list components of deep and specific lesson planning discussion based on the research we have read. This activity further enables participants to create a shared understanding of deep and specific lesson planning conversations. Expect that the components on the slide come out in the discussion. If they do not, ask questions to advance their thinking about components. During the whole group discussion, reveal the components.

Information for facilitator:
Deep and specific lesson-planning conversations between coaches and teachers address mathematical concepts, pedagogy, and student thinking (Kazemi & Franke, 2004; Russell et al., 2020; Stein et al., 2021)

One potential high-leverage coaching practice found in the literature is facilitating deep and specific lesson-planning conversations between coaches and teachers that address mathematical concepts, pedagogy, and student thinking (Kazemi & Franke, 2004; Russell et al., 2020; Stein et al., 2021). During lesson planning conversations, teachers and coaches focus on key mathematical ideas, student thinking about those ideas, and teaching moves that guide student thinking toward conceptual understanding (Coburn & Russell, 2008; Gibbons et al., 2016; Stein et al., 2022). Collaborative detailed lesson planning discussions that focus on mathematical content, student thinking, and teaching practices prepare teachers to identify and build on student thinking during instruction (Kazemi & Franke, 2004; Martin et al., 2018), an integral element of ambitious teaching (Windschitl et al. 2012).

Growth in coaches' capacity to facilitate those discussions predicted teaching improvement, "specifically, increased opportunities for students to engage conceptual thinking." (p. 439, Russell et al., 2020)

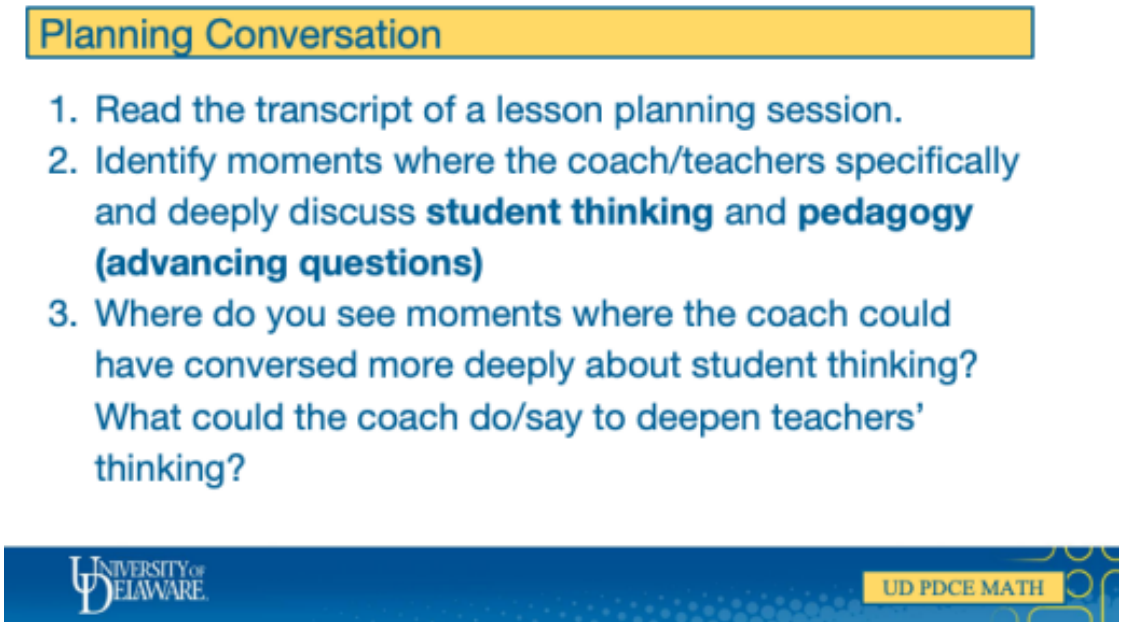


Total Time: 20 minutes

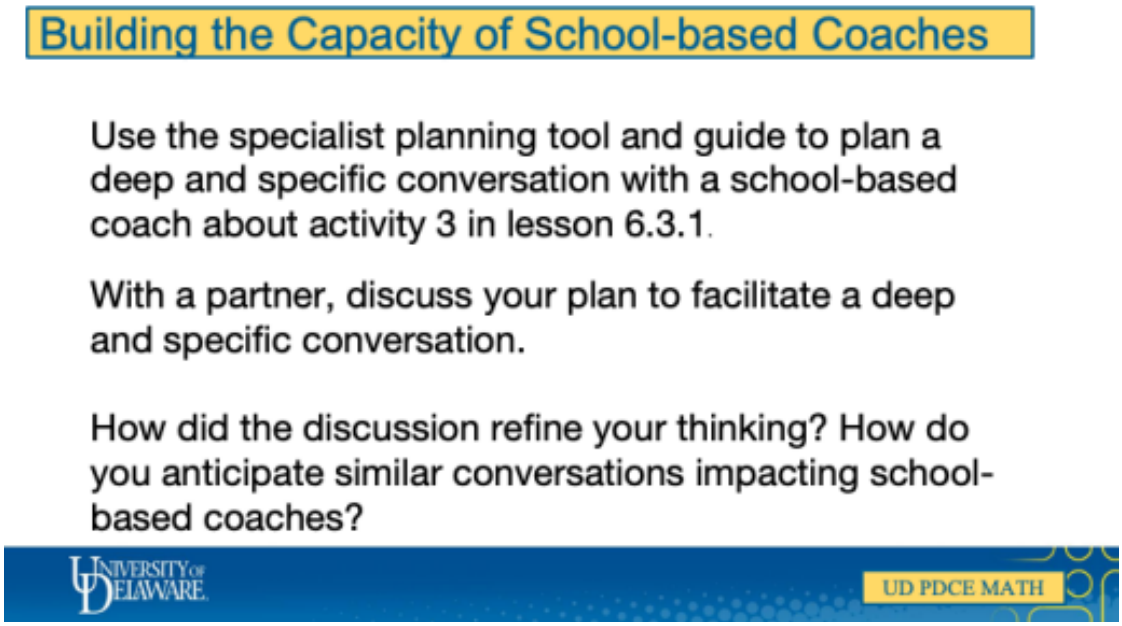
The purpose of this activity is to examine the lesson goals closely to determine how students are to enact with them and the type of reasoning it will require. This activity will allow participants to experience the depth of thinking around lesson goals required to support lesson planning.

Facilitator notes: Have participants read the lesson narrative and goals of 6.3.1 https://im.kendallhunt.com/MS/teachers/1/3/1/preparation.html

Give participants 5 min to read the lesson narrative and goals and think about the questions and 5 minutes of table talk, then a 5-minute whole group conversation Be sure participants discuss how this depth of understanding of the lesson's goals is crucial to lesson planning. Ask: How does this way of thinking about the goals of a lesson support teachers to build lessons that maximize student learning opportunities? You may want to refer back to slide 4 (8 math teaching practices– goals are the destination)



Facilitator notes:
Use fictitious version of a coach/teacher conversation, participants will identify indicators of coach and teachers specifically and deeply discussing student thinking. They will then identify moments where the coach missed opportunities to converse more deeply about student thinking and possible ways the coach could have supported teachers' ability to elicit, build on, and advance student thinking.



Time: 30 min
The purpose of this activity is to provide an opportunity for specialists to interact with the tool, hold a deep and specific conversation, and refine their thinking about the process.

Anticipate some participants to discuss modifications that may have to be made for elementary teachers and high school teachers, particularly those supporting curricula other than IM and focus attention to the depth and specificity of discussions.
Facilitator: Invite participants to use the planning tool and guide to plan for a deep and specific conversation about activity 3 in lesson 6.3.1. (10 min). Then have participants discuss their planning (to mimic holding deep and specific planning discussions) 10 min

Synthesis: Give participants 3 minutes to think/ jot down thoughts about the final questions. Discuss in tables, then in whole group. (10 min)
Specialist planning tool
https://docs.google.com/document/d/1HzPR8lMsBM5ajgCjzH1A4z9idSSMRGOB64K GGc3cn1s/copy

Appendix H

ARTIFACT 8 – AMY BROWN ELP PROPOSAL

Introduction

As an instructional specialist at UD Professional Development Center (PDCE), I work closely with teachers performing curriculum-specific coaching to support ambitious teaching. In the past few years, in addition to coaching teachers, I have also begun to coach and mentor school-based coaches. Although the PDCE has tools, protocols, and supports for coaching teachers, we have not developed tools to specifically support the school-based coaches in their work with teachers. I find coaching school-based coaches requires different skills, norms, and tools. Through this ELP, I will work to design tools to support UD PDCE Instructional Specialists to coach school-based coaches to use one high-leverage coaching practice, namely, engaging teachers in deep discussions of the content.

I situate this case study in my partnership with Seaford Middle School because all educators, including district leaders, the principal, the school-based coach, and math teachers, are motivated to improve teaching and learning. District leaders and Seaford Middle School's principal have allocated resources, including high-quality instructional materials, collaborative grade-level planning time, and opportunities for the school-based coach/principal/district leaders/instructional specialist to collaborate. Additionally, I have a past history of working with Seaford Middle School's school-

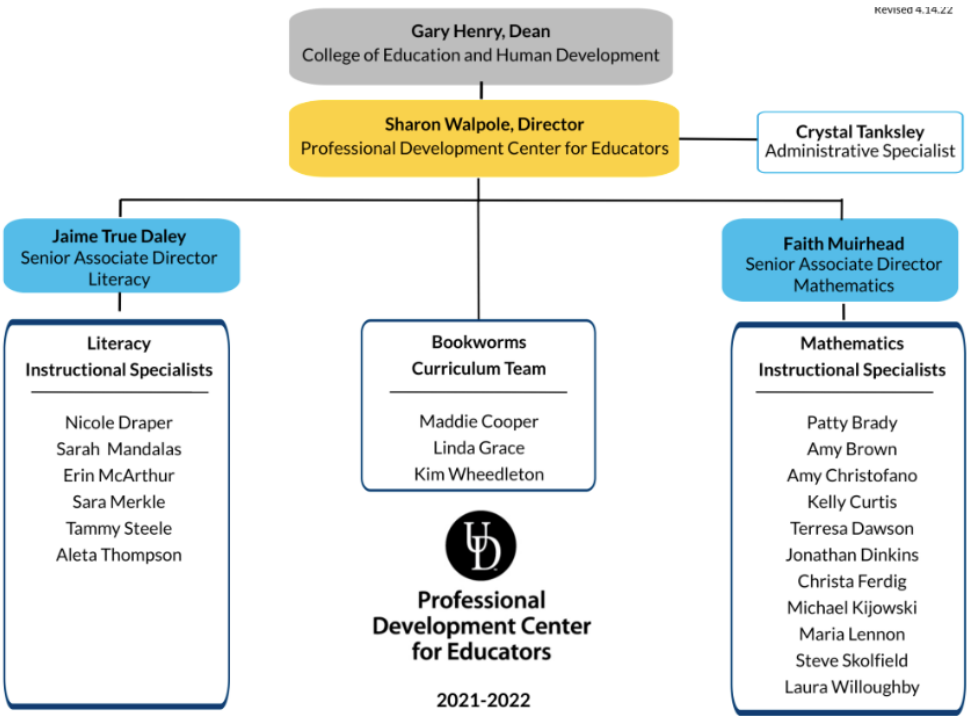
based mathematics coach Ms. Boyce, who is experienced, knowledgeable, and has become a valued thought partner. Her nuanced insights about state, district, and school policies and norms refine my understanding of the Seaford Middle School community in ways not otherwise possible. Next, I will briefly describe the contexts in which I will work in this ELP study. More detailed information about Seaford Middle School can be found in the appendices.

Organizational Context

University of Delaware Professional Development Center of Educators (PDCE)

The University of Delaware's Professional Development Center for Educators (PDCE) is an organization that provides ongoing evidence-based professional learning (PL) in English language arts and mathematics for teachers, coaches, and administrators in K-12 schools. Its mission is to "facilitate ongoing professional learning opportunities for educators that maximize student learning opportunities through the use of evidence-based practices" (PDCE, 2018). The PDCE team collaborates with the leadership of partnering school districts to assess their needs and develop initiatives to meet those needs. PDCE Instructional Specialists then create and facilitate capacity-building professional learning opportunities.

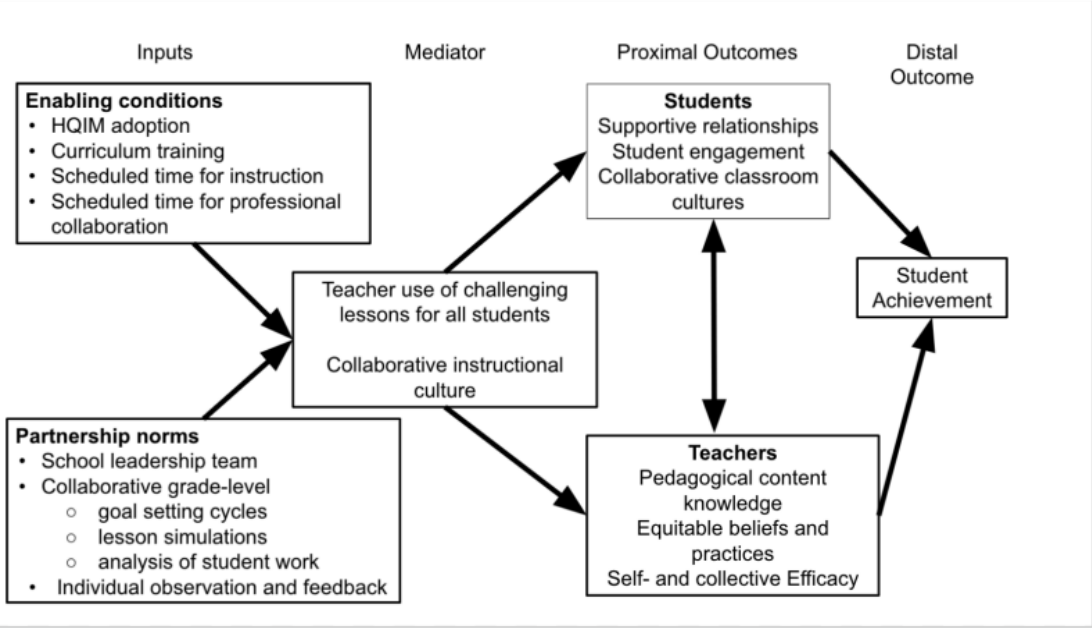
Figure H.1 PDCE Organizational Chart



Note. This chart illustrates the structure of the organization, including its hierarchy of positions and divisions of labor. (University of Delaware, 2021).

As shown in Figure 1, PDCE has a clear hierarchy. It is part of the University of Delaware's College of Education and Human Development and is under the direction of Dean Gary Henry. PDCE's leadership team consists of the center's director (strategic apex of the organization), the administrative specialist (support staff), and two senior associate directors who serve as the administrative component of PDCE. The instructional specialists and members of the Bookworms curriculum team are PDCE's operating core. Each role at PDCE is defined, and the professionals who fill the roles have specialized knowledge and skills.

Figure H.2 PDCE Theory of Change



Note: (Walpole, 2021; Walpole, Daley, & Muirhead, in press)

In 2021, the leadership team introduced PDCE's Theory of Change (Figure 2) which outlines how we facilitate system-wide instructional improvement to maximize the learning opportunities for all students. This theory of change stipulates the norms and enabling conditions necessary to support anticipated proximal and distal outcomes. The combination of enabling conditions and partnership norms is designed to result in a collaborative instructional culture that supports teachers' knowledge, beliefs, and practices to engage all students in thinking about and doing mathematics in collaborative classrooms. The ultimate goal of our theory of change is student achievement. PDCE's Theory of Change illustrates our belief that if partnering schools use standards-aligned materials known as high-quality instruction materials (HQIM), schedule time for curriculum training, instruction, and professional

collaboration (enabling conditions), and if we work closely with school leadership teams, collaborate with teachers and school leaders in grade-level goal setting cycles, simulations, and analysis of student work, and conduct individual teachers observations and feedback (partnership norms), then schools will establish a collaborative instructional culture in which teachers use challenging lessons for all students (mediator). We believe these inputs and mediation will result in supportive relationships and increased student engagement in collaborative classroom cultures as well as shifts in teachers' pedagogical content knowledge, equitable beliefs and practices, and self- and collective efficacy (proximal outcomes) and that these changes will result in improved student achievement (distal outcome).

When a school district aims to partner with PDCE, and before a coach ever enters a school, PDCE conducts a Needs Assessment (Appendix A) to determine the extent to which enabling conditions and partnership norms exist. Ideally, this needs assessment is completed through classroom observations and focus groups of teachers and administration and is accompanied by discussions with district and school leadership to specify the partnership's goals. Often, school districts write Re-Imagine grants that include details about their comprehensive plan to support ambitious teaching and learning. PDCE Instructional Specialists and district and school leaders determine which components of the PDCE's Innovation Configuration (IC), a continuum of descriptors of observable behaviors that indicate ambitious teaching practices (Appendix B), we will utilize to focus our work with teachers and collect data on shifts in teaching practices.

Individual mathematics coaching cycles that include lesson planning, observation, and evidence-based feedback are integral to the PDCE's PL model. In each individual coaching cycle, a teacher and instructional specialist refer to a component of the IC to guide their conversation. Teachers and instructional specialists collaboratively use the IC to set goals, plan lessons, reflect on instructional practices, and track progress toward professional goals. During each individual coaching cycle, the teacher and instructional specialist identify where the teacher's current practice falls on the IC component continuum and decide how to move their practice forward. Next, the teacher and instructional specialist plan or talk through an upcoming lesson focusing on the teacher's IC component goal. The instructional specialist supports the teacher in the classroom by modeling, co-teaching, collecting evidence of student learning, and coaching during teaching, using the IC to guide data collection in order to focus closely on the teacher's goal. Finally, the PDCE instructional specialist and teacher reflect on the lesson, discuss feedback, develop next steps, and decide to continue working on the same goal or set a new goal for the next coaching cycle.

As part of its support of the state's most disadvantaged students, Delaware has provided funding to build the capacity of school-based coaches to support teachers' professional development (Office of Governor John Carney, n. d.). With this funding, many school districts have hired school-based mathematics coaches. As a result, PDCE Instructional Specialists have been working with an increasing number of school-based coaches and partnering districts have begun to ask PDCE's instructional

specialists to provide ongoing professional development specifically to increase the capacity of their school-based coaches to support ambitious teaching practices.

PDCE Instructional Specialists partner with school-based coaches in varying ways based on individual strengths and personalities, the schedule and structure of PLCs, and the goals of the contract. My data will show that school-based coaches vary in their length of experience, their depth of knowledge of content and curriculum, and the ways their roles in their schools are operationalized. As a result, we at PDCE see the need to learn more about high-leverage practices that will support school-based coaches' growth and create a consistent approach to working with school-based coaches.

Organizational Role

I joined PDCE as a mathematics instructional specialist in August 2019, after 28 years of teaching mathematics at the elementary, middle, and high school levels in Maryland public and independent schools. Remembering the time, it took me to develop effective teaching practices, I strongly desired to support teachers as they developed theirs. I believed that PDCE was an organization through which I could pursue that dream, and I was delighted to be hired.

Under the supervision of Dr. Faith Muirhead, Senior Associate Director of Mathematics, I began my work at PDCE by participating in professional development to prepare for the responsibilities of an instructional specialist in mathematics. Dr. Muirhead and PDCE's mathematics department members facilitated workshops where I began learning and practicing math content-focused coaching strategies. In addition,

my colleagues and I read seminal research on coaching and discussed and rehearsed coaching strategies at math department meetings. During my first several months at PDCE, I read and annotated every lesson and completed every problem of every unit of Illustrative Mathematics in grades 6-8, the HQIM with which I would be working in my partnerships.

My responsibilities as an instructional specialist include creating and implementing professional learning (PL) programs to enhance the mathematical knowledge and pedagogy of district curriculum supervisors, school leaders, and teachers; coaching teachers to enact HQIM so students develop mathematical understanding and skills prioritized by CCSS-M and participating in the development and implementation of PDCE's policies and initiatives which enable us to meet these objectives. In addition, I actively engage in PDCE's ongoing professional development of evidence-based coaching practices, including content-specific and coaching for equity practices.

As a PDCE instructional specialist, I collaborate with PDCE colleagues and district/ school leaders to design and implement evidence-based PL sessions that support each district's goals for improving student achievement. PL sessions strategically focus on improving participants' mathematical knowledge for teaching (MKT) and effective teaching practices to ensure that every student has access to high-quality mathematics instruction. In subsequent professional learning communities (PLCs), teachers and I collaboratively extend the work of the PL sessions through rehearsals of evidence-based practices, reflections on current practices, review of

student data, and goal setting for next steps. Additionally, within a coaching cycle of planning, observation, and debriefing, individual teachers and I decide which teaching practice on which to focus (i.e., facilitating student mathematical discussion) and collaboratively plan a goal-focused, student-centered lesson by discussing the lesson goals, solving the math tasks in multiple ways, anticipating student thinking, and understanding how the tasks support the goals. Through this process, the teacher now has a vision of what a student-centered, problem-based lesson could look like in their classroom. Together we decide the role I will play in the classroom (modeling, co-teaching, real-time coaching, etc.) and the data I will collect that will inform our next steps. After each lesson, we reflect on the lesson using the IC tool and student formative and summative data to develop next steps.

Background and History of Work with Seaford Middle School

While under the supervision and leadership of the Delaware Department of Education, each Delaware school district has its own organizational structure, as does each school within each district. This study is situated in one middle school in a Delaware public district, Seaford School District. In the 2021-2022 school year, Seaford School District served approximately 3300 students (Delaware Report Card, 2021) and ranked in the top 20% of Delaware school districts for the diversity of student population (Public School Review, 2022). Of the approximately 830 students who attended Seaford Middle in the 2021-2022 school year, 36% identified as African American, 30% as White, and 24% as Hispanic or Latino. Additionally, 40% of the

students are identified as low-income, 17% of the students are identified as students with disabilities, and 16% of Seaford Middle School students are identified as English learners (Delaware Report Card, 2021).

As seen in Table H.1, in 2018, 74% of Seaford Middle School students scored below or well below the math proficiency level on the Smarter Balanced Assessment Consortium (SBAC) test, and in 2019, 73% of Seaford Middle School students scored below or well below the math proficiency level on the SBAC (Delaware Report Card, 2021). In 2021, the next SBAC scores available due to the worldwide Covid-19 pandemic, 87% of Seaford Middle School students scored below or well below the math proficiency level (Delaware Report Card, 2021). In each of those years, a greater percentage of Seaford Middle School students scored below or well below in math proficiency compared to both Seaford District and Delaware State statistics.

Table H.1 Seaford Middle School Math Proficiency

Year	Well Below	Below	Meets	Exceeds
2018	47	27	17	9
2019	43	30	16	11
2021	58	29	9	3

Note: Delaware Report Card, n.d.) This table shows the percentage of Seaford Middle School students whose scores were well below, below, met, or exceeded the proficiency level in the given years.

In 2018, Seaford School District adopted Illustrative Mathematics (IM), a Common Core-aligned, problem-based math curriculum that incorporates ambitious teaching practices, for Seaford Middle School, the district's only middle school. IM curriculum materials are designed, so all students have opportunities to build conceptual understanding and procedural fluency by grappling with and working through sequenced mathematics problems both individually and in small groups and engaging in teacher-guided discussions that capitalize on students' thinking.

The IM teacher's edition contains educative elements that support ambitious teaching and learning practices, including embedded supports for English language learners and students with disabilities. These supports reflect IM's key design principles (a) access for all students, (b) presume student competence, and (c) build on students' strengths (Open Up Resources, 2017). Teachers facilitate student learning using instructional and language routines embedded in the IM curriculum. These routines provide structures for students and teachers as they encounter both mathematical concepts and student thinking. For example, IM has a version of "Five Practices to Orchestrate Productive Mathematical Discussions" (Smith & Stein, 2011) called "Anticipate, Monitor, Select, Sequence, and Connect." In IM's problem-based lessons, these routine structures activities so "they more reliably result in students making connections and learning new mathematics" (Kendall Hunt, 2019). The IM curriculum also includes Math Language Routines (MLRs) adapted with permission from work done by Understanding Language at Stanford University (Zwiers et al., 2017). IM's math language routines support all students, especially English language

learners, to develop mathematical language skills by providing structures that support sense-making, optimize verbal, written, and visual communication about mathematics, and strengthen students' meta-awareness (Zwiers et al., 2017). For example, through the MLR Clarify, Critique, and Connect, students analyze and refine others' mathematical writing. This MLR helps students think about their own and others' mathematical ideas and clearly communicate their thoughts to peers. While much of the work that enables teachers to anticipate, sequence, and connect student thinking and attend to and support students' developing mathematical language skills is handled in the IM teacher's edition, teachers need opportunities to examine, understand, and practice effective facilitation of MLRs and the five practices.

Seaford District leaders adopted IM for Seaford Middle School in 2018 and partnered with the Southern Regional Education Board (SREB) for the 2018-2019 school year to support the teachers, coach, and administrators in unpacking the IM units. SREB provided PL for Seaford and Caesar Rodney school districts in tandem, beginning with several days of PL in the summer and continuing with PL about once a quarter throughout the school year. After each PL session, the SREB coach spent a few days at Seaford Middle School to discuss lessons with teachers, observed their teaching, and provided feedback. The SREB coach collaborated with Ms. Boyce, the school-based coach, to plan PL that centered on lesson planning around the Five Practices that was then facilitated by the SREB coach. It is important to note that three of the five current math teachers and two of the six current special education teachers were working at Seaford Middle during the 2018-2019 school year, meaning that 40%

of the current math teachers and 67% of the current special education teachers have been teaching the IM curriculum without the initial training SREB provided.

In addition to their work with the SREB coach, during the 2018-2019 school year, Seaford Middle School teachers voluntarily met with Ms. Boyce weekly to talk about upcoming lessons. The students did not have IM workbooks, so teachers created student-facing documents and slides for each lesson. This process reduced the time that teachers spent doing the mathematics and anticipating student thinking during planning. In an informal interview, Ms. Boyce shared that they did not have deep mathematical discussions or do much of the math together during the first year of implementation as they focused on their immediate daily implementation needs. She spent a good deal of time supporting teachers by creating materials such as card sorts, handouts, and lesson slides. In the classroom, teachers primarily used direct instruction practices when implementing IM.

In an attempt to shift practices to meet CCSS-M standards Seaford District adopted high-quality instructional materials (HQIM) and provided implementation training to support teachers in the use of these materials. Despite the adoption of HQIM and initial training, teachers at Seaford Middle continued to use traditional teaching practices rather than ambitious teaching practices. During the 2019-2020 school year, Ms. Boyce continued to support teachers as they implemented the IM curriculum. The teachers and Ms. Boyce created a pacing calendar for each grade level, including assessment, review, and reteaching days and multiple days for various state and district assessments. They adapted the curriculum to fit into the remaining

school days by combining and sometimes eliminating lessons. The teachers and school-based coach continued to meet weekly to discuss upcoming lessons, pacing, and student data. Teachers were beginning to include IM's instructional practices into their teaching but often returned to direct instruction. Around Thanksgiving, one of Seaford Middle School's administrators left, and the principal asked Ms. Boyce to take up administrative duties in addition to her usual workload of coaching math teachers, collecting and organizing student assessment data, and assisting teachers in all subject areas to analyze student data to inform instruction. These additional responsibilities reduced the time available for Ms. Boyce to plan with, observe, and provide feedback to teachers.

In March 2020, the worldwide Covid-19 pandemic completely changed everything for everyone. In an effort to provide instruction to students in their homes, Seaford Middle School's principal relied heavily on Ms. Boyce and two teachers to create, structure, and monitor the use of the Schoology platform. During this time and into the next school year, the ways in which students and teachers experienced math content profoundly changed. Lesson planning sessions were focused on how to push content out to students synchronously, asynchronously, and in hybrid formats. Teachers and students grappled with communicating with each other within these formats. Class time was limited, and grading policies changed so that no student would be penalized for not completing work. Student assignment completion and class participation waned. With everyone in survival mode, lesson planning and classroom

mathematical conversations were not as deep as Ms. Boyce envisioned they needed to be.

I chose to situate my study at Seaford Middle School for two reasons. First, Seaford School District is motivated to improve teaching and learning at Seaford Middle. The district and school administration have allocated resources, including materials, collaborative grade level planning time, and time for the school-based coach/ administration/ district leader and me to collaborate. Secondly, Ms. Boyce is an experienced and knowledgeable school-based coach who has become a valued thought partner. Her insights about state, district, and school policies and norms refine my understanding of the Seaford Middle School community in ways not otherwise possible.

In the summer of 2021, Seaford School District asked PDCE to partner with Seaford Middle School's school-based coach, principal, and math teachers. Because Seaford School District sought the partnership during the summer, PDCE was unable to collect observational data on teacher practices; however, Dr. Muirhead completed the Needs Assessment based on the reflections and assessments of focus groups of teachers, the school-based coach, and administrators concerning their instructional needs. As the instructional specialist assigned to Seaford Middle school, my task based on the Needs Assessment and Seaford's Reimagine Grant was to assist teachers as they worked to implement ambitious teaching practices that would positively impact student achievement and build the capacity of the school-based coach and principal to support teachers in this endeavor.

I began working with Seaford Middle School in August 2021, more than a year into the pandemic. The administrators, school-based coach, and teachers were preparing for in-person-only instruction. Mask mandates and social distancing protocols were in place. Many students had not been in a school building for over a year and needed support to take up the norms and routines of school. I was equipped with information provided by Seaford School District and planned the initial PL accordingly. Two PDCE Instructional Specialists and I facilitated our initial two-day PL, which focused on re-engaging students with mathematical concepts using IM's cool-down guidance and mathematical language routines (MLR).

While facilitating the first PL session, my colleagues and I collected evidence that indicated that teachers were unfamiliar with MLRs used in the IM curriculum and that the administration and teachers embraced direct reteaching practices instead of re-engagement practices. During the next day's PL session, we discovered that when planning lessons, teachers focused on the tasks of the lessons instead of the goals and sometimes made adaptations to lesson tasks that changed the lesson goals, or the way students encountered mathematical concepts without realizing that is what they had done. My colleagues and I realized that in order for teachers to implement problem-based and student-centered instruction, they needed assistance in planning lessons focusing on the lesson goals and student thinking. I knew I needed to observe classroom instruction to gather more information, so Ms. Boyce and I scheduled classroom visits.

In classrooms, Ms. Boyce and I observed teachers implementing IM lessons using traditional instruction, with many teachers using an 'I do, we do, you do approach. Often, students were disengaged and reluctant to contribute to discussions; some did not even attempt to complete the handouts. Teachers asked students to share their answers and sometimes how they got an answer but were frustrated that students did not participate more. Some teachers thought students lacked the prerequisite skills to do grade-level mathematics work and several thought their students could not do the mathematics in the curriculum due to learning or language differences.

As a result of our observations and reflective discussion, Ms. Boyce and I began designing PLs and PLCs that focused on unpacking the mathematical goals of lessons and how and why teachers plan and implement lesson tasks to support these goals. In PL, we included time for teachers to do math tasks in multiple ways and share their approaches to anticipate possible student solution paths or misconceptions. Teachers also had opportunities to engage in instructional routines that increased student engagement, such as launching tasks to provide entry points for every learner and using MLRs to support student discourse.

In subsequent lesson planning sessions, teachers would often begin by talking about the math tasks. I would redirect and facilitate discussion of the lesson goals and standards addressed. Then everyone worked on the math tasks, looking for and sharing multiple solution paths in an effort to anticipate student thinking. When anyone held misconceptions about mathematical concepts, we examined them together. I talked about how each task of the lesson worked in tandem to support the lesson goals as

well as student thinking, and we looked for ways to incorporate instructional routines into the lessons. Some teachers expressed frustration at the amount of time these discussions took and felt it left too little time to plan the lesson slides/handouts.

Based on Seaford Middle School's Re-Imagine Grant goals, the Needs Assessment, and classroom observations, the school-based coach, principal, and I decided to focus on two IC categories, *Teacher Encourages Meaningful Contributions* (Table H.2) and *Teacher Uses Student Contributions to Advance Lessons* (Table H.3) for our coaching cycles These IC categories helped us operationalize our PL and PLC work on planning and implementing goal-centered, problem-based lessons that foregrounded student thinking. We began with *Teacher Encourages Meaning Contributions* because student participation was very low, and teachers seemed unsure how to increase it. During lesson planning sessions, we discussed how instructional routines such as notice and wonder, think-pair-share, and discussion supports invite and support student engagement with each other and the mathematics. Ms. Boyce and I felt that when teachers experienced how instructional routines increased student engagement, they would be motivated to shift practices to be more student-centered. Late in the fall, we added the IC category *Teacher Uses Student Contributions to Advance Lesson* because while we wanted to maintain attention on student engagement and support teachers as they used students' responses to advance their understanding of mathematical concepts within the lessons, we wanted teachers to begin to see that *what* the students discussed (i.e., the math concepts and how they undergird the algorithms),

Table H.2 IC Tool: Teacher Encourages Meaningful Student Contributions

Teacher Encourages Meaningful Student Contributions				
Note: 5 Practice thinking should be embedded in all tasks and activities.				
Exploration	**Preparation**	**Adoption**	**Implementation**	**Sustainment**
The teacher prompts students for one-word or short answers.	The teacher provides opportunities for students to share answers and to share the steps in their solution path but not necessarily their thinking. The teacher also provides opportunities for students to ask questions about how to solve a problem or carry out a procedure.		The teacher provides opportunities for students to share substantive contributions. The teacher is satisfied with short answers as long as the students attempt to reveal their thinking.	The teacher provides opportunities for all students to share substantive contributions. The teacher is not satisfied with short or one word answers and presses students for more detail and their reasoning. Students may provide detail and reasoning without prompting from the teacher.

Note: PDCE, 2021

Table H.3 IC Tool: Teacher Uses Student Contributions to Advance Lesson

Teacher Uses Student Contributions to Advance Lesson				
Exploration	**Preparation**	**Adoption**	**Implementation**	**Sustainment**
The teacher evaluates students' one word or short answers as correct or incorrect and then moves on to the next prompt. This results in the discourse being mostly teacher talk, directed by teacher ideas. Students may contribute more (e.g. asking a clarifying question) but the teacher ignores or only briefly addresses these contributions. The teacher does not explicitly highlight which key mathematical ideas, concepts and connections are important to attend to in the lesson.	The teacher evaluates students' procedural explanations (e.g., "first I did this, second I did that, ...") as correct or incorrect and then moves on to the next prompt. The discourse is mostly teacher talk, directed by teacher ideas. The teacher highlights which key mathematical ideas, concepts, and connections in the lesson are important.	The teacher collects student ideas or solution strategies and may display them to the class. However, the teacher does not build off these ideas directly unless a student asks a direct question. The discourse is mostly teacher talk but may be guided by some of the student ideas. The teacher highlights which key mathematical ideas, concepts, and connections in the lesson are important.	The teacher builds the mathematics of the lesson off of student substantive contributions by commenting on student ideas (highlighting key ideas or features), pressing for clarification, inviting students to make connections between their ideas or other topics, or inviting students to ask questions. The teacher allows students to answer each other's questions. However, the lesson continues without strong use of student ideas and shares only correct student contributions. The teacher (through the students' contributions) highlights which key mathematical ideas, concepts, and connections in the lesson are important.	The teacher consistently builds the mathematics off of student substantive contributions. The teacher may comment on student ideas (highlighting key ideas or features), press for clarification, encourage students to make connections between their ideas or other topics, or invite students to ask questions. The teacher encourages students to answer each other's questions. The teacher is also intentional about sequencing student ideas to share with the class to highlight key ideas, not shying away from incorrect responses.The discussion (led by student ideas) extends or solidifies the key mathematical ideas, concepts, and connections in the lesson.

Note: PDCE, 2021

not just discussion in general, was of great importance. One way we enabled teachers to elicit and use student contributions was to help them redefine their role during individual and small group work time. Rather than positioning themselves as giving individual students help to get an answer, we wanted them to see their role as collecting data about students' level of understanding to use during class discussion. Ms. Boyce and I realized how important it is for teachers to understand the lesson goals and do the math tasks in multiple ways so they could recognize what students' work tells them about their levels of understanding.

After each observation, Ms. Boyce and I discussed the data we collected. Over the course of several months, we found that teachers tried using moves they encountered in PL/ PLCs in their classrooms and many incorporated moves such as task launches consistently. Data showed that while some teachers' instruction remained teacher-centered, others attempted to improve student engagement by using routines such as turn and talk. However, classroom discussions remained focused on answer-getting rather than concept-building. Additionally, during debriefing sessions, several teachers repeatedly shared that they felt they did not have enough time for student inquiry and that the real problem was that students had too many holes in their mathematics education due to the pandemic. Some shared their belief that their students with learning disabilities or those learning English were not capable of being successful with the IM curriculum. Instead, these teachers thought students needed to be directly taught specific skills followed by practice worksheets.

Changing educators' beliefs, mathematical knowledge for teaching, and teaching practices takes focused work over a lengthy period of time (West & Staub, 2003). It requires investment, collaboration, and commitment from the district leaders, teachers, school-based coaches, administrators, and PDCE staff. My vision of lesson planning (goal-centered planning in which teachers do math tasks in multiple ways to be able to identify, build on, and extend students' conceptual understanding of the lesson's goals) did not become a norm that all teachers embraced during the 2021-2022 school year and teaching strategies did not shift as much as I had hoped. I realized I needed to examine my practice to find coaching protocols/ tools that would shake up the status quo and effectively support ambitious teaching and learning practices. The teachers, school-based coaches, and students deserve it.

Problem Statement

The wide adoption of Common Core State Standards-Mathematics (CCSS-M) calls for a change in mathematics teaching from traditional teacher-centered, algorithmic-based practices (i.e., direct instruction, think: "I do-We do-You do") to teaching that is responsive to student ideas and concept-building, referred to in the literature as ambitious teaching. Ambitious teaching strategies such as facilitating mathematical discussions that build on and extend student thinking require teachers to possess mathematical knowledge beyond rules and algorithms to engage every student in rigorous work and in-depth discussion that develops their understanding of both the what and the why of mathematics consistently (Lampert & Ghousseini, 2012). Shifting to ambitious teaching practices includes planning cognitively challenging tasks

(Jackson et al., 2013) that support specific mathematical goals (Hiebert et al., 2018), anticipating student thinking (Smith et al., 2008), effectively selecting and using mathematical representations (Mitchell et al., 2014), and facilitating class discussions in ways that enable students to develop a conceptual understanding of the mathematics as they engage with each other's strategies and thinking (Webb et al., 2017). Additionally, teachers engaging in ambitious teaching practices must treat students as sense makers and maximize opportunities for all students to engage in rigorous mathematical work (Lampert et al., 2013) by purposefully noticing, building on, and extending students' thinking (Jacobs, et al., 2010). Responsive, ambitious teaching emphasizes students' mathematical thinking and "autonomy in choosing solution methods" (Rubel, 2017, p. 70).

While literature suggests that ambitious teaching practices enhance students' conceptual understanding of mathematics, it is challenging for districts to shift teachers' current practices (Russell et al., 2020). In an attempt to shift practices to meet CCSS-M standards, many school districts, including Seaford, adopted high-quality instructional materials (HQIM) and provided implementation training to support teachers in the use of these materials. Despite the adoption of HQIM and initial training, many teachers continued using traditional teaching practices. Subsequently, districts realized that while HQIM and implementation training support ambitious teaching, these resources alone are insufficient. Districts hired school-based mathematics coaches (often former mathematics teachers) and outside organizations

such as the PDCE to provide ongoing, job-embedded professional learning opportunities for mathematics teachers.

PDCE's theory of change (Figure 2) describes our comprehensive plan to operationalize our approach to a system-wide transformation of K-12 teaching. This theory of change is designed to guide how PDCE Instructional Specialists work with mathematics *teachers* and includes protocols for *teacher*/math specialist coaching cycles, collaborative planning, data collection, and student data analysis. These protocols were not designed to develop the skills and knowledge necessary for the growth of *school-based coaches*.

Some researchers have suggested that well-designed coaching programs positively impact teaching practices and student achievement (Kraft et al., 2018; Campbell & Malkus, 2011) and suggest that mathematics coaches need training in mathematics content and pedagogy to shift teaching practices. As school districts turn to PDCE to build the capacity of their school-based coaches to support ambitious teaching practices, we need to expand our theory to include protocols/tools explicitly designed to deepen school-based coaches' knowledge of and ability to implement coaching practices that enable teachers to shift their practice. However, few studies have examined which coaching practices have the greatest impact on shifting teaching practices from more traditional to more ambitious teaching practices and how mathematics coaches learn to enact them (Russell et al., 2020).

Improvement Goal

PDCE is in the process of expanding our theory of change to address working with school-based coaches specifically. In order to support school-based coaches' growth and strengthen our model, we can begin by identifying high-leverage coaching practices that may significantly impact teaching practices. One such high-leverage coaching practice is facilitating deep and specific lesson-planning conversations between coaches and teachers that address mathematical concepts, pedagogy, and student thinking (Kazemi & Franke, 2004; Russell et al., 2020; Stein et al., 2022). Collaborative detailed lesson planning discussions focusing on mathematical content and student thinking prepare teachers to identify and build on student thinking during instruction (Kazemi & Franke, 2004; Martin et al., 2018), an integral element of ambitious teaching. Coburn and Russell (2008) found that the depth of conversations between coaches and teachers about teaching and learning varied. I have gathered anecdotal evidence that suggests that coach/teacher conversations vary in depth among PDCE instructional specialists. By designing protocols/tools for PDCE Specialists to support school-based coaches' uptake of deep and specific mathematical discussions, PDCE will be able to implement this potential high-leverage coaching practice more consistently.

Researchers posit that professional learning experiences are impactful when situated in the daily work of educators (Martin et al., 2018; Stein et al., 2022). In this study, I will engage Seaford Middle School's coach Amber Boyce in deep, specific mathematics discussions about mathematics concepts, pedagogy, and student thinking of an upcoming lesson that school-based coaches will plan with teachers. I will use a

novel coach planning tool to structure these conversations around the MKT teachers need to successfully implement the lesson and specific coaching strategies that engage teachers in a deep and specific discussion about the mathematical concepts of the lesson. My theory of change is that by engaging school-based coaches in conversations that focus on supporting teachers' MKT, school-based coaches will be prepared to facilitate deep mathematical discussions with mathematics teachers as they co-plan lessons that are responsive to and build upon students' thinking. Deep, specific mathematical discussions between coaches and teachers during planning guide teachers to foreground student thinking about the mathematical concepts addressed in the lesson. When coaches push teachers to articulate the goals of the lessons clearly, they support teachers' understanding of how tasks support students' understanding of the mathematical goals (Stein et al., 2022). Therefore, planning sessions should include in-depth discussions about the mathematical goals of the lesson, time to do each task in multiple ways, and discussion about the constraints and affordances of each solution pathway in an effort to prepare teachers to notice and interpret student thinking (Stein et al., 2022). This type of planning discussion primes teachers to respond, monitor, select, and sequence student solution paths to build on and extend student thinking during instruction (Hiebert et al., 2018).

Evidence suggests that improvements in the depth and specificity of coach-teacher conversations are associated with changes in teaching practices (Russell et al., 2018). My vision of lesson planning (goal-centered planning in which teachers do math tasks in multiple ways to be able to identify, build on, and extend students'

conceptual understanding of the lesson's goals) did not become a norm at Seaford Middle School, nor did teaching strategies shift as much as I had hoped. Unfortunately, this experience was not unique. Therefore, I want to expand PDCE's Theory of Change to include protocols/tools designed to support school-based coaches' uptake of the potential high-leverage coaching practice facilitating deep and specific pre-lesson mathematical discussions with teachers.

Improvement Strategies

To accomplish this, I plan to pursue the following improvement strategies.

- Improvement Strategy 1: Using the high-leverage coaching practice for deep mathematical discussions, create a theory of change, and protocols/ tools to assist PDCE Instructional Specialists in building the capacity of school-based coaches to support teachers to facilitate rich student discourse that is responsive to student ideas.
    - I will continue to research the high-leverage coaching practice of facilitating deep and specific mathematical discussion and the role it plays in lesson planning and implementation.
    - I will reach out to researchers such as the University of Pittsburgh/ Institute for Learning research group (i.e., Russell et al., 2020) to learn more about their model for math coaching to improve coaches' capacity for facilitating and reflecting on deep and specific pre-lesson planning conversations. Based on this research and collaboration, I will

create the following tools for both PDCE instructional Specialists and School-based coaches:

  - Planning template--to plan discussions
  - Discussion guide--to guide conversations
  - Data collection tool--to collect impact data
  - Reflection tool--to reflect on work

- Improvement Strategy 2: Pilot the tools to determine ease of use, accessibility, and professional learning needs for the school-based coach at Seaford Middle School.
  - I will collect data by audio-taping my coaching discussions with Ms. Boyce, maintaining copies of the artifacts created during planning discussions, and interviewing Ms. Boyce about her impressions of the usefulness and impact of the tools.
- Improvement Strategy 3: Study the impact of the use of the tools/protocols on Seaford MS building coach practice in planning sessions with teachers.
  - I will transcribe, read, and analyze the recorded conversations between the school-based coach and myself and between the school-based coach and math teachers using coding informed by coaching and teaching measures created by Russel et al. (2020).
  - These analyses will focus on indicators of deep disciplinary discussions, including discussion of student thinking (multiple solution paths) and discussions of math content.

- I will train my advisor in my coding scheme and ask her to code sections of the transcripts to increase reliability.

Proposed Artifacts

Artifact 1: PDCE Policy & Practice Change Map to describe how I will instigate the policy and practice changes into PDCE. This will include a policy practice timeline (historical and forward-looking), name the supports using systems-level policy thinking and incorporate the finding of the study.

Artifact 2: Literature Review on Ambitious Teaching and High-leverage Coaching Practices to situate my work in the current mathematics education research and literature on teacher learning and coaching.

Artifact 3: Suite and Introduction to Tools and Protocols. A practitioner-facing document will clearly describe the tools, guides, and protocols developed as a result of this study. I will use this to introduce district administrators, building administrators, and school-based coaches to our work coaching school-based coaches and reflecting on our practice. There will be eight tools in the suite--four for Instructional Specialists and four for School-based Coaches:

1. A planning template for Instructional Specialists to Plan a discussion to focus on deep mathematical ideas with the school-based coach.
2. A Discussion Guide for PDCE Instructional Specialists to guide the discussion with the school-based coaches.
3. A Data Collection tool to collect data on the impact of the discussions on school-based coaches' practice.

4. A tool to guide a reflection on the impact of the discussions of the Instructional Specialist with the school-based coach.
5. A Planning Template for school-based coaches to plan a discussion to focus on deep mathematical ideas with teachers.
6. A Discussion Guide for school-based coaches to guide the discussion with teachers.
7. A Data Collection tool to collect data on the impact of the school-based coach's discussions on teacher practice.
8. A Reflection tool to reflect on the influence of the discussions of the school-based coach on teacher practice.

Artifact 4: Methodological Memo for detailing my methodological process that includes my data collection, my coding scheme and technique, how I will analyze my data, and how I will synthesize my findings.

Artifact 5: White Paper to disseminate my findings, rationale, and research base of my study regarding supporting teachers to use ambitious teaching practices through deep discussions of mathematics for district/building administrators and building coaches.

Artifact 6: Self-assessment Tool for District Personnel to assess building coaches' capacity. This tool will be used to help the district and school administrators determine whether and how coaching activity has impacted teacher and student learning.

Artifact 7: PL Session, "How Do You Support School-Based Coaches to Hold Deep Mathematical Conversations with Teachers?" for PDCE Instructional Specialists, which will include current research and facilitator notes.

Table H.4 Table of Artifacts

Artifact	Description/audience
Artifact 1: Policy & Practice Change Map	Map of how organizational change happens at PDCE and where my coach-the-coach tools fit into the large arena
Artifact 2: Literature Review	Ambitious teaching and high leverage coaching practices
Artifact 3: Suite & Introduction to Tools and Protocols	Two levels of tools (PDCE Instructional Specialist & School-based coaches): • Planning template--to plan discussions • Discussion guide--to guide conversations • Data collection tool--to collect impact data • Reflection tool--to reflect on work
Artifact 4: Methodological memo	A description of my coding scheme, how I analyzed data, and how I synthesized the results.
Artifact 5: White paper	For the dissemination of my work-- to include findings, rationale, research base
Artifact 6: District Reflection Tool	A tool for district and school admin to assess my building coaches' capacity, and how/whether coaching activity has impacted teacher learning & student learning.
Artifact 7: PL Session	Slide deck with facilitator notes for PDCE Instructional Specialist research and to answer the question: how do you support school-based coaches to have deep, meaningful conversations with teachers

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Enabling Conditions			
HQIM Adoption			
Inadequate	Developing	Good	Full
The school is considering evidence-based practices, but teachers use them in idiosyncratic ways.	The school is constructing its own curriculum and all teachers are using the evidence-based practices it contains.	The school is piloting a set of HQIM but it is not required for all teachers.	All teachers have access to and use a full set of HQIM exclusively.
Curriculum Training			
Inadequate	Developing	Good	Full
The materials were adopted without adequate training.	The school has arranged for initial training but not all teachers were able to participate.	The school has arranged for initial training and induction training for new teachers.	The school has arranged for initial training, induction training of new teachers, and advanced training for experienced teachers.
Scheduled Time for Instruction			
Inadequate	Developing	Good	Full
Teachers make their own schedules and pace the curriculum independently.	The school has either a clear daily schedule and a pacing guide consistent with the demands of the HQIM, but not both.	The school has a clear daily schedule and a pacing guide consistent with the demands of the HQIM.	The school has a clear daily schedule and a pacing guide consistent with the demands of the HQIM. There is a plan for intervention and support for students who need it.
Scheduled Time for Professional Collaboration			
Inadequate	Developing	Good	Full
Teachers may collaborate during planning periods, but it is not required.	Teachers must collaborate during one planning period each week for a variety of reasons.	Teachers must collaborate during two planning periods each week for a variety of reasons.	Teachers must collaborate for at least one 90-minute block for the sole purpose of improving implementation of HQIM.
Partnership Norms			
School Leadership Team			
Inadequate	Developing	Good	Full
PDCE coaches set school implementation goals as needed.	PDCE coaches set school implementation goals with administrators based on previous experience with implementation and review of achievement data.	PDCE coaches set school implementation goals with administrators and grade-level team leaders based on previous experience with implementation and review of achievement data.	PDCE coaches set school implementation goals with district representatives, building administrators and grade-level team leaders based on previous experience with implementation and review of achievement data.

Collaborative Grade-Level Goal Setting			
Inadequate	Developing	Good	Full
PDCE coaches or administrators communicate school implementation goals to teachers.	PDCE coaches and administrators pursue school implementation goals independently with each teacher.	PDCE coaches and administrators set short-term implementation goals linked to school goals, and then pursue goals with individual teachers.	PDCE coaches, administrators, and grade level teams set short-term implementation goals linked to school goals, and then pursue goals with individual teachers.
Lesson Simulations			
Inadequate	Developing	Good	Full
PDCE coaches model lessons on an ad hoc basis in individual classrooms.	PDCE coaches model lessons related to grade-level goals in individual classrooms.	PDCE coaches model lessons related to grade-level goals in individual classrooms with all team members watching.	Teachers model lessons related to grade-level goals for one another with PDCE coach support during collaborative planning meetings.
Individual Observation and Feedback Discussions			
Inadequate	Developing	Good	Full
Participation in observation and feedback discussions are voluntary.	Coaches schedule and implement observations with all teachers, but there is no specific time and process for feedback discussions relative to goals.	Coaches schedule and implement individual observation and feedback discussion cycles for all teachers relative to goals, but scheduling permits only one teacher to participate on each coaching day.	Teachers and coaches work together to schedule and implement individual observation and feedback discussion cycles for all teachers relative to goals, using either live observation or video or a combination to maximize the number of cycles completed each quarter.
Analysis of Student Work Samples			
Inadequate	Developing	Good	Full
Student achievement data is not formally used to reflect on implementation.	Student achievement data external to the curriculum is used to reflect on implementation, but not student work inside the curriculum.	Student achievement data internal and external to the curriculum are used to reflect on implementation with individual teachers as requested.	Student achievement data internal and external to the curriculum are used to reflect on implementation in a systematic way with all teachers on the grade-level team.

Note: Walpole, 2021

For the PDCE's Innovation Configuration -- please click on link