6-17-2021

Coaching to develop teacher professional noticing: planning with students and mathematics in mind

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College of Education, Health, and Human Sciences, University of Nebraska at Omaha, Omaha, NE, USA

Abstract

Purpose – This paper examines how intentional mathematics coaching practices can develop teacher professional noticing of "ambitious teaching practices" (NCTM, 2020) through connected, collaborative coaching cycles.

Design/methodology/approach – Narrative analysis is used to examine observations of a mathematics coach and novice teacher to better understand the role of the coach in helping teachers attend to ambitious mathematics teaching (AMT) practices.

Findings – The initial findings of this study suggest that intentional use of focused goals, iterative coaching cycles and a gradual release model of coaching can support shifts in noticing of AMT from being led by the coach to being facilitated by the teacher.

Originality/value – This study offers new insights into the functions of mathematics coaching that can foster shifts in teacher noticing and practice toward AMT. It contributes to the literature on what mathematics coaching looks and sounds like in the context of conversations with teachers, as well as the potential influence that structured, intentional, ongoing coaching supports can have on teacher noticing.

Keywords

Coaching, Mathematics, Professional noticing, Teacher education

Introduction

Research on effective teaching practices in K–12 mathematics at the international level suggests that instruction should be student-centered, engage

learners in high-quality mathematics tasks and problem-solving, and promote the development of procedural fluency from conceptual understanding (Australian Association of Mathematics Teachers, 2006; Eurydice, 2015; Kilpatrick *et al.*, 2001; National Council of Teachers of Mathematics [NCTM], 2014, 2020; Smith and Sherin, 2019). Teachers are expected to engage students collaboratively and support connection-making between mathematical concepts and real-world contexts, where previously, instruction may have focused on teaching procedures and processes. These demands of teaching reform often require teachers to plan and enact mathematics lessons in ways that are dramatically different from traditional models and likewise require teachers to develop new pedagogical and content knowledge to do so successfully. Although the Trends in International Mathematics and Science Study (TIMSS) highlights the international use of teaching practices such as relating mathematics to everyday life, problem-based learning, and active learning and critical thinking, memorization is still cited as a commonly used (albeit less frequently than others) approach (Eurydice, 2015).

In 2014, NCTM succinctly summarized these reform-oriented strategies into eight mathematical teaching practices (MTPs):

1. Establish mathematical goals to focus learning,
2. Implement tasks that promote reasoning and problem-solving,
3. Use and connect mathematical representations,
4. Facilitate meaningful mathematical discourse,
5. Pose purposeful questions,
6. Build procedural fluency from conceptual understanding,
7. Support productive struggle in the learning of mathematics,
8. Elicit and use evidence of student thinking (p. 10).

The MTPs provide a framework and common language for mathematics educators to work from in developing a praxis that Van Es *et al.* (2017) call “ambitious mathematic pedagogy” (p. 165). Helping teachers to envision what these practices look like *in situ* and supporting their implementation of the MTPs into daily practice can be challenging. K–12 schools and districts often design their own professional development opportunities and models to support teachers, and implementation may happen unevenly across organizations (Gibbons *et al.*, 2017). Understanding how to maximize

these opportunities requires educators and researchers to carefully examine facets of their implementation.

Developing professional noticing in teachers

What is professional noticing?

In student-centered, problem-based mathematics instruction, teachers are required to engage in "adaptive and responsive teaching," reflecting on and learning from episodes of instruction by decomposing their practice to identify specific teaching activities that lead to implementation of reform-oriented teaching practice (Sherin *et al.*, 2011, p. 6). This requires teachers to focus on teaching moves that support or hinder learning and to allow them to pivot in the midst of a lesson. For teachers to implement such strategies and adapt in the moment to student thinking, they must notice how the lesson is evolving in real time and react accordingly. Researchers describe "teaching noticing" and "professional vision," or a teacher's ability to attend to and interpret various elements of a lesson as a critically important skill to develop (Sherin and van Es, 2009; Van Es *et al.*, 2017). Noticing provides teachers with common languages and lenses through which to examine the complex act of teaching.

According to Jacobs *et al.* (2010), "Learning to notice in particular ways is part of the development of expertise in a profession" (p. 170). Selective attention and knowledge-based reasoning can lead to teachers acting on what they notice with intentionality (Sherin and Van Es, 2008). Teachers tend to focus their attention on a range of lesson elements during the complex act of teaching, such as student behaviors and engagement (Van Es and Sherin, 2008). To address this, utilization of video clubs as professional development toward looking at things like student engagement can help teachers intentionally focus on students' mathematical thinking, allowing them to interpret evidence in ways that inform in-the- moment decisions and planning (Van Es and Sherin, 2008).

Sherin (2001) and Jaworski (2001) described these shifts as supporting teachers in learning to attend to student thinking and learning in ways that can transcend planning for or reflecting on a single lesson. Van Es *et al.* (2017) stated

that developing routine, systematic ways to help teachers learn from practice, requires supporting teachers as they attend to and make sense of classroom interactions. Kersting (2008) found that teachers with more sophisticated noticing showed gains in student achievement. Lacking in the literature is an examination of how, if at all, these shifts in noticing impact teachers' integration of reform- oriented teaching practice to their praxis. If the goal of coaching is to support teacher learning to successfully plan for and teach mathematics in reform-based ways, which are responsive to student thinking (McGatha *et al.*, 2018), then coaches must also help teachers consider ideas that transcend one lesson. Since site-based coaches face many challenges in working with all teachers and in doing so frequently, it is worth understanding the sorts of coaching moves that can promote these shifts in noticing in ways similar to that of video clubs.

What is worth noticing in mathematics instruction?

According to Ball *et al.* (2008), teachers utilize specific types of knowledge to engage in a variety of tasks that pertain to the planning and implementation of mathematics instruction. These "mathematical tasks of teaching" (MTTs) require teachers to apply this knowledge in ways that are both specific and demanding in their daily practice and include activities such as finding examples to make a specific mathematical point, recognizing what is involved in using particular representations, and evaluating students' claims and explanations (Ball *et al.*, 2008, p. 400). The MTTs are not dissimilar to the eight MTPs advocated for by NCTM (2014). Both provide a framework for *what* goes into planning and teaching high-quality mathematics lessons and what lesson features are worth developing teaching noticing around.

In order to design and implement well-crafted mathematics lessons, teachers must call upon specialized mathematical knowledge that is in some ways very different than the mathematics they learned as elementary students or even in college preparatory classes (Ball and Forzani, 2011; Hill *et al.*, 2008). Teachers must anticipate the various strategies students may use to solve problems and consider ways to monitor and scaffold students' progress during instruction. They must listen to and make sense of student explanations and make in-the-moment decisions that guide discussion as it is unfolding with learners. Even when these practices are not new for a teacher, such skills are often enacted

differently in reform-based teaching models than in more traditional mathematics classrooms (Ball and Forzani, 2011). Specialized content knowledge, as well as knowledge of how that content connects to students, is necessary for teachers to conduct mathematics instruction in the ways advocated for by recent literature (NCTM, 2014, 2020). Unfortunately, not all teachers do this in practice; therefore, it is important to recognize *what* is worth helping teachers notice and attend to during mathematics instruction and *how* to support an increased focus on research-based teaching practices.

Roller (2016) examined *what* pre-service mathematics teachers attended to, categorizing reflections around noticing of self, students, mathematical content and the broad understanding of moments in teaching. Although the researchers categorized the inclusion of mathematics discussion/reflection at a surface level, their study did not examine the specific mathematical concepts or teaching practices that participants noticed. In contrast, Van Es *et al.* (2017) described the *what* that is critical for teachers to attend to as "ambitious mathematics instruction," whereby teachers create learning environments that are student centered and focus on the incorporation of reform-oriented practices. The researchers described this ambitious pedagogy as one that "focuses on creating and sustaining learning environments where student work is the center of activity, with the goal of students developing procedural fluency, deep and enduring mathematics understanding, and productive dispositions and identities as mathematics learners" (p. 167). Their study employed a framework of three professional noticing practices: developing teacher noticing of *what to focus on* in a lesson, developing teachers' attention of *what is worth reflecting on* in their teaching and enhancing a teacher's ability to *make connections* between observed instruction and broader teaching practices (i.e. MTTs and MTPs). This research focused on the development of professional noticing through the use of video analysis but is not the only potential professional development model that could develop ambitious mathematics teaching (AMT) practice. Other options, such as coaching, also strive to support teachers' recognition and employment of research-based teaching practices, but there is currently little research examining

the ability of mathematics coaches to develop professional noticing in teachers.

Coaching as professional development that promotes teacher noticing

Over the past two decades, instructional coaching has become an avenue for providing professional development to teachers (Costa and Garmston, 2015; Knight, 2009, 2017; West, 2008). Coaching offers on-site, in-the-moment, differentiated supports for teachers, which studies such as Darling-Hammond *et al.*'s (2017) describe as necessary for transfer of learning to take place. Although some initial studies found mixed results on the effectiveness of instructional coaching (Murray *et al.*, 2008; Olsen and Barrett, 2004), more recent work indicates coaching can affect positive change, including increases in student achievement (Campbell and Malkus, 2011, 2013; Matsumura *et al.*, 2012), successful implementation of research-based teaching strategies (Knapp, 2017), and increased teacher self-efficacy and competence (Frazier, 2018; Taylor, 2017). This research also shows that simply installing coaches in schools is not enough to influence such change (Knapp, 2017). Current studies seek to better understand what coaches say and do in the moment to affect positive changes in teacher practice and student learning.

Recent studies have focused on identifying "productive coaching strategies" (Gibbons and Cobb, 2017) and, within the context of mathematics more specifically, helping teachers to engage with effective MTTs/MTPs and understand students' mathematical thinking (Baker *et al.*, 2018; Jacobs *et al.*, 2010). Killion (2008) defined "coaching heavy" as focusing on instructional change. Much of this deep coaching involves the coach and teacher engaging in a three-part coaching cycle, where the two co-plan a lesson, enact the plan and gather evidence of student thinking, then debrief to reflect on and analyze the observed data and teaching practices (McGatha *et al.*, 2018). Coaches can position teachers as co-facilitators of facilitated discussion and reflection, helping them to not only reflect on practice but also generalize these reflections to future practice (Collet, 2015; Wetzel *et al.*, 2017). Planning and debriefing conversations are intended to engage teachers in dialog and reflection about AMT, and as such, this coaching platform holds the potential to make shifts in teacher noticing and subsequently teaching practice (Mudzimiri *et al.*, 2014; Saphier and West, 2009). Coaching for teacher change requires that the instructional coach meets each individual teacher's learning

needs. Collet (2015) found that, much like with student learners, the type and amount of support needed from the coach occurred as the teacher's competence and confidence increased. This suggests that, although the goal of coaching is co-construction of ideas around practice, a gradual release model of coaching can be beneficial. There is currently sparse literature on how mathematics coaches might support teachers' development of professional noticing of AMT practices via such a coaching model. This study provides an examination of the potential for targeted coaching practices to offer another avenue (besides video clubs) to help teachers develop professional noticing of MTTs/MTPs that are reform oriented, research based and "ambitious."

Methods

This paper is situated within the context of a larger qualitative study designed to better understand how mathematics coaches interact with teachers during coaching conversations to promote the noticing and use of ambitious, reform-oriented teaching practices, utilizing MTTs and MTPs as qualifiers for developing AMT. My background knowledge and experience as a mathematics coach at the time of the study situated me as a researcher with unique expertise, both with emic knowledge as a coach in the same district as the participants, as well as the etic perspective of a researcher observing the coaching process from the outside (Merriam, 2009).

Research design

In this paper, I utilize narrative inquiry to examine in further detail a subset of data from my broader study (Jakopovic, 2017, 2020). Initially, I sought to deeply understand how coaching could influence teachers' noticing and implementation of MTTs and MTPs (Jakopovic, 2017, 2020). The smaller snapshot explored in this paper stems from findings of the original study about the potential influence of persistent, targeted use of coaching moves over time. Therefore, the goal of this analysis is to more closely examine one mathematics coach working with the same novice teacher over multiple iterations of the three-part coaching cycle. Narrative

inquiry is well-positioned to examine educational experiences and encounters for, as Savin-Baden and Van Niekerk (2007) put it, “humans are storytelling organisms who lead storied lives” (p. 461). The field texts, or data, collected in this study illustrate the “actions, events, and happenings ... whose analysis produce stories” (Polkinghorne, 1995, p. 6). In this instance, the stories of the coach and teacher are retold as a way to better understand the phenomenon of coaching as a mechanism to develop teacher noticing. Retelling allows the researcher and participants to interpret these lived events and extrapolate new meaning (Connelly and Clandinin, 2006). Therefore, the research question this study seeks to examine is “How do multiple coaching cycles between the same coach and classroom teacher influence a novice teacher’s professional noticing of ambitious mathematics teaching practices?”

Participants and context

The larger qualitative study followed six elementary mathematics coaches working in a large urban district. For this analysis, I narrowed my focus to two coaching cycles between one coach and teacher situated at one school site. Data collection for the larger study occurred via ongoing invitations from the participant coaches for me to observe. Since the coaches created their coaching schedules and offered invitations independently of my anticipated data collection goals, I typically observed coaches working with different teachers each visit. The participants here (both identified by pseudonyms) represent the only data I collected of a coach meeting iteratively with the same teacher, making their interactions a unique snapshot worth examining further. At the time of the study, the coach, Martha, had over ten years of teaching experience in the school district, as well as extensive instructional coaching and mathematics content training, and it was her second year working at the site as a coach. Martha and I had worked together in this role previously, and our resulting collegial relationship allowed me to broker her as a gatekeeper into her school and her work with Ellie, a first-year teacher. The school was labeled “low achieving,” based on results of the statewide mathematics assessment, and primarily served students of low socioeconomic status, determined by a free and reduced lunch rate of over 85% at the time of the study. The two typically met once to twice monthly to complete a three-part coaching cycle around

teaching mathematics with Ellie's first-grade class. I observed two complete coaching cycles that occurred approximately two weeks apart, with one unobserved coaching visit that occurred between the two data points.

Data collection and analysis

I collected textual data in several forms for this study. I conducted an interview with Martha before and after both observed coaching cycles, along with a semi-structured interview at the end of the semester. The interview questions focused on understanding the story of the previous work Martha had done with Ellie, the nature of their coach–teacher relationship and any specific coaching goals for the observed cycle. In addition to the interviews, I observed and recorded the planning and debrief sessions between Martha and Ellie for two coaching cycles. My analysis focused on the transcripts of these conversations between Martha and Ellie, pre- and post-cycle interviews with Martha, and the final coach interview.

To analyze the data, I began by reading the transcripts of the coaching conversations between Martha and Ellie and the interviews with Martha to look for emerging themes. I utilized the MTTs and MTPs as a framework to both deductively and inductively code the text (Miles *et al.*, 2014). This allowed me to identify places where the conversation focused on MTTs/MTPs as evidence of developing teacher noticing of AMT practices. I then reread the data to recheck and refine these codes into broader themes around AMT, which I labeled as "Developing Mathematical Goals," "Planning and Adapting Mathematical Tasks/Lessons," and "Examining Student Thinking." Finally, I deconstructed and reconstructed the data to develop a snapshot of what Martha's role was in helping to facilitate conversation about, and thereby Ellie's noticing of, AMT practices. This process is illustrated in Table 1 below.

I wanted to identify places in the conversation that focused on AMT and was particularly interested whether Ellie was the one initiating conversation around this or if Martha was leading her there as the coach. In narrative inquiry, this process of deconstructing the text as I read and coding and constructing

themes through analysis allowed me to reconstruct the meaning of these narratives through the lens of professional noticing. In the following section, I retell the story of Martha and Ellie's attempts to engage her first-grade students in productive struggle and problem-solving. The vignettes help to illustrate the shifting nature of the role of coach and novice teacher in developing the ability to notice with intention the elements of AMT that go into crafting these experiences.

Table 1. Qualitative coding process to develop AMT themes

Emerging themes of ambitious mathematics teaching practices		
Initial codes	**Themes**	**Examples**
(1) Finding an example to make a mathematical point	Developing mathematical goals	Coach: Tell me more why you picked that [problem]
(2) Linking representations to underlying ideas/ representations		Teacher: I think the wording in it was one reason .. . because I feel like a lot of the issue when it comes down to problem-solving is a lot of the wording throws them
(3) Appraising/adapting the content of textbooks		Coach: Okay, so how do we reason about this problem? You're going to read the problem to the kids and have them use the marker boards?
		Teacher: And eventually I want to get to the point where they choose what they want to use. I see that happening eventually
(1) Presenting mathematical ideas	Planning and adapting mathematical tasks/ lessons	Coach: Some of them are having a little more trouble with where the numbers [in the word problem] are coming from
(2) Posing productive questions		Teacher: But how do you get them in the right direction without giving it to them?
		Coach: Okay, so I'm [Student 1] and I just said, "Well, I added the four square beads and eight circle beads so I have 12 beads." What question would you ask him?
(3) Modifying tasks to be easier/ harder		Teacher. See, that's where I'm getting help up, taking them to that next level. Would you say, "Is that for both bracelets?"
		Coach: I think that's great. Will that provoke them?
(1) Recognizing what is involved in using a representation	Examining student thinking	Coach: We have a roadblock that the story had too many words. They could not get to know what the math was in the story
(2) Evaluating the plausibility of student claims		Teacher: They could not tell me what I was looking for
(3) Giving/evaluating mathematical explanations		Coach: Because the story was too much. But there was progress, because [Student 2] said, "But we're not just find out the blue ones." He knew what it was *not*, but he did not know what he needed

Findings

Gaining traction: shifting away from "*the basics*" *and toward mathematical problem-solving* Although Martha and Ellie engaged in a number of coaching cycles prior to my observations, they had taken a significant break mid-year due to personal illness on the part of the teacher. In our first conversation, Martha shared that in the fall, she and Ellie had completed four or five coaching cycles in which they planned, co-taught and debriefed lessons together. She explained that the two often talked about content, struggling students and formatively assessing student understanding. Martha described this as typical of working with a new teacher in that they focused on "the basics of her wanting to figure out how she wants her math block to work" (Martha, Pre-Cycle 1 Interview).

Now, the pair were more than halfway through Ellie's first year of teaching, and Martha noted a shift in coaching focus the two had co-constructed around engaging Ellie's students in problem-solving. This MTP requires teachers to engage in phase one of AMT ("noticing *what* to focus on in a lesson") by attending to elements such as student thinking, the cognitive demand of mathematical tasks, and the types of questions and discourse promoted by the teacher (Van Es *et al.*, 2017). Earlier that day, Martha had observed Ellie's mathematics lesson to help her prepare for their upcoming conversation, and she shared with me,

> I actually went into the lesson today to observe a little bit, and really want to give her some support on problem-solving. So like everything we've worked on up until this point has been falling apart and we do not get the traction we need to make real progress. I think she can make a lot of progress with problems developmentally, it's just, you know, it's kind of like starting over on something new [each time]. (Martha, Pre-Cycle 1 Interview)

Martha's remark about gaining traction by focusing on a consistent mathematical goal across multiple lessons indicated a shift away from coaching focused on "the basics" and toward helping Ellie engage intentionally in developing her AMT. In this instance, Martha and Ellie had a specific goal in mind related to one MTP, "Implement tasks that promote reasoning and problem solving" (NCTM, 2014), which aligned with the AMT theme of developing mathematical goals.

Van Es *et al.* (2017) explained that, for novice teachers to develop a vision of their teaching as ambitious, they often need support identifying elements of instruction (MTTs/MTPs) that are worth attending to in lesson planning and implementation. Here, Martha describes Ellie's goal AMT and her belief that Ellie could make progress if they shifted away from doing "something new" each coaching cycle. For Martha, gaining traction meant identifying a focused element of AMT to work on over a sustained period of time to help Ellie move toward her goal of engaging students in problem-solving.

"*How do you get them talking?*"

After this initial conversation with Martha, I observed the pair meeting the same afternoon as they planned for the upcoming lesson. Ellie confirmed this shared goal of engaging students in collaborative problem-solving and productive struggle. As she reflected on her last, somewhat unsuccessful attempt to do this during a lesson, she looked to Martha for reassurance:

> Ellie: But I started questioning myself and I even asked you, is this too hard for them? Martha: Okay.
>
> Ellie: I do not know, what do you think? Do you think it was too hard? Do you think I should have explained?
>
> Martha: I do not think so. I do not think it was too hard and I do not know that I think you should have explained it to them … but I want to talk about what we can do without explaining, because we talked about the gradual release and stuff. So what can you do to support them without giving [the procedure] to them?
>
> Ellie: Right, and that's the part I feel uncomfortable with, or that I'm shaky on, I feel like. (Cycle 1 Planning Session)

As Ellie shared her concerns about the cognitive demand of the mathematical task and sought advice, Martha reassured her about the validity of her attempts to engage students in the MTP of productive struggle. She then posed a question to press Ellie to think more deeply about the features of her teaching practice that could provoke this in her students without stepping into direct Ellie's decision-making. Although Ellie recognized engaging students in authentic problem-solving as an effective teaching practice, she struggled to identify what she needed to do to facilitate this in the moment.

Martha's question pressed Ellie to consider possible scaffolds that could engage students more productively without diminishing the cognitive demand of the task. Ellie's response suggests that she may not yet have had the awareness, or noticing, of the facets of AMT practices she could adjust to promote productive struggle. Both observed that, during the previous problem-solving lesson, students did not engage in discourse while they worked, and the two saw this as problematic in helping learners progress through the task. Ellie shared that she had attempted to have students work with partners, but in the moment, students elected not to talk with one another, and many struggled with the task. In response to Martha's questions about possible supports Ellie could put in place, she shared her thinking aloud:

> Ellie: So maybe more of a model of how that would look? Model the partner work and maybe pair up a little better?
>
> Martha: Yeah, so I think the real thing here is how do you get them talking?
>
> Ellie: So, I mean, is it more just walking around and calling out people that you see tackling, using a different strategy?
>
> Martha: I think so.
>
> Ellie: So how long do you let them sit there and stew, you know what I mean? Because half of them were not getting it. (Cycle 1 Planning Session)

Although Ellie engaged in brainstorming here, she still sought advice from Martha about how to enact a lesson in ways that facilitated productive student talk, suggesting a lack of confidence in her own ability to identify effective strategies for the lesson. Martha initially responded by posing a question to help Ellie expand on her ideas about engaging students in more discourse. However, Ellie's continued questions led Martha to follow up with specific suggestions to offer more concrete ideas of what it might look like to facilitate this discourse:

> Martha: I think there's a couple of things. You could take Ingrid [']s strategy] here, and you could go straight to sharing something like that. Or you could take what Elijah did, and he did four plus eight and four plus eight, or twelve plus twelve, and that was wrong, but he had—

Ellie: The right idea. Yeah, I knew what he was thinking.

Martha: So, we could go straight there, or you could go to one of these kids who had twelve and just give them a question.

Ellie: So, what kind of question would you ask them? (Cycle 1 Planning Session)

This notion of monitoring what students did mathematically and selecting specific students to share their thinking with the class requires the teacher to notice student thinking in the moment in order to respond. Martha shared sample questions that could help students explain their thinking and strategies to peers, highlighting two MTPs ("pose purposeful questions" and "facilitate meaningful mathematical discourse") that might increase the amount of student talk during the upcoming lesson.

At this point in the exchange, although Ellie appeared to notice the purpose of the questions, she still struggled to connect back to her original goal of facilitating discourse. Ellie needed additional support in noticing what to do, as evidenced by questions like "How do you get them in the right direction without giving it to them?" and "See that's where I'm getting held up, is like taking them to that next level. Would you *say* that it is for both bracelets [to clarify] or not?" These follow-up advice-seeking questions about how Ellie should go about enacting the MTPs during the lesson represented the typical flow of the conversation between the coach and teacher in cycle 1. Often, the goal of instructional coaching is for the coach and teacher to co-facilitate planning and reflection as a partnership approach (Knight, 2009, 2017). However, Campbell *et al.* (2013) explained, "If the coach needs to make suggestions, then she should try to make those suggestions fit with the teacher's ideas" (p. 45). During this conversation, Ellie's inexperience as a new teacher often left her looking to Martha for explicit ideas on how she could engage students in authentic problem-solving without stepping into model procedures or strategies. Martha's role as the coach in this episode was to more directly support Ellie in developing a sense of what to notice mathematically, both in terms of lesson design and facilitation of student discourse in the moment.

These excerpts illustrate Martha's promotion of a sustained coaching goal of helping Ellie learn to facilitate problem-solving and productive struggle effectively. This required Martha to pose questions and offer suggestions focused on specific elements of AMT (in this case reflecting on "planning/adapting mathematical tasks") to guide the

conversation. Ellie appeared receptive to Martha's ideas and tried them out during her lesson, but it was evident that she still felt discomfort enacting these practices on her own. Ellie explained wanting to see "how kids reacted to beginning a lesson with them working on a problem with a partner, some manipulatives and just more of an explore activity. That's kind of what I was taught in school to start [with]" (Cycle 1 Planning Session). This demonstrates Ellie's awareness of *what* effective MTPs involve, which aligns with the first phase of developing "ambitious mathematics instruction" (Van Es *et al.*, 2017).

As Martha facilitated their talks to help Ellie develop her AMT, Ellie's questions and advice seeking began to focus on the mathematical details worth reflecting *in* and *on* in her practice (Sch€on, 1983) to help her more successfully engage students in productive struggle. In my conversation with Martha after the coaching cycle, she shared,

> I think she is starting to see and is going to see the benefit of letting her kids do this. One, she already believed in it, and just did not know how to make it happen. And I think it's kind of a nice thing, since I did not have to get her to buy in, all we have to do is figure out how to make it work. (Martha Post- Cycle Interview 1)

This statement illustrates Martha's focus on helping Ellie consider what to focus on in the lesson (phase one noticing), attend to what is worth reflecting on about her teaching (phase 2 noticing), and begin to make connections between her current and future practice (phase 3 noticing). Van Es *et al.* (2017) described this as a sort of "figuring out the logistics" needed to shift teachers between phases of noticing. Martha acted as a facilitator of Ellie's idea generation but also generated ideas at Ellie's request to provide guidance in what the MTTs/ MTPs could look like.

"*I thought about … giving them like a minute to just see what they get*"

Between observations, Ellie and Martha worked on a second, unobserved problem-solving lesson before I returned two weeks later. At the start of this next observed coaching cycle, I noted a change from the first session–Ellie led off the conversation this time by telling Martha she had a new word problem picked out for her students. She selected another two-part problem like before but had already

made an adjustment to use smaller numbers this time. Unlike cycle 1, where Ellie sought Martha's advice prior to making any decisions about developing the task or considering scaffolds for discourse and productive struggle, this time, Ellie began to lead the discussion around the theme, "Planning and Adapting Mathematical Tasks."

> Ellie: So, I put that I have red and blue pens so that way we can use the cubes if we needed to. Red and blue pens, so I have three red pens and then I have five more blue pens than red pens.
>
> Martha: Three red and five more blue. So, you're simplifying the numbers. Ellie: Yes. Do you think that will help? I hope—
>
> Martha: I think it will, yeah … . I like that plan. (Planning Session, Cycle 2)

In cycle 1, Ellie appeared uncertain how to help her students access challenging problems without giving them too much support. In cycle 2, she demonstrated her noticing of ways to adjust the features of the task design to support her focus on engaging learners in productive struggle. Ellie considered aspects of adapting the task based on her observations of students during the previous lesson (phase one and two of noticing) to make this subsequent task both accessible and challenging for students. In some regard, Martha's role shifted from advice giver to affirmation provider as Ellie shared her plan. Despite this shift, Ellie's question to Martha illustrated a lingering insecurity about her ability to engage in AMT effectively on her own.

As the planning conversation continued, Ellie shared additional ideas for the task design in terms of how she wanted to present the problem and scaffold students' work if they struggled. She planned to read the problem, write the numbers on the board, and wait to see if the smaller numbers made the task more accessible for students.

> Ellie: Because I thought about, even when I'm reading the problem, or writing the numbers, giving them like a minute to just kind of see what they get on their board. Stopping and drawing the mountain … . what's the term?
>
> Martha: The math mountain's fine.
>
> Ellie: Yeah, trying that, then giving them a few more minutes and if it's still hard, trying to go that route. And then if it's still hard, go right into using the cubes.
>
> Martha: Yeah, I like seeing if that helps, and then saying something like, "Show me all the kinds of pens … ." could guide them into trying out the blocks if they

need to. (Planning Session, Cycle 2).

Here, Ellie thought through multiple scenarios for “Planning and Adapting Mathematical Tasks,” noticing ways that she might initially present the problem to students, along with additional supports she would provide if they failed to access the mathematics successfully. Each support was intended to maintain the integrity of the productive struggle and problem- solving focus by adjusting the content of the task and the processes students might use to solve. She continued the conversation, sharing additional ideas she had to jumpstart student thinking by considering potential strategies she could use to scribe their thinking visually for peers during the lesson. Martha often interjected comments like, “I like that. I think that’s good stuff” (Planning Session, Cycle 2) to support Ellie’s plan. In contrast to cycle 1 where Ellie heavily relied on Martha to show her how to use AMT to design an inquiry-based lesson, in cycle 2 there was a noticeable shift in Ellie’s noticing of aspects of task design with intention.

After the lesson, Ellie and Martha met to debrief and discuss continuing challenges in helping students explain their strategies to peers, as well as progress they saw from the previous two lessons. The pair unpacked Ellie’s plan for the next lesson and identified additional adaptations Ellie wanted to make to ensure all students could access the task. At the end of the conversation, Martha asked what support Ellie needed going into this next lesson, and Ellie replied, “Maybe give me like a week to try a few on my own and then come back. Would that be okay?” It was unclear to me in the moment whether this remark was made in response to Ellie’s growing confidence in her ability to facilitate problem-solving on her own or whether she wanted to alleviate the added pressure of being observed (by Martha and possibly myself). The two planned to meet again in two weeks to debrief the unobserved lesson and meet for another coaching cycle.

Afterward, Martha and I met to have a conversation about her impressions of the coaching cycle. She shared with me the changes she saw in Ellie’s thought process about planning for problem-solving, stating, “She’s starting to feel out how ... [to deal with] practical roadblocks that are interfering” (Martha, Post-Cycle 2 Interview). Rather than Martha giving advice, her role began to shift to that of an

active listener as Ellie shared ideas and proposed adjustments to her task implementation. Much like Ellie's questioning of her own ideas about task design, Martha's comment here implied that Ellie's developing confidence and competence using MTTs/MTPs was still tenuous. This is similar to findings of Van Es *et al.* (2017), whose study of novice teachers participating in a course engineered to develop professional noticing of AMT found that participants' degree of noticing varied and that teacher noticing primarily increased in two areas: attending to features of MTTs/MTPs in their planning and teaching and elaborating on their thinking and reflection around AMT.

Discussion

This study sought to examine the question "How do multiple coaching cycles between the same coach and teacher influence a novice teacher's professional noticing of AMT practices?" The findings presented here offer preliminary evidence that instructional coaching focused around iterative coaching cycles can begin to shift novice teachers' professional noticing of AMT over time. Two key takeaways from this analysis are the role that developing sustained goals around specific AMT can play in developing teacher noticing of AMT and that utilizing a gradual release model of coaching can help shift the work of noticing from coach to teacher. In restorying the experiences of Martha and Ellie's coaching work, these features of their conversations stood out as potentially relevant to the work of mathematics coaches engaging teachers in utilizing reform-oriented practice.

Sustained goals tied to mathematics teaching practices

At the beginning of my time observing Martha and Ellie, Martha shared a major shift that was happening in the coaching relationship. Ellie was moving away from focusing on organization and logistical issues as she set up her mathematics block and toward attending to the mathematical content and student thinking in her lessons. Attending to self and to issues related to things like classroom management are common among pre-service and novice teachers; however, professional development can foster shifts toward a focus on AMT (Roller, 2016; Van Es, 2011; Van Es *et al.*, 2017). As Martha and Ellie settled into the goal of engaging students in productive struggle and

problem-solving, this provided a targeted lens through which Ellie began to notice the features of her planning and reflection that could foster successful implementation of AMT. I inquired about this consistent focus in their work, and Martha shared with me,

> I'm really excited about how this is going because .. . I think if coaching was not connected, this is an instance where a teacher might try something and then it did not go great and they just abandon it after day one. I'm excited about this because, with this little extra support and feedback and encouragement, it's like a teacher is potentially going to latch onto a worthwhile practice that could last. (Martha, Final Interview)

Despite Martha's praise of connected coaching cycles, this sort of occurrence was the exception rather than the norm in my larger study (Jakopovic, 2017, 2020). Often, coaching cycles with teachers were spread far enough apart that no common focus was evident. The dual factors of Martha's ongoing work with the same teacher paired with targeted goals and close proximity of coaching cycles afforded her the ability to gain traction in fostering Ellie's professional noticing. This idea of establishing goals and using targeted coaching moves to support teacher noticing aligns with coaching frameworks in the professional literature (Baker *et al.*, 2018), yet it does not always occur in practice (Jakopovic, 2017, 2020). When a targeted goal continues across multiple coaching sessions with the same teacher, they may be more likely to internalize the goal and develop noticing of what it takes to consistently implement AMT into their teaching praxis.

Utilizing a gradual release model of coaching to develop AMT

Van Es *et al.* (2017) described the need to support teachers to focus their development of AMT practice by noticing *what is worth focusing on* in a lesson, *what is worth reflecting on* after, and the connections that transcend individual lessons and impact broader teaching practice. In the two coaching cycles analyzed for this study, Martha supported new teacher Ellie's learning of *what to focus on* in her planning. This included considering how to set up mathematical tasks to engage students in productive struggle. She also helped Ellie attend to *what is*

worth reflecting on about a lesson, examining students' work and mathematical thinking, to refine future lessons in ways that worked toward Ellie's goal of developing her students' problem-solving skills (Van Es *et al.*, 2017). By the end of cycle 2, Ellie's developing sense of noticing allowed her to make connections between what she observed and learned in cycle 1 and how her subsequent adjustments helped her make progress toward her goal in cycle 2. This shift from the coach highlighting AMT to the teacher noticing them suggests that novice teachers may require more support initially to identify and engage with MTTs/ MTPs in their developing practice.

Martha's coaching provided scaffolded support, allowing a novice teacher to make shifts in her teaching practice that better aligned with her beliefs about mathematics teaching. Research has indicated the need for professional development, including coaching support, to be differentiated to meet the individual needs of teachers (Darling-Hammond *et al.*, 2017). Collet (2015) found that utilizing a gradual release model of coaching resulted in increased confidence and competence of teachers who had recently participated in professional development and had begun to implement ideas into their classroom. Over time, the teachers required less scaffolding and support from the coach and increased their own responsibility to successfully implement newly learned teaching practices into their praxis. Collet (2015) described this "Gradual increase of Responsibility Coaching Model" as a potential conceptual guide for coaches to be responsive to teachers' needs (p. 285). The findings from this paper indicate that this model of coaching could be particularly beneficial for novice teachers, who have less experience planning and facilitating AMT in practice.

Implications

Findings from this study can inform professional development and training for mathematics coaches and those who work in similar roles to support teachers in reframing the lens through which they view lesson planning and reflections on teaching mathematics. Coaches can develop systematic approaches (including a gradual release model of coaching) to create targeted goals and sustained, ongoing supports to develop teacher noticing and AMT. Recognizing the benefits of implementing such a coaching model could allow coaches to improve the quality of their work with

teachers over shorter intervals of time. Developing noticing in both novice and veteran teachers alike could lead to opportunities for coaches to extend ideas and practices beyond individual lessons and help teachers to generalize their noticing to their ongoing practice. As teachers increase their noticing, they can begin to self- reflect on MTTs/MTPs and increase their use of AMT practices without the support of a coach. Teachers who use their noticing to develop their AMT practices can then act as levers for change in their schools. Utilizing the knowledge gained by coached teachers, a school or district could increase the use of peer coaching, lesson study and other collaborative professional development models that could create consistent and sustainable use of research-based AMT practices over time.

Limitations and future directions

There are several limitations in this study. Since this was a small study that only examined one coach with one teacher across two coaching cycles, it can be hard to make generalizations about the nature of a teacher's development of professional noticing. This study adds to the professional literature on the development of professional noticing, however, and there are concepts presented here that could be transferrable to other settings. Gibbons and Cobb (2017) described a need for more studies that explicitly examine what coaches do to provide various types of feedback that can positively influence teacher learning and practice. Specifically, they cited the need for studies that "focus explicitly on the relationship between the types of feedback coaches give to teachers, the extent to which feedback is tailored to teachers' current practices, and any subsequent improvement in their instructional practices" (p. 422). This study provides potential insights into how to maximize the utilization of mathematics coaches as a lever for developing novice teachers' use of AMT. Future studies involving larger sampling of coaches working with the same teachers over time would better saturate the preliminary nature of the findings and conclusions of this analysis.

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