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OF MATHEMATICS EDUCATION LEADERSHIP

VISUALIZING A VISION FOR HIGH-QUALITY, EQUITABLE MATH INSTRUCTION

INTRODUCING ROUGH DRAFT MATH TO SUPPORT TEACHER'S EFFORTS TO FOSTER STUDENT ENGAGEMENT AND LEARNING

EXAMINING DISTRICT MATHEMATICS LEADERS' SUPPORT FOR SCHOOL-BASED MATHEMATICS COACHES

CALL FOR MANUSCRIPTS

The editors of the ***NCSM Journal of Mathematics Education Leadership (JMEL)*** are interested in manuscripts addressing issues of leadership in mathematics education which are aligned with the NCSM Vision.

The editors are particularly interested in manuscripts that bridge research to practice in mathematics education leadership. Manuscripts should be relevant to our members' roles as leaders in mathematics education, and implications of the manuscript for leaders in mathematics education should be significant. At least one author of the manuscript must be a current member of NCSM upon acceptance for publication.

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2. A blinded Word file (.docx) as above but with author information and all references to authors removed.

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NCSM–LEADERSHIP IN MATHEMATICS EDUCATION

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About NCSM

NCSM Mission Statement

NCSM is a mathematics education leadership organization that equips and empowers a diverse education community to engage in leadership that supports, sustains, and inspires high quality mathematics teaching and learning every day for each and every learner.

NCSM Vision Statement

NCSM is the premier mathematics education leadership organization. Our bold leadership in the mathematics education community develops vision, ensures support, and guarantees that all students engage in equitable, high-quality mathematical experiences that lead to powerful, flexible uses of mathematical understanding to affect their lives and to improve the world.

High-quality leadership is vital to this vision. NCSM is committed to:

Developing and Informing Vision

- Provide leadership to influence issues and policies affecting mathematics education in ways consistent with the mission and vision of NCSM;
- Equip leaders to be critical consumers of educational information, research, and policy to become change agents in their communities;
- Support leaders to develop an actionable vision of mathematics instruction consistent with a view of mathematics as a sense-making endeavor.

Ensuring Support to All Stakeholders

- Develop networking and communication opportunities that connect the mathematics education community as well as the broader education community;
- Equip leaders with the tools to create and sustain systems that fully align with the vision of mathematics and mathematics instruction promoted by NCSM;
- Equip leaders with the understanding, knowledge, and skills to continue their own personal growth, support emerging leaders, and further develop excellence in mathematics teaching.

Guaranteeing All Students Engage in Equitable, High-Quality Mathematical Experiences

- Provide advocacy and support regarding issues and policies affecting mathematics education in ways consistent with the mission and vision of NCSM;
- Provide resources for the implementation of research-informed instruction to ensure students engage in relevant and meaningful learning experiences that promote mathematics as a sense-making endeavor;
- Advocate for each and every student to have access to rigorous mathematics that develops their understanding, skills, and knowledge, along with the confidence to leverage their learning, in order to improve their world.

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COMMENTS FROM THE EDITORS

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As winter settles in, the editorial team at the *Journal of Mathematics Education Leadership (JMEL)* invites you to engage with the latest issue of our journal. We hope that the articles in this issue will help spark new ideas, challenge perspectives, and encourage meaningful dialogue within and beyond the field of mathematics education leadership.

With our commitment to collaboration, we would like to take a moment to remind our readers about the Association of Mathematics Teacher Educator's (AMTE's) updated *Guidelines for Preparing and Supporting Elementary Mathematics Specialists*. Recall that in 2022, AMTE, the Association of State Supervisors of Mathematics (ASSM), the National Council of Supervisors of Mathematics: Leadership in Mathematics Education (NCSM), and the National Council of Teachers of Mathematics (NCTM) published a new position statement reiterating the goal stated 13 years earlier in their first joint position statement of every elementary school having access to an elementary mathematics specialist professional. A recommended action in that statement was to "[p]rovide high-quality mathematics professional learning that not only prepares elementary mathematics specialists for their work but also supports and sustains district and school ongoing mathematics improvement efforts," suggesting a need to revisit the audience for the Elementary Mathematics Specialist (EMS) Standards. In July 2024, AMTE released the updated and expanded *Guidelines for Preparing and Supporting Elementary Mathematics Specialists* to inform both the initial preparation and ongoing support of EMSs.

The updated and expanded guidelines achieve several goals. For one, the guidelines define the necessary mathematics content, pedagogy, and leadership knowledge and skills for the broad range of roles and responsibilities of EMSs as both formal and informal teacher leaders. Furthermore, the guidelines provide guidance for mathematics teacher educators (i.e., those working in districts, states, institutions of higher education, etc.) responsible for preparing and providing ongoing support to EMSs, and advocating for practices, structures, and policies that lead to mathematics program improvement. We thank Drs. Susan Swars Auslander and Nicole Rigelman for leading the effort to update and expand these guidelines and encourage our readers to explore the new guidelines and consider how they might be taken up and applied in their unique contexts.

In this issue of *JMEL*, we invite readers to engage with three articles. In our first article, "Visualizing a Vision for High-quality, Equitable Math Instruction" by Baker and colleagues, the authors provide an overview of a professional learning task that involves drawing one's vision for high-quality, equitable mathematics instruction (HQEMI). Specifically, the authors share an overview of the drawing task, its implementation with educators, and sample drawings. The authors provide recommendations for implementing the task and also consider how the task might be adapted for others who are steeped in different contexts to support professional learning about and development of a shared vision for mathematics.

In our second article "Introducing Rough Draft Math to Preservice and Novice Mathematics Teachers to Support their Efforts to Foster Student Engagement and Learning" Bondurant and Jansen explore the potential of Rough Draft Math (RDM), which is a pedagogical approach where students discuss and share their preliminary mathematical ideas without fear of being wrong. According to this approach, teachers welcome students' rough draft thinking and students are given explicit opportunities to revise their work or thinking. In their study, Bondurant and Jansen partnered with preservice and novice teachers and found that teachers became more aware of how RDM could foster a more comfortable and engaging learning environment for students. These findings elevate the importance of the teacher's role in facilitating mathematical discourse and teachers' holding a non-evaluating stance towards students' thinking.

In our third article "Examining District Mathematics Leaders' Support for School-based Mathematics Coaches," Kochmanski and colleagues partnered with 15 district mathematics leaders to understand whether and how they supported school-based mathematics coaches. Qualitative analyses of interview data revealed that most of the leaders worked closely with coaches to support them. Furthermore, the authors identified the following seven ways they did so: (a) facilitating professional development (PD) for coaches, (b) engaging in strategic planning, (c) providing individualized support for coaches, (d) visiting classrooms with coaches, (e) training coaches to deliver district PD, (f) preparing and co-facilitating PD for teachers, and (g) co-facilitating professional learning communities with coaches. The authors' findings have implications for research on district leadership as well as support for coaches.

In closing, as readers engage with the three articles featured in this issue, we invite readers to consider how the findings from each article can inform and strengthen their own leadership practices in mathematics education. We wonder how might the professional learning task described by Baker and colleagues be adapted to meet the specific needs of your school or district? Additionally, we wonder what barriers might students face in embracing a rough draft mindset, and how can teachers help mitigate these challenges? Last, we wonder what professional learning opportunities might help district-level leaders better understand and support the work of school-based mathematics coaches?

EQUITABLE MATH INSTRUCTION VISION

VISUALIZING A VISION FOR HIGH-QUALITY, EQUITABLE MATH INSTRUCTION

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ABSTRACT

In this article, we overview a professional learning task that involves drawing one's vision for high-quality, equitable mathematics instruction (HQEMI). The task is part of the ongoing work of a statewide research practice partnership that supports a shared vision of mathematics across the state K–12 system. Our work of HQEMI is rooted in the development of Munter's (2014) four dimensions for visions of high-quality mathematics instruction (VHQMI): the role of the teacher, classroom discourse, mathematical tasks, and student engagement. The first three dimensions are particularly useful in the work of the drawing task. In this article, we share an overview of the drawing task, its implementation with educators, and sample drawings, detailing how personal drawings were made visible across participants and the conversations resulting from viewing and reflecting on one another's drawings. These conversations helped surface disparities in notions of ideal mathematics instruction and provided space for negotiation of shared meaning. We provide themes and overarching considerations from these conversations to highlight discussions that might be elicited through this task in future iterations. Finally, we provide recommendations for implementing the task and consider how the task might be adapted for others' contexts to support professional learning about and development of a shared vision for mathematics.

Keywords: vision, drawing, equity, codesign, VHQMI, HQEMI.

Take a moment, close your eyes, and picture mathematics instruction in an ideal elementary classroom. Now reflect: What components did your vision include? What were the students and the teacher doing? What did the classroom discourse look like? What were the mathematical tasks in which students engaged? If you posed these same questions to a colleague, do you think they would answer similarly? Draw a quick sketch of this mathematics classroom on a piece of paper.

A teacher's vision for instruction can be viewed as what they consider "ideal" (Hammerness, 2001); therefore, a vision is seen as aspirational rather than necessarily descriptive of current practice. We are members of a research practice partnership called the North Carolina Collaborative for Mathematics Learning (NC2ML), which supports a shared vision for high-quality, equitable mathematics instruction (HQEMI) across the state. As members of the partnership and as part of the aligned research project called the VISIONS Project, we care deeply about what is envisioned from the opening prompt. In this article, we unpack briefly why developing a shared vision of HQEMI is important and describe our project's goals, structure, and context. We then share a professional learning task we use with mathematics teachers and leaders around making visions explicit and creating shared visions. Asking participants to draw their visions of HQEMI has served as a tool for productive conversations and for negotiating our shared vision of HQEMI across constituents, representing a wide range of those identifying as educators, including but not limited to classroom teachers, math specialists, math teacher educators, families, and administrators. Lastly, we provide details of the drawing task implementation and discuss how it might be facilitated in other contexts.

VISIONS OF HQEMI

Vision of HQEMI is a discourse by which educators talk about how they view ideal mathematics instruction. By making their visions explicit, teachers can understand how far or how closely aligned they are with HQEMI and hopefully improve their efforts related to teaching and learning (Hammerness, 2001). As such, instructional visions act as both filters and reflective tools as teachers work to grow in their practice (Munter & Correnti, 2017).

Unpacking Vision

Several terms and considerations are used when discussing vision in mathematics education. Goodwin (1994) first termed "professional vision" to characterize the unique ways those in a professional group look at phenomena of interest to them.

Teaching professional vision (Sherin et al., 2008) would then refer to teachers' concern about the phenomena of classroom interaction as well as their ability to notice and interpret significant interactions in a classroom (Sherin, 2001, 2007). Our project built on Hammerness's (2001) idea of instructional vision as an ideal image of practice and, more specifically, on Munter's (2014) manner of detailing the sophistication of teachers' articulation of their or others' mathematics classroom practices. As part of our work with the VISIONS Project, we examine and unpack individual and collective visions for mathematics instruction, with the understanding that individuals' visions must be surfaced to shape and negotiate a shared vision.

Unpacking High-Quality Mathematics Instruction

High-quality mathematics instruction is rooted in the reform-based mathematics movement, informed by the National Research Council's (2001) intertwined strands of mathematical proficiency that include adaptive reasoning, strategic competence, conceptual understanding, productive disposition, and procedural fluency. HQEMI is also informed by the National Council of Teachers of Mathematics's (2014) *Principles to Actions*. In *Principles to Actions*, the council outlined effective mathematics teaching practices, which included establishing mathematics goals to focus learning, implementing tasks that promote reasoning and problem solving, facilitating meaningful mathematical discourse, and building procedural fluency from conceptual understanding. To explore instructional visions of high-quality mathematics instruction, Munter (2014) conducted interviews with teachers, principals, and mathematics coaches, focusing on how they described and characterized high-quality instruction. His research interactions led to the development of four main dimensions and rubrics to classify increasingly sophisticated levels of visions of high-quality mathematics instruction (VHQMI; Munter, 2014). These four dimensions include: the role of the teacher, classroom discourse, mathematical tasks, and student engagement. The first three dimensions are particularly useful in thinking about ideal mathematics teaching and are overviewed next.

The *role of the teacher* dimension examines if and how teachers coparticipate in the learning of mathematics with students by establishing a learning environment that gives authority to students to problematize and make sense of mathematics (Lampert, 1990). Regarding *classroom discourse,* of importance is establishing a discourse community (Hufferd-Ackles et al., 2004; Lampert, 1990) in which whole-class discussion elicits and follows student contributions, and student-to-student talk is used to support mathematical sensemaking around concepts and content. The dimension of *mathematical tasks* draws upon Hiebert et al. (1997) and Smith and Stein's (1998) work around the classification and rubrics for four categories of high-quality mathematical tasks, with the highest categorization being tasks that require complex thinking and exploration of mathematics.

Equitable Mathematics Teaching

Since Munter's (2014) introduction of the VHQMI rubrics, equitable mathematics teaching has emerged as a pressing priority for the mathematics education field and, subsequently, for our project. As a result, the "E" became part of our work, meaning HQ***E***MI was used in our thinking about vision for the project. We grounded our project's work in past research that has framed and characterized equitable mathematics teaching practices (Aguirre et al., 2013; Bartell et al., 2017; Gutiérrez, 2009; Hand, 2012; Nasir et al., 2014). In the project, we pulled upon these characterizations and a National Council of Teachers of Mathematics research brief (Chao et al., 2014) to recognize equitable mathematics instruction as teaching that (a) accounts for oppressive norms perpetuated or maintained by mathematics teaching and then (b) actively seeks to work against those norms, so each student can participate, and belong, in the mathematics space (Bishop, 2012; Gutiérrez, 2013; Martin et al., 2010; Nasir & Hand, 2008).

To better understand this instruction in action, we examined the vision of equitable mathematics teaching. Recently, Haines et al. (2023) identified equity-specific aspects of vision as missing from current research on instructional vision in mathematics education. Research into trajectories of the ways teachers' instructional vision is characterized related to equity is still emerging (Haines et al., 2023; Wilson et al., 2024), and we hope these trajectories will eventually be informed by the work of the VISIONS Project. In the meantime, raising equity as a conversation starter around the drawing task in this research surfaced participants' current notions and helped us connect to other existing conceptions of equity-based practice. Shared vision is essential for professional development and collaborations to be effective in schools (Birkeland & Feiman-Nemser, 2012; Cobb et al., 2020; Fulton et al., 2010) and for the implementation of new programs or policies (Gamoran et al., 2003). Our research practice partnership (RPP; Coburn et al., 2013), NC2ML, has been working for statewide systemic change in North Carolina since 2016, with an explicit focus in the last 3 years on promoting a shared vision of high-quality, equitable instruction among administrators, teachers, and other constituents. We are committed to the defining characteristics of RPPs, which are long-term collaborations among members from distinct communities who work toward education improvement (Farrell et al., 2021; Penuel et al., 2015).

THE WHO, HOW, AND WHY OF NC2ML AND THE VISIONS PROJECT

The VISIONS Project is part of a wider NC2ML RPP (Coburn et al., 2013) formed in 2016 to build infrastructures (e.g., white pages and research briefs, social media groups, professional learning opportunities, networks, connections across various statewide professional organizations) and create coherence across a state educational system as newly revised statewide mathematics standards were adopted. Over 300 district and state leaders, teachers, mathematicians, and mathematics teachers from all regions of the state engaged in design-based implementation research (Fishman et al., 2013) to codesign resources iteratively for mathematics standards implementation (see Table 1 for overview of roles and involvement in VISIONS Project).

Table 1
VISIONS Project Membership Description

Team composition descriptions	K–5 team (24 members)	6–8 team (26 members)	9–12 team (24 members)
Project leaders	Two university researchers Responsibilities: Overarching facilitators of project and its professional learning experiences, lead distribution of codesign materials to promote consistency, research principal investigators	Two university researchers One doctoral student	Two university researchers One doctoral student
Steering committee members	Two district leaders One university researcher Responsibilities: Facilitators of the codesign team professional learning experiences and meetings, cohesion and clarity across all codesigned resources, direct support to project leaders	One district leader One school principal One university researcher One classroom teacher/researcher	Three district leaders
Codesign team	Two project leaders Three steering committee members Four classroom teachers Five district leaders Three district coaches Three school coaches Four higher education faculty Responsibilities: Lead and support the development of codesigned resources and experiences to support HQEMI across state, distribution of project resources through local contexts and networks	Three project leaders Four steering committee members Three classroom teachers Five district leaders Three district coaches Three school coaches Three district math and science coordinator/specialists Two higher education researchers	Three project leaders Three steering committee members Six classroom teachers Five district leaders One district coach One school coach Four higher education researchers One testing coordinator
District type	Totals: 44% urban, 22% suburban, 33% rural Region diversity: Evenly spread Four educators from minoritized populations	Totals: 30% urban, 25% suburban, 40% rural, 5% private Region diversity: Missing three regions Three educators from minoritized populations	Totals: 50% urban, 20% suburban, 30% rural Region diversity: f our from two regions, the rest equally distributed Three educators from minoritized populations

Note. The K–5 team was the team of focus for this article's math exploration.

In 2021, the RPP began the Visions Project, a 4-year cycle in which a team of approximately 80 codesigners from across the state used a design process (Stanford d.school, 2018) to investigate how we can elicit and shape a shared K–12 vision for HQEMI across North Carolina. North Carolina is a geographically varied state with three regions that often influence the organization of districts and access to educator professional learning. Although 78 of the 100 counties are considered rural, they serve only 34% of students in this state (Dollar, 2024). As of Dollar's (2024) reporting, the teaching population was 76% White compared to 46% of students. The VISIONS Project codesigners were selected through a deidentified application process and represent math teachers; math teacher leaders (i.e., at school, district, and state agency levels); and university faculty from the three geographic regions and rural, suburban, and urban schools. The VISIONS Project remains ongoing at time of publication.

Throughout the collaborative's projects, we assumed that developing a shared vision of HQEMI is foundational to systemic coherence and, further, that codesigning resources and learning experiences can surface differences in and support the negotiation of shared meanings for HQEMI among constituents. Part of an RPP involves taking on a shared problem of practice (Cobb et al., 2020; Miller & Pasley, 2012; Munter et al., 2020; Munter & Wilhelm, 2020; Van den Akker & Nieveen, 2021). Because the codesign team operates at a statewide level, the project began with open invitations to districts through state organizations and networks to engage in surveys, interviews, and in-person focus groups held in each of the eight regional educational alliances of the state. Participants were asked to describe their vision of HQEMI and to identify challenges in their educational communities in enacting those visions. The grade-band teams (i.e., K–5, 6–8, and 9–12) used these data to select a particular problem of practice, with the overarching focus on codesigning K–12 supports and infrastructure (e.g., resources, networks, development opportunities) toward a coherent, shared vision of HQEMI. For 3 years, each grade-band codesign team met yearly in a 3-day summer institute and monthly via Zoom to decide how they wanted to uniquely codesign resources for developing a shared vision across the state to promote systemic coherence. We were involved in the K–5 codesign team with the following roles, respectively: steering committee member, project lead, mathematics teacher educator in the codesign team, research associate.

In planning for and designing the first 3-day summer institute, the K–5 project lead and steering committee acknowledged that even with an expressed shared vision and desire for enacting HQEMI, this might look and feel different for each person, depending upon their situational contexts and lived experiences. During the institute, we engaged in activities adapted from the Stanford University design school (d.school, 2018) and focused on creating learning experiences for the codesigners who embodied the instructional aspects of discourse community and high-cognitive demand tasks. We aimed to spark discussion about the nuances of problem solving and fluency in relation to HQEMI in elementary settings, especially because fluency can be interpreted controversially, and discussions about the role of fluency were beginning to happen in the statewide political landscape. As project leaders, we relied on the National Research Council's (2001) definition of *fluency* as "carrying out procedures flexibly, accurately, efficiently, and appropriately" (p. 5). Grounded in what we knew about vision and the importance of engaging in shared vision, especially VHQMI, we dedicated time to elicit the participants' visions in the room. We wanted to extend beyond discussions of vision to employ other senses, including considering what a vision of HQEMI may look like, sound like, and feel like in elementary settings. Just talking about our visions of HQEMI would not be enough to spark the robust discussions needed to unpack and align vision, particularly because individuals assign different meanings to common phrases like "hands on" or "collaborative;" we needed to visualize our visions. To accomplish this task, we used a professional learning task we refer to as "Visualizing Your Vision," which involved drawing, displaying, viewing, and discussing our visions of HQEMI. In the next section, we describe (a) the enactment of this task in our 3-day summer meeting, (b) discuss how this task has since been used in multiple settings statewide, and (c) outline how it might be implemented in other contexts.

Visualizing a Vision: Drawing HQEMI

In this section, we describe the different aspects of our professional learning experiences for and with educators. We provide an overview of the value of using drawings with educators and spotlight past research that discusses the process. Then, we discuss our own process for having participants produce drawings of HQEMI. We transition to how we surfaced opportunities to share and reflect on drawings through a gallery walk, which provided opportunities for noticing and wondering. Finally, we conclude by discussing two ways we supported participants to notice disparities in their visions.

Previous research has examined the importance of drawings as pedagogical and research tools for exposing individuals' perceptions, thoughts, and attitudes toward various subject areas (Finson, 2002; McKay & Kendrick, 2001). Specific to mathematics, Burton (2012) and, more recently, Ruef (2020), used drawings with prospective teachers during university coursework to better understand the prospective teachers' connections to and relationships with mathematics. Both researchers used pre- and post-drawings for comparison points across a semester to analyze prospective teachers' changing perceptions and mindsets toward mathematics. Both researchers also used the drawing experience to further pedagogy and research to inform future iterations of their courses and consider how the education field might best prepare prospective teachers. In Ruef's study, the prospective teachers were asked to draw an optimized vision of teaching. Although what we explain next also considers vision in the context of our codesign team's drawings, we expanded on past research by enacting this task with various educational constituents across various roles in mathematics education to use the pictures to negotiate shared vision. Our package of the drawing activity, with tools for surfacing conversations about the drawings as a cohesive professional learning task, makes our work a contribution to various fields in education, specifically the fields of mathematics education and professional development.

The professional learning task began with providing the codesign members independent thinking time to visualize their vision of HQEMI in a K–5 context. Each codesign member was asked to draw what HQEMI would look like in the elementary setting and was encouraged to be open to the drawing process. The K–5 codesign team leaders modeled openness and willingness by also drawing their visions.

The full prompt used in our summer institute can be seen in Figures 1 and 2. Although the prompt focused on "making sense of operations," this exploration and prompt can be opened up or narrowed depending on the specific context needs. In Figure 1, participants were focused in general on "what ought to be" as a way of pulling attention to images of "ideal" practice rather than current practices they saw or experienced in their contexts. After a short, silent time of reflection, Figure 2 was shown to spark ideas for drawing and to support participants in including items in their drawings that fit with Munter's (2014) dimensions of the role of teacher, discourse, and task. Figure 2 remained posted for the duration of the drawing time, as the first five bullet points in Figure 2 could be a starting point for any vision drawing task.

Figure 1
Drawing Prompt for the "Visualizing Your Vision" Task

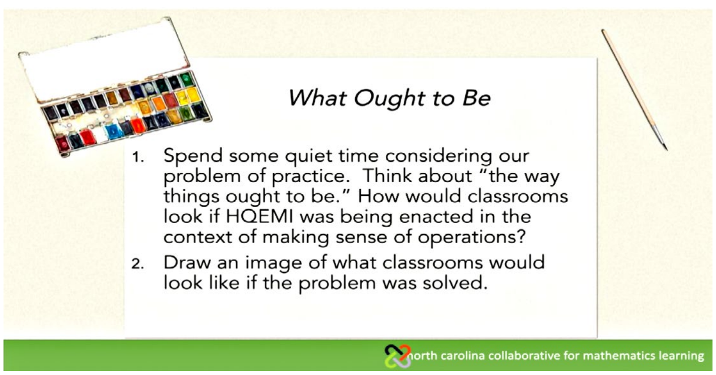
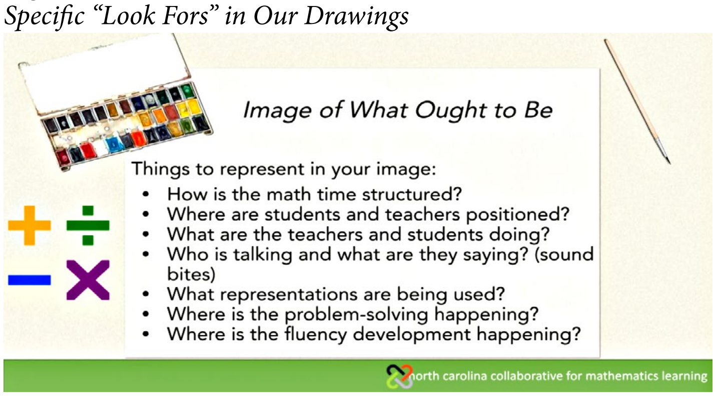


Figure 2
Specific "Look Fors" in Our Drawings



To begin the drawing process, codesign members sat in quiet reflection and sketched and drew. Some asked for another sheet of paper and restarted, whereas some quietly commented about their lack of drawing skills. Codesign members were encouraged and reminded to remain open to the process and interpret drawings flexibly and creatively based on their assets. This reminder to stay asset-focused and open to the process was another unifying reminder of how we hope to establish mathematics classrooms as places of flourishing (Su, 2020).

In Figure 2, the last two bullet points, asking, "Where is problem solving happening?" and "Where is the fluency development happening?" were included for the group because they aimed to come to a shared understanding of these terms among codesigners. During the summer institute, it became clear the codesigners used the terms problem solving and fluency with different interpretations and different mathematical definitions or experiences attached; for example, one person might have surfaced a more rote, memorization view of fluency, whereas another may have looked at fluency as being more holistically intertwined with conceptual understanding of algorithmic processes.

Similarly, although codesigners used the term problem solving in their discussions of HQEMI, how it was being used and what it represented in a mathematics space was distinctly different. As a response, steering committee members decided to focus on these terms as part of the drawings. After the drawings were completed for the initial vision of HQEMI, codesigners were then asked to label their drawings with "PS" or "F" for where they showed problem solving (PS) and fluency (F) development. Fine tuning drawings of visions to specific mathematics content or processes (e.g., problem solving, fluency) may not be needed or found useful amid all iterations of this professional learning task. The prompts might remain more open ended and focused on the initial five bullet points of Figure 2 to best match the context, purpose, and readiness for exploring vision.

Using Drawings to Unpack and Negotiate Shared Vision: Our Process

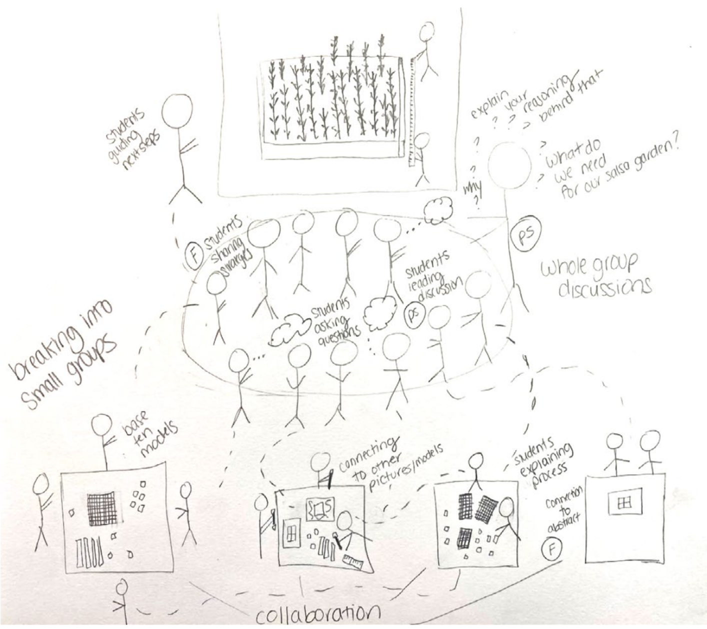
Once drawings were completed, the professional learning task transitioned from revealing individual visions to revealing and reconciling visions collectively. The drawings could now serve to spark conversation about differences in visions of HQEMI and different interpretations of our terms of focus: problem solving and fluency. The drawings were hung around the room as a gallery walk, a method of displaying images around a space to be viewed and examined by all participants. Initially, the gallery walk time served as an opportunity to absorb what colleagues had created and simply notice. Codesigners noticed some members drew specific classroom moments in time, some drew maps across time and experiences, some focused on the teacher and students, and some focused on a learning experience or a specific mathematics task.

We also noticed the drawings could help us see, hear, and feel HQEMI in ways that discussion alone could not; for example, rather than an individual saying, "Classroom discussions are important," they drew this sentiment in Figure 3 (Drawing 1) using thought bubbles with actual snippets of an imagined conversation. Further, in the first two thought bubbles in the right-hand corner, students interact with each other, not just the teacher.

Figure 3
Drawing Example 1

Conversely, in Figure 4 (Drawing 2), although discourse was clearly happening, the codesigner more generally described what students said as "students asking questions" or "students sharing strategies." However, although Drawing 2's discussion aspect may not be as robust as in Drawing 1, more was gleaned about the drawer's notions of the tasks on which students work in ideal classrooms. Students were working to determine what they needed in a "salsa garden"—a garden that grows ingredients typically in a salsa recipe (e.g., tomatoes, peppers, herbs)—and collaborative small-group work showed multiple tools, representations, and strategies that could be discussed.

Figure 4
Drawing Example 2



Surfacing and Negotiating Disparities in Vision
Drawing images of ideal practice allowed codesign team members to consider concrete images and "sound bites" together, allowing them to look across drawings for commonalities and differences in these concrete moments. Before the corresponding gallery walk, team members expressed concern about the different interpretations in the room surrounding problem solving and fluency, as it was not clear how the differences would impact trying to design for shared visions of HQEMI statewide as a team. At the end of one of the institute days, after the drawings had been created and labeled but before the gallery walk and conversations, one team member wrote in her designer's notebook (i.e., a personal reflection tool used throughout meetings for both prompted and free writing), "I felt that my definition of 'fluency' very much differed from some of the group members. I was especially taken aback by a comment that fluency comes before problem solving."

After the initial gallery walk and opening conversation around general noticing and wondering about what might be recurring or what might be missing from the drawings, viewing became more directed toward the labels of fluency and problem solving. This directed viewing lens led to deep discussions about the process of finding and labeling fluency and problem solving in our drawings of elementary classrooms and sometimes the difficulty of separating those aspects. Figures 5 and 6 (Drawings 3 and 4) emphasized this complexity, as Figure 5 was helpful in showing comparisons between problem solving and fluency as different components of math teaching and learning, versus in Figure 6 where the illustrator could not always separate the problem solving and fluency and labeled points in the drawing as both "PS/F." These discussions led to regrounding ourselves in definitions from the interwoven strands of mathematics proficiency (National Research Council, 2001); work from the National Council of Teachers of Mathematics (2014); and state standards to guide what we meant about the conceptual understanding of whole-number operations, including problem solving and fluency.

Figure 5
Drawing Example 3

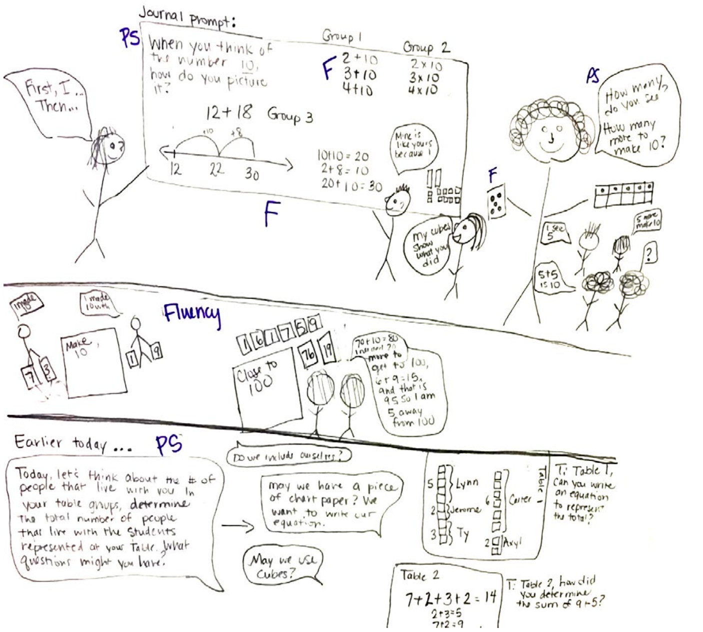
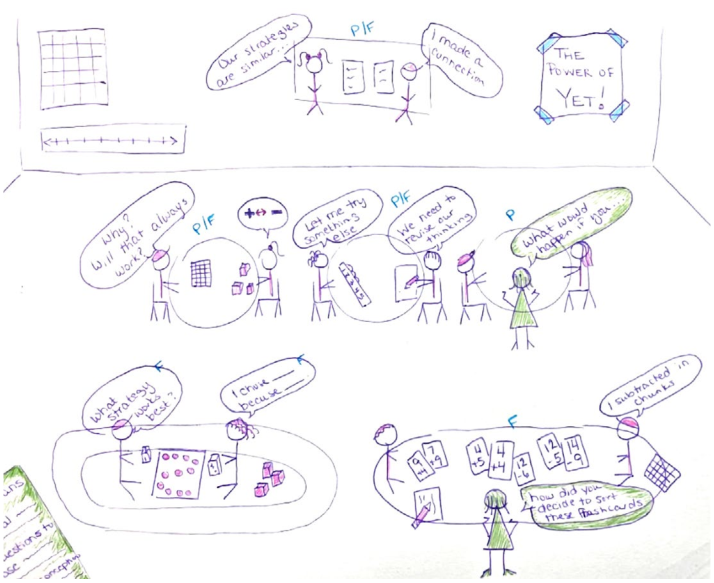


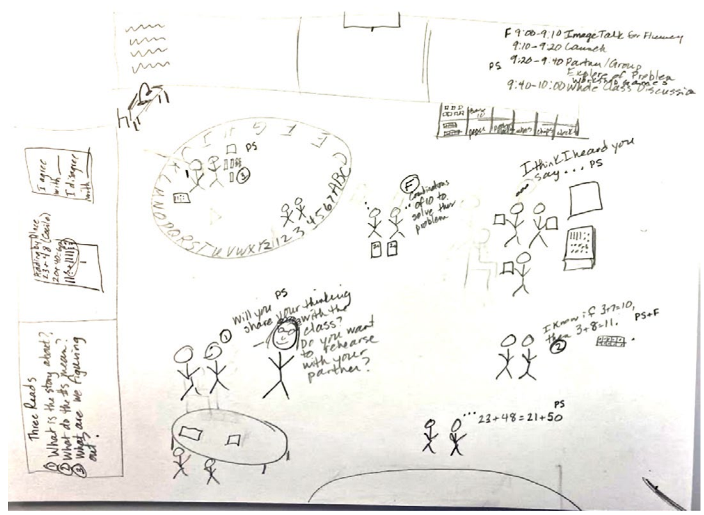
Figure 6
Drawing Example 4



In our instance, the drawings of our visions of HQEMI served as a springboard by providing concrete examples to use in conversations about aligning our visions of fluency and problem solving. For example, one codesign member mentioned, “My energy increased as we did the gallery walk and saw and discussed others’ drawings. I saw things I’d like to add to mine, and it was neat to see how different people focused on different aspects.” Through focused discussion, participants discovered our visions of problem solving and fluency were more shared than we first thought, but we used language and terminology differently. Another codesign member commented, “We came together to agree on common definitions for language, and it was affirming to see so many similarities in our ideal HQEMI classrooms.”

Although visions or language used around HQEMI can be similar in a group with role-alike similarities, it is also likely these visions are disparate. Although discovering such differences could be uncomfortable and will likely be messy, surfacing rather than avoiding these discrepancies, or perceived discrepancies, facilitates opportunities to negotiate meaning collectively. For example, later in our work, after some professional readings and discussions surrounding equity, participants were asked to revisit their drawings in individual interviews to identify places in their drawings they thought showed equitable mathematics teaching practices. Some participants attended to the positioning of students and lifting of student’s voice as in Figure 7 (Drawing 5), where the teacher not only invites a student to share their thinking but also scaffolds time for rehearsal before sharing—see toward bottom left, “Will you share your thinking with the class? Do you want to rehearse with your partner?” Many codesigners commented on aspects of differentiation being part of equitable instruction.

Figure 7
Drawing Example 5



In Figure 8 (Drawing 6), different number choices are listed in the task on the board, and students are collaborating with a selection of representations and strategies. Fewer pictures presented explicit attention to students of color or other marginalized populations, as in Figure 9 (Drawing 7). Noticing these differences across pictures opened the door for conversations about broader meanings of equity and equitable teaching practice. When thinking about the “E,” or equitable, part of HQEMI, we still have work to do to align our vision. Having participants sort the pictures concerning how they viewed a particular aspect of vision—in this case, equity—can be a way to raise conversation about differences explicitly and to negotiate shared meaning.

Figure 8
Drawing Example 6

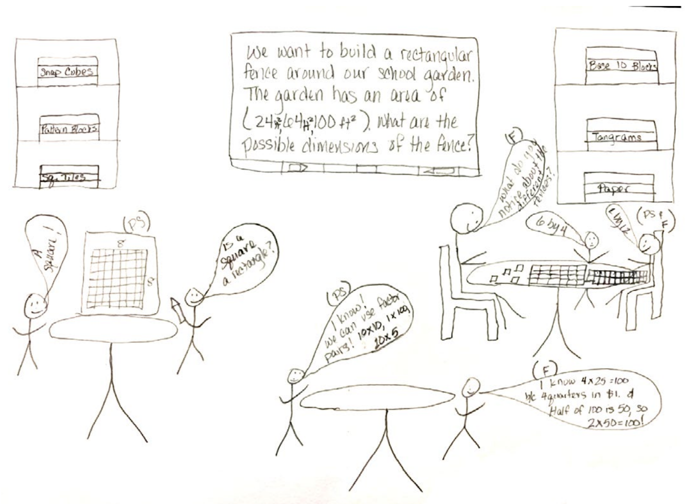
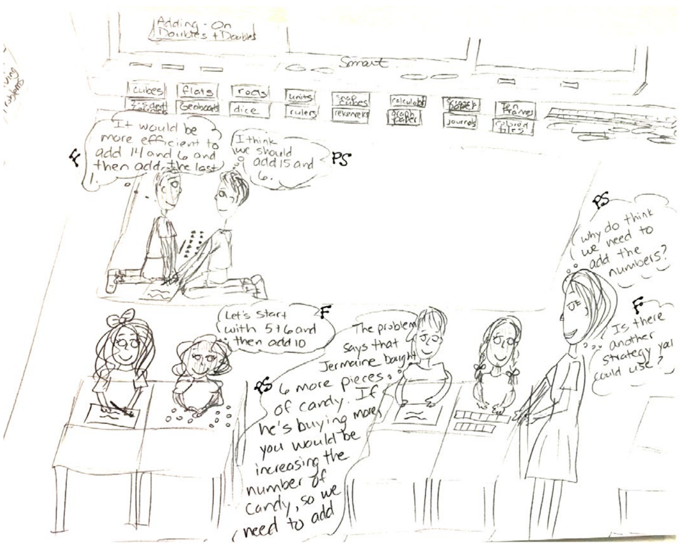


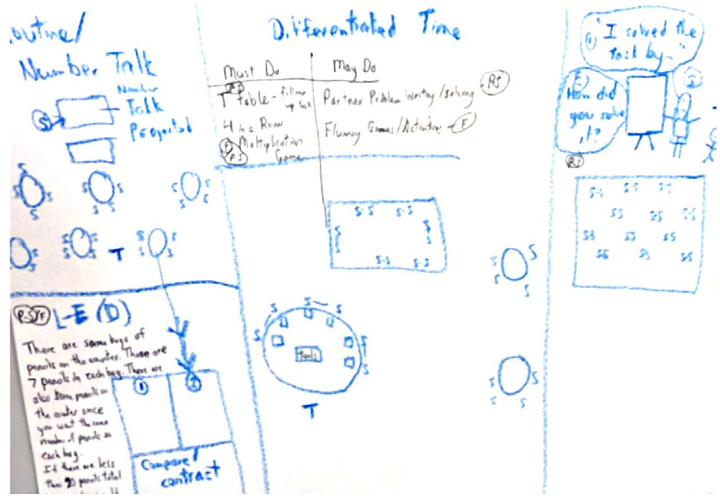
Figure 9
Drawing Example 7



Another strategy to springboard discussion was to center everyone on a single picture rather than doing another gallery walk. An exchange about Figure 10 (Drawing 8) in a small-group meeting later in the year clarified both the illustrator's intent and the group's shared notice of appropriate differentiation:

> *Illustrator: "I see it as differentiated time . . . as equitable because students are sharing their own solutions and commenting on different strategies."*
>
> *Participant: "I saw the Must Do, May Do as somewhat problematic as if leading into a directed "I do, we do, you do" in the small table group with the teacher."*
>
> *Illustrator: "Ohhh, no, that's not how I intended it. The follow-up task would also be open with multiple tools available and students choosing their own strategies."*

Figure 10
Drawing Example 8



As facilitators and as codesign members, we returned to the drawing task and the drawings themselves repeatedly in meetings because we found the drawings sparked conversations or turning points in the project better than our words alone. Codesigners referred to the process of drawing and the feelings evoked from drawing. They also re-anchored themselves in the drawings to support thinking through conceptualizations of HQEMI whenever words alone could not express our full thoughts.

Using Drawings to Unpack and Negotiate Shared Vision in Other Contexts

The flexibility of this professional learning task is powerful for work in different settings with varying purposes, as shown by our experience in using the task to focus on a vision of HQEMI, to narrowing focus on misalignment in term use (e.g., fluency), to then revisiting the same pictures to discuss equitable mathematics teaching. One codesign member wrote in their designer's notebook:

> *I LOVED the drawing activity as I thought a lot could be taken away from that activity. I am NOT a good drawer :-) But I find sketching ideas very powerful and even more powerful, looking at other people's sketches. So much can be said from visual images.*

The codesign team found the task thought provoking and worthwhile enough to include it in the professional learning experiences they designed for statewide audiences, including a statewide mathematics professional development webinar for K–5 educators (i.e., teachers, administrators, and coaches); a 4-day elementary mathematics leadership retreat for district teams composed, again, of teachers, administrators, and coaches; and for various K–12 educators at a conference session during the state's affiliated National Council of Teacher of Mathematics organization. Some team members also used this activity to support vision alignment on a smaller scale in their grade levels or school settings. Figure 11 describes the experience of one district leader who used it to frame discussion during a professional development session with elementary teachers.

Figure 11
District Leader Shares Experience Using the Visualizing a Vision Task

> *This year, I met with my elementary teachers for 3 full days of professional development focusing on instructional math practices. A portion of the professional development focused on our "Vision of Mathematics Instruction." Teachers participated in several activities focused on their instructional visions, but one of my favorite tasks was having them illustrate their ideal math classroom. Each teacher received a blank sheet of white paper and had access to colored pencils, markers, and crayons. The activity was powerful! It allowed teachers to dream and imagine what their math classrooms could look like and sound like. The teachers had to think carefully about their math classrooms, what aspects of instruction were important to them, and how to capture it in a drawing. For example, it made them reflect on: the room arrangement, where the teacher was positioned, how students were interacting with one another, how students were flourishing with mathematics, etc. We often do not ask teachers to do this or give them the time to reflect and dream. Instead, we TELL them what their classrooms should be.*
>
> *As a whole group, we did a gallery walk around the room. We noticed many commonalities in the drawings. This activity helped us to craft a common vision for our elementary mathematics classrooms. Because the activity focused on drawings and images, it allowed us to visually see how our math classrooms should look and sound—not just to talk about it with words but SEE it with images and drawings. It provided us with a common VISION of what we wanted our math classrooms to look like. We reflected on what we did not see as well (e.g., worksheets, rows of students, direct instruction with the teacher at the front of the room).*
>
> *District Elementary Mathematics Curriculum Specialist*

Because our codesign team is composed of several mathematics teacher educators, they also took the drawing task back to their contexts as a learning experience with preservice teachers. One team member had preservice teachers make their drawings at the beginning of the semester and then revise and add to them throughout the semester. Another shared:

> *I asked my preservice teachers to write a "Dear Math" letter at the beginning of the year and then at the end I had them reflect on their letter and draw their vision of a mathematics classroom. Some students felt more comfortable finding free-access photos online and creating a collage of their vision rather than an actual drawing. This representation still allowed me to understand their vision, especially when paired with their reflection. Overall, it was so interesting to see many of the things we had talked about during the semester (and within the collaborative) coming out in their drawings. I wish I had asked them to do a predrawing, and I might even do that next semester instead of the paper.*

Given the collaborative aims to design resources to promote a shared vision of HQEMI across the state, we have been excited about the conversations this task has sparked across role groups, from future teachers to current educators and leaders.

Suggestions for Implementation
The professional learning task of drawing one's vision to surface vision alignments and misalignments can be used on a small scale (e.g., coteachers, grade-level teams) or large scale (e.g., school sites, district professional developments). When considering the use of drawing visions with a team of educators, several key suggestions from our experience may help guide others' implementations. First, it may not be appropriate to start a team of educators on drawing their visions of HQEMI depending on the group size and group trust that has been established. A more appropriate starting point might be to focus on two of the images provided in Appendix A and begin a discussion with some prompts we used in our experience, like the "Look fors" in Figure 2. This approach would help to compare the images and also start to reconcile personal visions about HQEMI; for example, a team might consider the labels of PS (problem solving) and F (fluency) development in Figures 6 and 7 and reflect on how these labels resonate with teammates' own meanings for the terms. Do the labels align with personal visions for how problem solving and fluency are enacted in a classroom? What questions could be asked of the illustrators?

Another suggestion involves attending to a particular dimension of Munter's (2014) rubric or a facet of an equity framework like Gutiérrez's (2009) four dimensions of equity (i.e., power, access, achievement, identity) to examine one or two of the drawings and subsequently hold fruitful discussions. A sample prompt might be, "What might Drawings X and X tell about the view of the role of the teacher in [our] group?" or "What evidence is there in the drawing(s) that students' voices are taken up?" or "How might this set of drawings be sorted using the role of the teacher as the lens?"

Another suggestion is to use the Thinking Organizer introduced in Figure 12 to look across Drawings 1–8 (see Figures 3–10) throughout this article. In Appendix A, Drawings 3–10 are grouped together to review them side by side as a possible modality for comparison and contrast. We encourage the use of Figure 12 to organize individual thoughts about the different drawings before discussion. After individual reflection, teams can discuss these questions collaboratively: What do you notice about the role of the teacher in these drawings? What do you notice about the role of the students? What do you notice about the pedagogical tools being employed? What might each person's vision encompass, and what might it leave out?

Figure 12
Thinking Organizer for Examining Drawings 1–8

Figure	What do you notice and wonder about . . .			
	the role of the teacher?	the discourse used?	the types of tasks?	other?
1				
2				
3				
4				
5				
6				
7				
8				

After a team completes examination of all drawings, they may come to the same realization we did—drawing of visions and subsequent discussions around those drawings are useful because drawing forces the vision's concretization in ways that simply asking a person to discuss their notions of ideal instruction does not (Finson, 2002; Ruef, 2020).

Finally, if a team of educators is ready to draw their visions of HQEMI, Figure 13 provides some considerations and ideas to support the planning and implementation of the actual drawing task. We encourage reading over Figure 13 and reflecting on affordances and challenges of implementing this professional learning task in each personalized context. It is also important to remember, just as in our experience, when others are asked to draw, they may feel intimidated or discouraged. We acknowledge drawing could be uncomfortable and acknowledged this point during our real-time experience; however, we also drew alongside codesigners even if it was uncomfortable for us, and we shared drawing was important to our group's learning because it surfaced ideas in ways just having a conversation without the personalized images could not.

Figure 13
Planning Your Implementation of the Drawing Task

When planning an implementation of a Vision Drawing Task:

- Consider: What initial prompts could be used to inspire the drawings? Will focused prompts be added to the initial HQEMI questions? (e.g., examples of problem solving and fluency)
- Draw! Set the expectation that everyone in the space draws, including the facilitators. Share with an open-ended and/or guided gallery walk when everyone is finished.
- Get together and talk about your pictures. What is seen? After sharing, note what was not seen. Why? (be prepared for messiness and discomfort.)
- After general noticings and wonderings, focus the discussion on your particular issues. Some ideas for facilitating a focus area:
    - Ask participants to label drawings in particular ways
    - Pull a single or subset of drawing examples from the group to focus the discussion
    - Have participants determine how they would sort the pictures based on a particular component or idea.
- Consider: How will participants reflect on the discussion? How will they express how their vision was confirmed, expanded, or changed through this experience? This reflection may include individual journaling about their picture or talking in small groups.
- How can the set of pictures be used to support negotiating a shared vision in your community of educators? What steps are needed to work toward coherence? What is the first area of focus and subgoals to move toward shared vision?

Conclusion

In the literal visualization of our visions, each codesign team member took away a self-reflection and a better shared direction of an HQEMI vision with whole-number operations in elementary classrooms. As a group, we reflected on the murkiness and stickiness of creating a shared vision. We gained an appreciation of why we might not have that vision across schools and systems, allowing us to think about what we might do together to get there. This task also allowed us to engage in productive conversations about how we define procedural fluency and problem solving and how our visions of equitable teaching practices vary among constituents. Examining visions of HQEMI is important to have a shared language and focus among constituents. We can use research (Haines et al., 2023; Munter, 2014) to help us attend to the role of teacher, discourse, mathematically rich tasks, and equitable mathematics teaching practices to begin conversations related to visions of HQEMI; for example, are educators working from the same vision in your school? Furthermore, are educators working from the same vision in your district? Without coherence among constituents in the different roles and levels of the system, decisions may be made that contradict, rather than support, the enactment of HQEMI in classrooms.

Although our drawing task is one way to begin this discussion, this paper also shared ways to modify the task to fit a particular team's needs. By engaging in eliciting and negotiating shared visions, despite the initial discomfort the task might bring, constituents can begin to home in on discrepancies in language or vision and work toward alignment. Achieving a shared vision among education constituents is critical to the enactment of HQEMI and, thereby, critical to the mathematics learning and opportunities for K–12 students.

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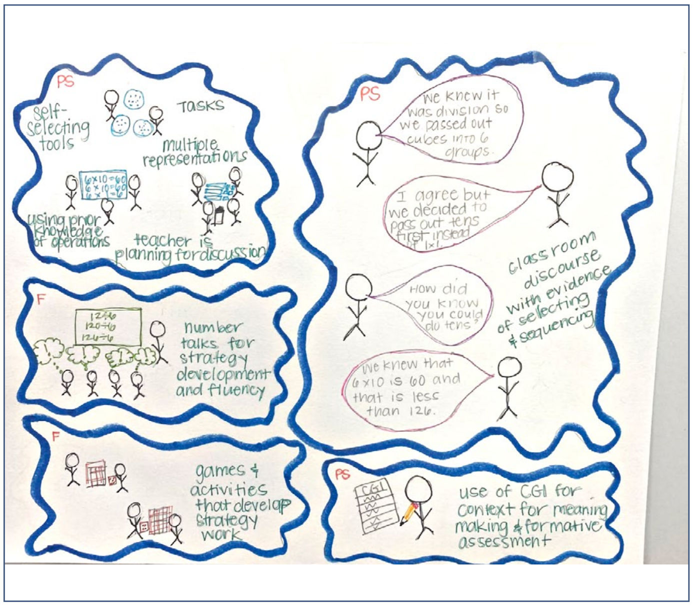
Appendix A

Drawing Examples 1-8 Side by Side

Drawing 1:



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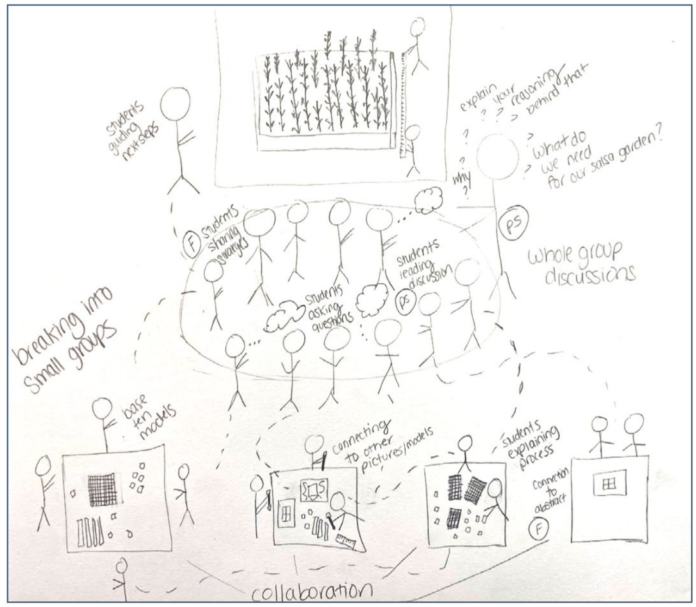

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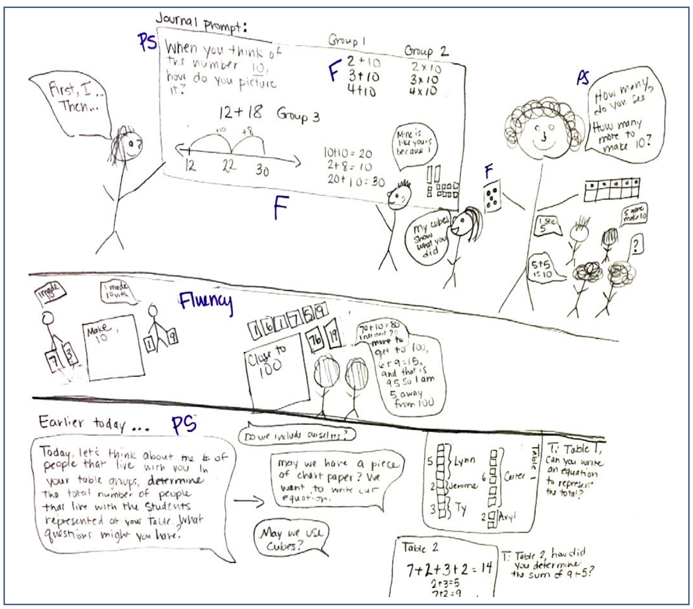

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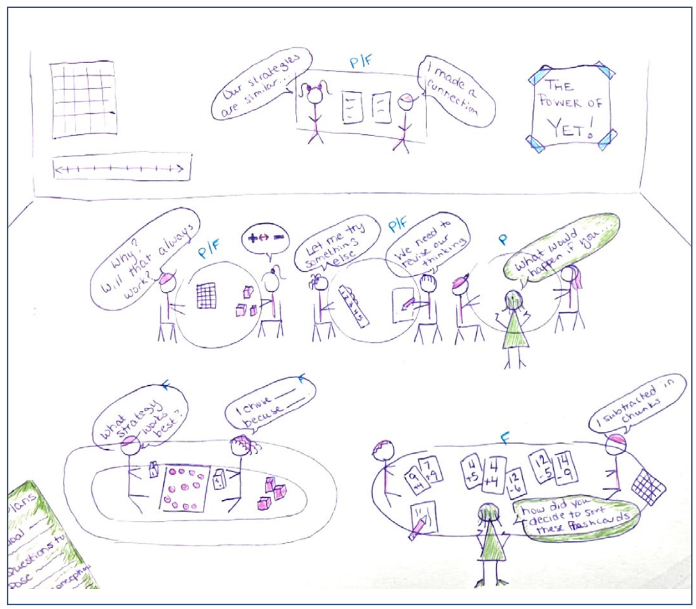

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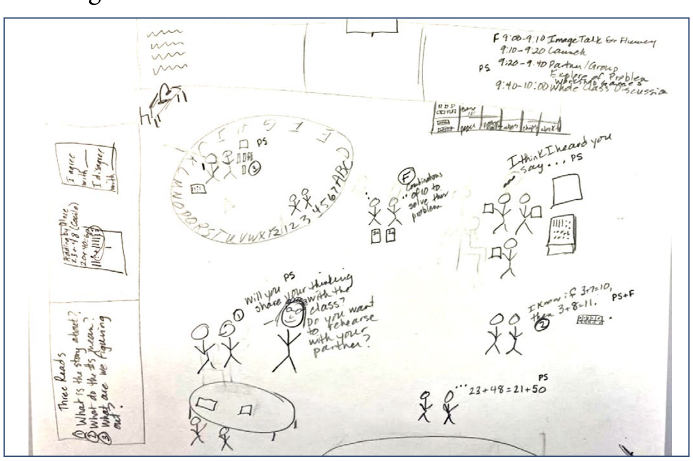

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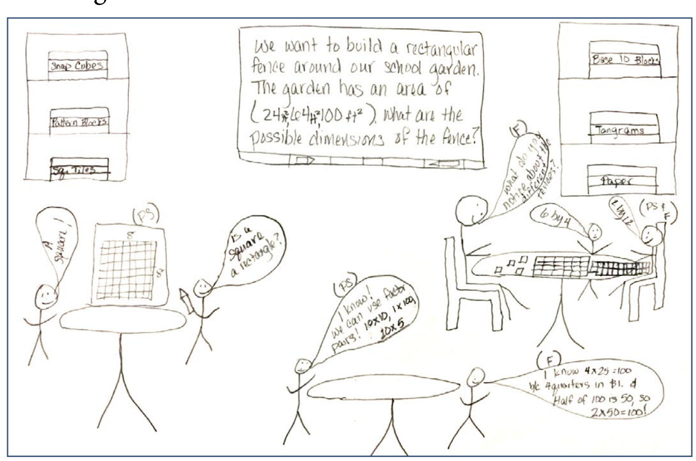
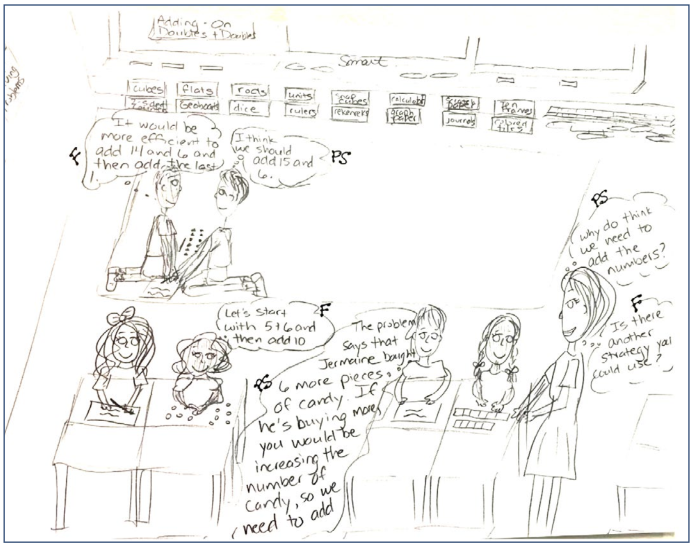


Appendix A
Drawing Examples 1-8 Side by Side cont...

Drawing 7:



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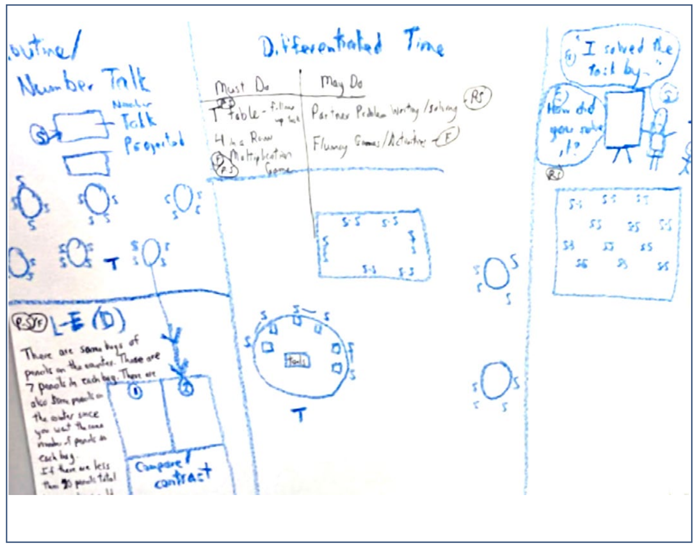

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ROUGH DRAFT MATH FOR ENGAGED LEARNING

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JMEL 2025 INTRODUCING ROUGH DRAFT MATH TO PRESERVICE AND NOVICE MATHEMATICS TEACHERS TO SUPPORT THEIR EFFORTS TO FOSTER STUDENT ENGAGEMENT AND LEARNING

ABSTRACT

Mathematics educators often face the challenge of students disliking mathematics or experiencing a negative relationship with the subject. Intentional teaching practices can be a mechanism to mitigate this challenge; thus, preservice and novice teachers would benefit from opportunities to develop such teaching practices. This research explored the potential of rough draft math (RDM) to support teachers in addressing these issues. RDM is a pedagogical approach where students discuss and share their preliminary mathematical ideas without the fear of being wrong. Teachers welcome rough draft thinking, which gives students explicit opportunities to revise their work or thinking. This study examined the impact of RDM on preservice and novice secondary mathematics teachers through their written reflections on opportunities to learn about the approach through readings. Findings suggested that the readings can promote preservice and novice teachers' awareness of how RDM can foster a more comfortable and engaging learning environment, highlighting the importance of teachers holding a nonevaluative stance toward students' thinking and teachers' roles in facilitating mathematical discourse.

Keywords: mathematics teacher education, teaching practices, mathematical discourse, rough draft math

Background
The challenge of mathematics instruction in modern K–12 classrooms in the United States is multifaceted, encompassing the need to foster student engagement, instill confidence in students, and improve their mathematics performance. Despite the critical importance of mathematical literacy in a technology-driven world, many students report disliking mathematics, feeling anxious about it, and often failing to see its relevance to their lives (Ashcraft & Krause, 2007; Boaler, 2016, 2024). These challenges have been amplified since the COVID-19 global pandemic began in March 2020 (Hornstra et al., 2022). Such negative perceptions and experiences can lead to a vicious cycle of students avoiding challenges and performing poorly in mathematics, ultimately affecting their academic and professional futures.

The Problem: Pedagogical Practices Contributing to Students' Mathematics Disengagement
Numerous studies have documented widespread disengagement with mathematics among students. Rather than situating the issue solely with students, mathematics disengagement can be understood as a rational response to traditional pedagogical practices dominating mathematics classrooms. Hembree (1990) found mathematics anxiety affects a significant proportion of students, often leading to avoidance behaviors and diminished achievement. However, disengagement is not restricted to struggling students; even high-performing students frequently report a lack of enjoyment and intrinsic motivation (Eccles & Wigfield, 2002). This issue stems from students' limited opportunities to engage in meaningful and powerful learning experiences. Research also has shown that mathematics student engagement is malleable and influenced by teaching practices (Irvine, 2020; Zavala & Aguirre, 2023). Traditional approaches to mathematics education, which prioritize quick, accurate, and procedurally conforming solutions, can alienate students by focusing on rote learning rather than fostering deep conceptual understanding (Boaler, 2016, 2024). The roots of disengagement are in these historical and pedagogical choices, highlighting the need for instructional shifts that prioritize learning as an evolving process.

A Possible Solution: Rough Draft Math
Rough draft math (RDM; Jansen, 2020; Jansen et al., 2016) offers a potential solution to disrupting trends of student disengagement. Inspired by practices in writing instruction, where students are encouraged to produce and revise multiple drafts, RDM applies a similar approach to mathematical thinking. RDM teaching practices include (a) fostering a learning community that welcomes mistakes, unfinished thinking, and ideas in progress; (b) enacting tasks that invite students to share reasoning or multiple strategies; (c) highlighting strengths in students' drafts; (d) inviting students to revise; and (e) asking students to reflect on how their thinking changed (Jansen, 2020). In an RDM learning space, students can share their rough draft thinking verbally or through written work. By framing students' initial ideas as

rough drafts, teachers can create a classroom culture where exploring and making mistakes is normalized and valued. This process aligns with creating a safe classroom where learning from mistakes is safe (Lampert, 2001).

The RDM approach to teaching creates a learning environment that emphasizes growth in understanding over time. RDM is an example of an instructional approach that aligns with the growth mindset principles (Dweck, 2006), emphasizing that abilities can be developed through effort and practice. Educating students about a growth mindset and encouraging them to have one is not enough; students also need to experience a classroom where teaching practices communicate that growth and changes in their thinking are valued.

Purpose of the Study

In this study, we examined the impact of two relatively minimal interventions to support preservice and novice teachers learning about RDM. The first intervention involved engaging preservice secondary mathematics teachers (PSTs) in reading a journal article written for practitioners about RDM (Jansen et al., 2016) to investigate their perceptions of the RDM approach. The second minimal intervention explored novice secondary mathematics teachers' perceptions of RDM after reading an entire book about RDM (Jansen, 2020) and implementing the approach in their classrooms. We considered these interventions "minimal" because they were relatively low lifts for teacher–leaders to support teachers by engaging them in reading and subsequent reflections, in contrast with extensive coaching, for example. We wondered about the degree to which this minimal intervention could have impacts on PSTs' thinking, novice teachers' thinking, and novice teachers' practice. The study sought to provide valuable information about PSTs' and novice secondary mathematics teachers' perceptions of RDM under different conditions, such as exposure to RDM through reading a short article, a more in-depth study through reading an entire book, and attempts to enact RDM in their classroom practices after completing the readings. Understanding the impact of different opportunities to learn from PSTs and novice secondary mathematics teachers' perceptions of RDM can inform mathematics teacher–leaders' practices.

LITERATURE REVIEW

Mathematics Anxiety and Its Impacts

Mathematics anxiety presents a significant barrier to student engagement and performance. It is characterized by feelings of tension, apprehension, and fear, interfering with students' abilities to manipulate numbers and solve mathematical problems in a wide variety of ordinary life and academic situations (Ashcraft & Krause, 2007). High levels of anxiety can lead to avoidance behaviors, where students resist taking advanced mathematics courses, participating in class discussions, or even attempting to solve problems (Hembree, 1990). Such avoidance also can result in a lack of foundational skills and a negative feedback loop, further entrenching students' fears and dislike of mathematics.

In a meta-analysis of 747 effect sizes from 1992–2018, Barroso et al. (2021) found a small-to-moderate, negative correlation between mathematics anxiety and mathematics achievement, moderated by factors such as grade level and types of mathematics assessments—with the effect starting in childhood and remaining significant through adulthood. In a meta-analysis of 177 studies involving 906,311 participants, Caviola et al. (2022) also found mathematics anxiety and test anxiety impacted mathematics performance significantly. Mathematics anxiety is often linked to a fear of making mistakes, which is tied closely to performance-avoidance goals (Skaalvik, 2018). Students with these goals strive to avoid situations where their peers might notice their struggles or mistakes in solving problems. Mathematics anxiety and test anxiety are highly correlated with one another (Kazelskis et al., 2000), so students may be anxious about being wrong while anxious about performing well when doing mathematics. Reducing the pressure of these experiences when students feel judged for not being immediately correct might decrease students' avoidance of challenging learning opportunities. In a study of 2,551 secondary students, Fiorella et al. (2021) found test anxiety was correlated negatively with mathematics achievement. Additionally, in a meta-analysis of 57 studies, Finell et al. (2022) found a negative correlation between mathematics anxiety and mathematics performance, confirming working memory significantly mediated this relationship. We posit that RDM could reduce pressure for students to be correct during initial attempts at mathematics problem solving (a) if students' rough drafts are treated as valuable resources for everyone's learning and (b) if multiple attempts are welcomed via opportunities for revision in mathematics classes.

Engagement and Discourse in Mathematics Classrooms

Engaging in mathematical discourse is essential for fostering deeper conceptual understanding and enhancing learning outcomes. Kazemi and Stipek (2001) emphasized the role of sociomathematical norms (i.e., requiring students to explain their reasoning and explore connections among strategies) in promoting meaningful mathematical discussions. These practices encourage students to articulate their thinking, justify their solutions, and engage with their peers' perspectives. Boaler (2016, 2024) further highlighted that traditional approaches often prioritize procedural fluency, neglecting the critical value of dialogue in understanding mathematical concepts. By integrating discourse into instruction, teachers create a collaborative learning environment where students feel supported in navigating challenges and developing a more profound mastery of mathematics.

Revising, as part of mathematical discourse, plays a crucial role in refining and deepening understanding. Errors and misunderstandings, when addressed openly, become valuable opportunities for the reconceptualization and exploration of alternative strategies (Kazemi & Stipek, 2001). Boaler (2016) noted encouraging students to view revision as a natural and essential part of the learning process helps shift their focus from correctness to growth and discovery. In this context, discourse allows students to reexamine their solutions, compare them with peers, and refine their ideas collaboratively. As Boaler (2024) later suggested, such iterative processes nurture mathematical mindsets by normalizing mistakes and emphasizing perseverance and creativity in problem solving. Through this cycle of discussion and revision, students enhance their understanding and develop a resilient and confident approach to learning mathematics.

The Concept of Rough Drafts in Education

The idea of using rough drafts is well established in writing instruction, where teachers encourage students to produce multiple drafts of their work, receive feedback, and make revisions. This process helps students develop their ideas and improve their writing skills over time (Murray, 1972). Applying a similar approach to mathematics can help students view their initial ideas as a starting point for further exploration and refinement rather than as final products to be judged and graded (Jansen, 2020; Jansen et al., 2016).

The process of rough drafts and revising in mathematics was inspired by the concept of exploratory talk (Barnes, 2008). As Barnes (2008) described, students often experience classroom discussions as being asked to perform what they know, which can feel like a final draft; however, if students engage in open discussion and the community learns together, this process feels more exploratory. When the second author read about exploratory talk with secondary teachers, they decided to rename Barnes's idea of exploratory talk as "rough draft talk" (Jansen et al., 2016), because they conjectured that the label of rough draft talk might carry more meaning for students than the label of exploratory talk. If discussions are referred to as rough draft talk, students can view classroom discussions as sites for continued learning rather than performing what they know for others. Rough draft talk conversations can help students revise their thinking while learning in community with and from their peers and teachers.

RDM in Practice

RDM involves several key practices that support mathematical discourse and student engagement. These practices include (a) fostering a learning community where mistakes and unfinished thinking are accepted, (b) enacting tasks that invite students to share their reasoning and strategies, (c) highlighting strengths in students' drafts, (d) inviting students to revise their work, and (e) asking students to reflect on how their thinking has changed (Jansen, 2020). Rathouz et al. (2023) found framing online discussion boards as RDM learning spaces encouraged every student to share their diverse mathematical approaches, perspectives, and ideas. Thanheiser and Jansen (2016) also showed how providing learners the opportunity to consider their perceptions of the completeness and correctness of their work before sharing it publicly helped learners feel more comfortable sharing. As a result, learners recognized the value of sharing, and their metacognitive skills improved. These prior studies conducted in mathematics educators' courses at the university level also have focused on engaging future teachers in RDM within the context of learning mathematics for teaching; however, there is still much for mathematics education leaders to understand about how to support future teachers' learning about RDM in pedagogical methods courses for teaching mathematics.

Teachers' Perceptions of Teaching Approaches and Their Impact on Implementation

Understanding mathematics teachers' perceptions of an instructional approach (e.g., RDM) is essential for facilitating its successful implementation. Such understanding enables educational communities to provide targeted support, address barriers, and customize approaches to fit various educational contexts, ultimately leading to improved teaching and learning outcomes. Several strands of educational research have substantiated the need to understand mathematics teachers' perceptions of a teaching approach to support their effective implementation of that approach.

First, teachers' perceptions influence their teaching practices and willingness to adopt new methodologies significantly. According to Pajares (1992), teachers' beliefs about education are linked closely to their instructional decisions and classroom behaviors. When math teachers view a teaching approach favorably, they are more likely to implement it with fidelity, subsequently enhancing its potential benefits for student learning (Richardson, 1996).

Moreover, understanding teachers' perceptions helps identify potential barriers to implementation. Beswick's (2007) research indicated teachers often face external and internal barriers when integrating new teaching approaches. External barriers include a lack of resources and support, whereas internal barriers involve beliefs and attitudes toward the approach. By understanding these perceptions, educational leaders can address specific concerns, tailor professional development (PD) programs, and provide the necessary resources to overcome these barriers.

Additionally, teachers' perceptions are crucial for adapting teaching approaches successfully to different educational contexts. As Spillane et al. (2002) pointed out, teachers interpret and adapt new approaches based on existing knowledge, experiences, and specific needs of their students. Understanding these perceptions allows for the customization of support strategies, ensuring the teaching approach is integrated effectively into diverse classroom environments (Darling-Hammond & Bransford, 2007).

Furthermore, research by Fullan (2001) emphasized that change in educational practice is a complex process that requires understanding and addressing teachers' subjective experiences. Teachers' perceptions provide valuable insights into the practical challenges and successes they encounter, thereby informing more effective and sustainable support mechanisms. To understand teachers' perceptions of RDM, we investigated how PSTs and novice teachers made sense of RDM after reading about the approach, including how novice teachers reported enacting RDM after the readings.

Research Questions

We addressed the following research questions for this study:

1. What are PSTs' initial perceptions and understandings of RDM before their internship?
2. How do PSTs' perspectives on RDM evolve after gaining classroom experience?

3. Which RDM teaching practices do PSTs and novice teachers find most salient, feasible, and challenging, and what are the reasons behind their choices?
4. What factors influence PSTs' and novice teachers' decisions to implement RDM practices, and how do these factors shape their teaching approaches?

METHODS

Opportunities for Teachers to Learn About RDM

We conjectured that exposing PSTs to the RDM approach through the minimal intervention of reading and reflecting on an article (Jansen et al., 2016) would plant a seed that could potentially grow during their field experiences. We anticipated PSTs might be skeptical, especially if they had not experienced RDM approaches as mathematics students. We thought experiencing RDM as students would help preservice teachers better understand the approach. Therefore, the first author modeled the RDM approach during participants' university coursework throughout the study. We were also concerned that participants may become more skeptical after attempting to implement RDM approaches in their classrooms. Given our concerns, the first author asked the second group of novice teachers to read and discuss the full *Rough Draft Math: Revising to Learn* book (Jansen, 2020). We conjectured that reading and discussing the book would have a positive impact on novice teachers' confidence, knowledge, and skills. Although we anticipated all teachers would desire some support in implementing the approach, we were uncertain which practices teachers would consider most challenging to implement.

Participants

The study involved 19 secondary mathematics teachers from a rural region in the southern United States. All participants were enrolled in mathematics education programs at a large research institution in the southern United States. Thirteen participants were undergraduate seniors enrolled in a secondary mathematics teacher preparation program. These 13 PSTs were invited to participate in the study by reading an article about RDM (Jansen et al., 2016) and providing reflections in an individual online assignment immediately after the reading. The reading and reflection assignments were required course assignments in a teaching secondary mathematics course, which was taught by the first author; however, PSTs could elect whether to participate in the study. All 13 PSTs gave their consent to participate. Four of the 13 PSTs identified as men, and nine identified as women. Two of the 13 PSTs were Black, and 11 were White. The first author modeled the RDM approach throughout the course so PSTs could experience the approach from a student's perspective.

Six months later, 13 PSTs and six additional novice teachers who read the full RDM book (Jansen, 2020) were individually asked additional questions in an online assignment. By this point, PSTs had opportunities to implement the RDM approach during their full-time internships. The six novice teachers were enrolled in a graduate-level teaching secondary mathematics course, also taught by the first author. One of the six novice teachers obtained her teaching license through an undergraduate secondary mathematics education teacher preparation program. This novice teacher was in her 4th year of teaching secondary math. The five other novice teachers had earned bachelor's degrees in kinesiology, information technology, physics, business administration, and meteorology; were each in their 1st years of teaching; and had obtained their secondary mathematics teaching licenses through an alternate route graduate degree program. All six novice teachers were White. Four novice teachers identified as men, and two identified as women. All worked at rural public schools. The six novice teachers were also invited to participate in the study by reading a book about RDM (Jansen, 2020) and sharing their reflections. All six novice teachers gave their consent to participate. As with the undergraduate course, the first author was the instructor and modeled the RDM approach throughout the graduate course so teachers could experience the approach from a student's perspective.

Positionality of Authors

The authors of this article are two mathematics teacher educators. The first author was the instructor of the undergraduate and graduate-level secondary mathematics education courses and designed follow-up prompts for the study in consultation with the second author. The second author was a recognized expert on the RDM approach, having authored an influential article and a book on the subject that teachers in this study read and discussed. We are strong advocates for the RDM approach, believing in its potential to influence students' beliefs and actions positively regarding mathematics. We both model RDM when we teach courses in mathematics education.

Still, we acknowledged the importance of ensuring the reliability of findings, particularly given our personal investment in the success of the RDM approach. To mitigate potential bias, we implemented several measures during the analysis. First, we engaged in reflexive practices, regularly discussing assumptions and ensuring we approached data with openness to positive and negative outcomes. We also employed member checking by seeking participants' feedback to validate the accuracy of our interpretations. Finally, we conducted peer debriefings with colleagues outside the project to scrutinize the findings further (Saldaña, 2013). These strategies helped to ensure results were grounded in the data and not overly influenced by personal RDM advocacy.

Data Collection

Data were collected through written reflections from the 13 participating PSTs and six novice teachers. To address Research Question 1 regarding PSTs' initial perceptions and understanding of RDM before their internship, the 13 PSTs who read an article about RDM (Jansen et al., 2016) responded to the following prompts:

1. What did you learn?
2. What did you find interesting?
3. A question you have.

To address Research Question 2 regarding how PSTs' perspectives on RDM evolved, 6 months after trying RDM with their mathematics students during their internships, four PSTs completing their full-time teaching internships responded to Prompt 4:

4. How has your thinking about RDM changed?

To address Research Questions 3 and 4 regarding which practices PSTs and novice teachers found most salient, feasible, or challenging—and what factors influenced their decisions to implement these practices in their classrooms—the four PSTs who were completing their full-time teaching internships and the six additional novice teachers who read the full RDM book (Jansen, 2020) responded to Prompts 5–8:

5. Which of the following RDM teaching practices do you consider salient (i.e., most important to you)? Why/how?
   a. fostering a learning community where mistakes, unfinished thinking, ideas in progress, and ideas that you are not sure about are okay;
   b. enacting tasks that invite students to share reasoning and/or multiple strategies;
   c. highlighting strengths in students' drafts;
   d. inviting students to revise; and
   e. asking students to reflect on how their thinking changed.

6. Which of the following RDM teaching practices do you consider feasible (i.e., most possible to put into practice in your classroom)? Why/how?
   a. fostering a learning community where mistakes, unfinished thinking, ideas in progress, and ideas that you are not sure about are okay;
   b. enacting tasks that invite students to share reasoning and/or multiple strategies;
   c. highlighting strengths in students' drafts;
   d. inviting students to revise; and
   e. asking students to reflect on how their thinking changed.

7. Which of the following RDM teaching practices would you like help with? Why/how?
   a. fostering a learning community where mistakes, unfinished thinking, ideas in progress, and ideas that you are not sure about are okay;
   b. enacting tasks that invite students to share reasoning and/or multiple strategies;
   c. highlighting strengths in students' drafts;
   d. inviting students to revise; and
   e. asking students to reflect on how their thinking changed.

8. What factors influence your decisions to use RDM or not? How and why do they influence your decisions?

The data corpus comprised 13 PST responses to Prompts 1–3, four PST responses to Prompt 4, and 10 responses (i.e., four PSTs and six novice teachers) to Prompts 5–8, resulting in 83 responses. We typed and organized the responses into a spreadsheet file to facilitate the coding process.

Data Analysis

We conducted a thorough examination of data using thematic analysis, as Braun and Clarke (2006) outlined. This method enabled us to uncover recurring patterns, overarching themes, and categories in the data set, providing a deeper understanding of PSTs' and novice teachers' responses (Braun & Clarke, 2006). Our analysis involved several key steps—(a) familiarizing ourselves with data, (b) coding, (c) developing themes, and (d) interpreting the findings—ensuring the process was rigorous and reliable (Nowell et al., 2017).

Once we identified codes, we shifted to deductive coding (Bingham & Witkowsky, 2022) to categorize responses. This step allowed us to organize data based on key themes identified in previous analyses. Subsequently, we analyzed data for representative and exceptional quotes to enrich our understanding of the PSTs' and novice teachers' perspectives. To ensure the consistency and accuracy of our analysis, two mathematics teacher–educators coded each response independently, working in an anonymous manner. Any discrepancies were resolved through collaborative discussions.

To uncover PSTs' initial perceptions and understanding of RDM before their internship (i.e., Research Question 1), we asked PSTs to read an article about RDM (Jansen et al., 2016) and share what they learned, found interesting, and questions they had. Overall, PSTs reported a perception that RDM can promote student confidence by creating a low-pressure environment conducive to risk taking and learning. Initially skeptical, they ultimately saw value in RDM talk as a strategy for improving student engagement and comfort with ambiguity; however, their concerns about implementation reflected the practical realities teachers can face in translating theory into practice, indicating successful adoption of RDM will likely require ongoing support and adaptation to various instructional contexts. Next, we elaborate upon this finding by sharing participants' voices.

RDM Fosters a Safe Environment for Risk Taking and Learning

PSTs consistently highlighted that RDM, particularly through RDM talk, provided students with a safe space to share their ideas without fear of being wrong. The participants perceived this sort of supportive atmosphere could help students feel comfortable taking risks, which would be critical for deeper learning and participation in mathematical discourse. For example, one PST stated, "It [RDM] allows the students to more comfortably share their thoughts and ideas about a given topic in math without having to worry about being wrong or right, which leads to higher confidence." Another PST shared, "RDM creates a more positive, safe classroom for thinking." PSTs recognized that RDM shifted classroom dynamics by reducing pressure to always be correct, fostering greater student engagement. This shift in classroom dynamics was seen as crucial for enhancing confidence, especially among students who typically felt hesitant to participate in class discussions.

Skepticism Evolving Into Appreciation of RDM's Impact
Many PSTs initially expressed skepticism about the efficacy of RDM talk in promoting meaningful classroom participation; however, after reflecting on the positive student responses presented in the article, they came to appreciate how RDM normalized mistakes as part of the learning process, thereby validating students' contributions regardless of correctness. For example, one PST shared, "I was a little skeptical at first. . . . But the quotes from the students [in the 2016 article] about how this strategy made them feel okay with being wrong made me believe that this would work." This shift from doubt to acceptance underscored how evidence of student experiences can reshape teacher perceptions. PSTs moved from questioning RDM's feasibility to recognizing its potential for cultivating a more inclusive and reflective classroom environment.

Concerns About Practical Implementation
Although PSTs appreciated the pedagogical value of RDM, they also raised concerns about its practical application. Key considerations included the time required to implement RDM talk, how it might fit into different subject areas, and its scalability across grade levels. For example, one PST stated, "How much time does this take out of the classroom, and is the amount it takes harmful against lecture time, or other time to be practicing problems?" Although PSTs were intrigued by RDM's potential, their concerns about logistical challenges suggested the need for further PD to integrate such practices into diverse classroom contexts effectively. Their reservations highlighted the balance between instructional innovation and practical feasibility.

Research Question 2
To uncover how PSTs' perspectives on RDM evolved 6 months later, after gaining classroom experience (i.e., Research Question 2) and trying the RDM approach in their classrooms during their teaching internship, we asked the PSTs how their thinking about RDM had changed. Overall, PSTs' perspectives evolved to reflect a more realistic understanding of RDM's application. Although they continued to believe in its potential to create a supportive learning environment, they also recognized the need for more active teacher involvement to overcome student resistance and facilitate deeper engagement. This finding highlighted the importance of scaffolding in RDM practices to help students become more confident and independent thinkers. We elaborate further on this finding by sharing participants' voices next.

Even after gaining classroom experience, PSTs maintained their belief that RDM can foster a positive, low-stress atmosphere conducive to student participation. These participants continued to view RDM as a valuable tool for encouraging students to engage in mathematical thinking without fear of making mistakes. Their initial understanding of RDM as a strategy for reducing student anxiety and promoting open discussion appeared to persist throughout their internship experiences; for example, one PST stated, "I still think it fosters a less stressful environment for students. I would still want to foster this mindset in my classroom." PSTs remained committed to using RDM to cultivate a safe space for student expression and risk taking, even as they recognized challenges of implementing it consistently.

Realizing the Challenges of Student Engagement and the Need for Scaffolding
Although PSTs upheld the benefits of RDM, their classroom experience highlighted practical challenges in student engagement. The participants observed many students were hesitant to take risks, struggled to start solving problems independently, and often required teacher intervention to begin their thought processes. Classroom experiences deepened PSTs' understanding of RDM's limitations when applied in practice. The PSTs realized although RDM can establish a supportive environment, the approach does not lead to active student engagement automatically. For example, one PST shared, "I have noticed that students do not know where to start when answering problems. Oftentimes, I have to ask students questions about the problems to start their thought process." These participants also recognized teachers need to provide additional scaffolding (e.g., asking guiding questions) to help students overcome hesitation and initiate their problem-solving efforts.

To address Research Question 3, we asked interning PSTs and novice teachers which RDM practices they found most salient, feasible, and challenging. PSTs and novice teachers clearly valued the practice of fostering a learning community where mistakes are embraced, viewing it as essential for creating a supportive classroom atmosphere. This practice increased student participation and laid groundwork for other RDM strategies to be effective. PSTs and novice teachers found inviting students to revise their work as the most feasible RDM practice, believing it fit well with their existing classroom routines and assessments. In contrast, encouraging students to reflect on their thinking posed a significant challenge, as it required deeper engagement and metacognitive skills with which students often struggled. This tension between fostering a supportive environment and promoting more complex cognitive tasks highlighted the need for further strategies and support to encourage reflection in students. Further elaboration and participant voices that reflected these findings are presented next.

Salient Practice: Fostering a Learning Community That Embraces Mistakes
PSTs and novice teachers overwhelmingly identified the importance of creating a classroom environment where mistakes, unfinished ideas, and ongoing thinking are accepted and encouraged. These participants viewed this practice as crucial for promoting student engagement, confidence, and intellectual risk taking. Many participants believed fostering this supportive community was the foundation for other RDM practices to succeed. PSTs and novice teachers saw fostering a mistake-friendly classroom culture as the most important RDM strategy. One representative quote was, "I think fostering a learning community where mistakes are okay is the most salient to me. This allows your students to feel safe in your classroom just as they should at home." Another participant said, "If the teacher can provide or create this [community],

then the others [RDM practices] will happen. Without it, I do not think [the other RDM practices] will happen naturally." The participants believed when students felt safe to make mistakes, they were more likely to engage in learning and share their reasoning, thereby deepening their understanding. This practice was seen as a prerequisite for other RDM activities, such as revision and reflection.

Feasible Practice: Inviting Students to Revise Their Work

When considering feasibility, PSTs and novice teachers found the practice of inviting students to revise their work to be the most actionable in their classrooms. They perceived this practice as easy to implement, often integrating revisions into assessments like quizzes and tests. PSTs and novice teachers appreciated the opportunity revising provided for students to learn from their mistakes and improve their understanding. They also viewed revision as a natural extension of fostering a supportive environment. PSTs and novice teachers found inviting students to revise their work highly feasible because they could incorporate it seamlessly into existing classroom structures, such as assessments. One participant reported, "Inviting students to revise would be one of the most feasible ones to put into practice. It would be easy to give students a quiz or test and ask them to revise any incorrect responses." Another participant wrote, "This [inviting students to revise] allows higher scores than just taking [assessments] at face value." Participants appeared to perceive that inviting revisions encouraged deeper learning by giving students additional opportunities to reflect on and improve their work, making it a practical and beneficial practice in the RDM framework.

Challenging Practice: Encouraging Student Reflection

One of the most challenging RDM practices for PSTs and novice teachers was engaging students in reflecting on how their thinking had changed. PSTs and novice teachers struggled with students' reluctance or difficulty articulating their thought processes, particularly in mathematics, where metacognition could be less natural for many students due to a lack of opportunities to reflect on their learning. Participants also discussed facing challenges in helping students see the value of reflecting on and learning from their mistakes. One participant wrote, "Asking the students to reflect on how their thinking changed is hard . . . students have a difficult time articulating their thoughts." Another wrote, "I think actually having students pinpoint how their actual thinking changed is hard for multiple reasons, but mostly due to students having a difficult time articulating their thoughts." PSTs and novice teachers found encouraging students to reflect on their thinking particularly difficult, as it required students to engage in metacognitive processes that many found uncomfortable or unnatural. The challenge was not only in getting students to reflect meaningfully but also in helping them recognize the importance of this reflection in their learning. Teachers expressed a need for strategies to facilitate and support student reflection.

Research Question 4

To address Research Question 4, we asked interning PSTs and novice teachers what factors influenced their decisions to implement RDM in their classrooms. Findings indicated PSTs and novice teachers were influenced deeply by their students' engagement levels when deciding to implement RDM practices. Their desire to create a supportive and mistake-friendly environment reflected their commitment to fostering student learning. However, time constraints and standardized testing pressures posed significant challenges that at times limited their effective RDM implementation. PSTs and novice teachers needed to navigate these challenges while balancing their pedagogical ideals with the practical realities of classroom constraints, suggesting a need for systemic changes that support more flexible teaching approaches.

Student Engagement and Responses as Driving Factors

Students' engagement and responsiveness are significant factors influencing PSTs' and novice teachers' decisions to implement RDM practices. PSTs and novice teachers expressed that their strategies were heavily guided by how students reacted to different teaching methods. For instance, when students showed interest and participation, teachers were more likely to continue using RDM practices. Conversely, apathy or disengagement from students prompted participants to reconsider or modify their approaches. One participant shared, "As a teacher, you have to know your students and what they respond to positively. I think ultimately how my students respond influences whether I use RDM throughout the class or not." Another participant wrote, "The responses I receive from my students influence my decisions to use RDM. If my students respond well to a strategy, I will continue using it." PSTs and novice teachers emphasized that understanding their students' needs and preferences is crucial for effective RDM implementation. Participants highlighted the importance of creating a classroom culture where mistakes were viewed positively because it allowed students to feel comfortable engaging in the learning process. Such awareness drove PSTs and novice teachers to adapt their methods based on student feedback, ultimately fostering a more interactive and supportive learning environment; however, novice teachers may not have recognized the significant influence they had on their students' responses to the RDM practices. If their students resisted RDM initially, they could engineer experiences where students experience the benefits of RDM, leading them to recognize RDM's values.

Time Constraints and Curriculum Alignment as Challenges

Although PSTs and novice teachers recognized the potential benefits of RDM, they also cited significant challenges that influenced their decisions. Time constraints, driven primarily by testing schedules and curriculum demands, were mentioned frequently as barriers to implementing RDM practices fully. PSTs and novice teachers expressed concern that the structured nature of state testing often limited their ability to allow for open discussions, revisions, and collaborative learning experiences, which are central to RDM. A participant reported, "The biggest factor in using RDM is time constraints and simplicity of information... sometimes information and problems presented do not align themselves well with RDM." Another participant wrote, "Several of the ideas [from RDM] seemed achievable, but there are many time constraints due to state testing schedules." The perceived pressure of curriculum requirements and standardized testing appeared to shape how these early career teachers approached RDM. Many participants felt the rigidity of their schedules did not align with the more flexible, discussion-oriented nature of RDM practices. Consequently, this mismatch could deter them from incorporating RDM strategies, as they prioritized covering essential content over facilitating a more open learning environment. However, if teachers do not invest time in having students draft and revise, students may not develop a full understanding of the material, and teachers may need to spend time reteaching it. Accordingly, investing time to draft and revise thinking in mathematics may be worth it.

Comparing PSTs and Novice Teachers

Both novices and PSTs indicated they valued RDM and used RDM practices; however, novices reported a more comprehensive integration of RDM into their teaching practices than PSTs. Novices also reflected on the transformative impact RDM practices had on their students' learning. Novices demonstrated a nuanced understanding of RDM practices and the purpose of enacting RDM practices. Novices connected RDM practices to fostering student confidence and deeper engagement. One novice stated, "I want students to see the progress in their abilities as well as know that my focus is on their progress and not just their initial thoughts." This quote highlighted the novice's commitment to prioritizing growth over correctness. Another novice reflected, "Students need to feel comfortable enough in class to make mistakes but still share their reasoning with other students to form deeper understanding." This quote demonstrated the novice's understanding of how RDM fosters collaboration and exploration. By explicitly recognizing the role of mistakes and revisions in conceptual learning, the novices illustrated their integration of RDM practices into their broader instructional goals.

In comparison, PSTs often focused on the logistics of implementing specific RDM practices but lacked deeper connections to the impact on student learning. One PST noted, "I think fostering a learning community where mistakes are ok is the most salient to me. I think this allows your students to feel safe in your classroom just as they should at home." Although this response indicated the PST valued their students' emotional safety, the participant failed to elaborate on the implications for mathematical thinking. Another PST described challenges with promoting student reflection, stating, "It is kind of hard to get students to reflect on their thinking or see how it has changed." This response indicated the PST struggled to implement a key RDM practice effectively. Although PSTs recognized the value of RDM practices, their reflections often highlighted difficulties in execution, suggesting their understanding of how to leverage these practices to support deeper learning remains in development.

Discussion

Findings from this study illuminated critical insights into the implementation of RDM practices among PSTs and novice teachers, revealing the perceived effectiveness of varied approaches to introducing RDM to teachers and challenges they reported encountering during classroom implementation. One significant discovery was the marked disparity in effectiveness between the different approaches to introducing RDM, particularly the advantages of reading a full-length book on RDM compared to a single article on RDM. The depth and comprehensive nature of the book appeared to foster a more profound understanding of RDM practices and philosophies among novice teachers compared to reports from preservice teachers. Although the article provided valuable introductory information, the book allowed novice teachers to engage with the material in more meaningful ways, encouraging them to delve into specific case studies, reflective exercises, and practical strategies for implementation. Such an in-depth exploration equipped the teachers with a broader range of tools and insights to adapt to their unique classroom contexts. The greater depth of understanding demonstrated by novice teachers compared to PSTs may also be attributed to their extended time in the field and their status as more experienced, older students. This insight reinforced the importance of mathematics education leaders selecting professional learning materials that align with the developmental needs of educators. Mathematics teacher leaders should consider integrating full-length texts as foundational elements of PD programs while designing supplementary guided discussions and reflections to deepen teacher learning.

Moreover, this study underscored that PSTs' and novice teachers considered it critically important to cultivate a supportive learning environment that emphasizes the acceptance of mistakes and unfinished thinking as part of the learning process. PSTs and novice teachers consistently expressed a desire to create classrooms where students feel safe taking risks and learning from their errors, aligning with RDM's foundational principles. Data reflected that many PSTs and novice teachers perceived fostering such an environment can boost student engagement and enhance the overall learning experience. This insight emphasizes the responsibility of mathematics education leaders to model these practices in PD sessions. Teacher–leaders should demonstrate how fostering a community of learners—where risk taking and revision are valued—can transform classroom cultures to align with the principles of RDM. By doing so, PD can serve as a mirror for classroom practices leaders hope to see implemented by teachers.

However, PSTs and novice teachers experienced challenges when implementing RDM, particularly concerning time constraints and curriculum alignment. This study revealed many novice teachers perceived and experienced systemic pressures, particularly from standardized testing schedules, which often limited their opportunities to engage their students in the reflective and collaborative processes essential to RDM. Several novice teachers noted the rigid nature of their curricular requirements sometimes clashed with RDM's ideals, making it difficult to incorporate practices that encouraged discussion and revision. This finding echoed previous studies (Horn, 2012; Lampert et al., 2010), highlighting the tension between ambitious instructional practices and institutional constraints. Mathematics education leaders must advocate for policies that allow flexible teaching methodologies and promote practices such as RDM, emphasizing the value of reflection and collaboration. By collaborating with policymakers and district leaders, teacher–leaders can work to reduce systemic barriers and create conditions for sustained implementation of RDM.

Another critical theme emerging from the data was the influence of student responses and behaviors on teachers' decisions to adopt RDM practices. Many PSTs and novice teachers articulated the level of student engagement and willingness to embrace mistakes impacted their commitment to implementing RDM in their classrooms significantly. This relationship is vital because it emphasizes the need for teacher–leaders to prepare PSTs and novice teachers to cultivate a classroom environment that encourages risk taking and open communication. Building on prior literature (Boaler, 2016; Jansen et al., 2024), this study highlighted how teacher–leaders can leverage PD opportunities to equip educators with strategies to implement RDM practices. For example, teacher–leaders might include explicit training on inviting revisions, purposeful task selection, and reframing mistakes as learning opportunities in professional learning communities (PLCs), which can help teachers see RDM practices as salient and feasible (Jansen et al., 2024).

The small sample size of this study presented limitations that also warrant discussion. Although findings provided significant insights into participants' perceptions and practices, their generalizability across broader contexts remains uncertain. Future researchers should aim to include a larger and more diverse cohort of participants to strengthen the validity of the findings and provide a richer data set for analysis. Incorporating a pre- and post-survey also would have enhanced our ability to measure changes in PSTs' and novice teachers' thinking before and after engaging with the article or book and applying RDM in their classrooms. Such a survey would have facilitated a clearer understanding of their shifts in perspectives and practices resulting from exposure to RDM. This recommendation aligns with frameworks for measuring teacher growth, such as those Guskey (2002) proposed, which emphasize the need for longitudinal data collection to capture the sustained impact of PD. Furthermore, longitudinal studies could provide insights into how participants implement RDM practices over time and how their perceptions evolve as they gain experience. A comprehensive approach to research on RDM could reveal consistent patterns and challenges in early career teachers, which can provide insight to inform the design of more targeted interventions to support teachers' learning.

In light of these findings, future iterations of the intervention should be redesigned to incorporate more interactive components, such as collaborative workshops or peer mentoring opportunities, alongside reading assignments. These elements would encourage PSTs and novice teachers to engage more actively with the material and learn from one another's experiences. Providing opportunities for real-time practice and feedback on RDM implementation also can better prepare these educators for the complexities of teaching mathematics. Technology-based tools, such as virtual coaching platforms or asynchronous forums, could facilitate sustained educator collaboration, further enhancing professional growth. Mathematics education leaders can play a pivotal role in facilitating these initiatives, ensuring teacher preparation programs and PD offerings are grounded in research-based principles and adapted to meet the contextual needs of teachers.

For example, since conducting this analysis, the second author has been experimenting with supporting PSTs by having more explicit engagement with RDM. In a recent pedagogical methods course for middle school PSTs, the second author modeled a discussion with PSTs about the value of rough drafting and revising in mathematics class. Then, the second author engaged PSTs in a mathematics learning experience that involved drafting and revising, which has happened regularly throughout the semester. At the end of the mathematics experience, PSTs reflected on how their thinking changed and the value of revising. Then, in their field placements or internships, PSTs (a) engaged their own middle school students in a conversation about rough drafts and revising; (b) enacted a three-act math task that involved establishing a problem to investigate through noticing and wondering, estimating possible answers, and then revising their thinking; and (c) had their students reflect on how their thinking changed. Their reflections from their practice were initially promising, but future analyses on this approach's effectiveness in teacher education are needed. Experiencing explicit modeling of what they can do with their students and immediately applying this approach in a classroom could impact PSTs' and novice teachers' learning to enact RDM.

This study highlighted the effectiveness of varied approaches to introducing RDM among PSTs and novice teachers. Implementation challenges, particularly regarding time constraints and student engagement, necessitate systemic support and comprehensive training in RDM philosophies. Mathematics teacher leaders can better equip future educators to embrace RDM practices by (a) redesigning the intervention to emphasize depth of understanding through reading the longer book rather than only the shorter article; (b) fostering collaborative learning environments, so PSTs and novice teachers experience RDM as learners and providing opportunities for immediate enactment of RDM in a classroom after reading about it; and (c) addressing implementation barriers. This approach to teacher preparation has promise for cultivating classrooms that prioritize growth, learning, and resilience in hopes of leading to improved mathematical understanding and confidence among students. The goal of mathematics teacher–leaders moving forward should be to create an educational ecosystem that nurtures both teachers and students, fostering an environment where every learner feels empowered to engage deeply with mathematics, learn from their mistakes, and develop a love for learning that lasts a lifetime.

Conclusion

This study explored PSTs' and novice teachers' perceptions of RDM and its potential impact on student beliefs and actions. Findings suggest the minimal intervention of exposure to the RDM approach through reading an article (Jansen et al., 2016) can catalyze changes in PSTs' perceptions. After implementing RDM practices, PSTs continued to view RDM as a promising approach to address longstanding challenges in mathematics education, such as student disengagement, anxiety, and underperformance. By creating a learning environment where mistakes, unfinished thinking, and ideas in progress are accepted, PSTs perceived that RDM fostered a comfortable and engaging atmosphere for students to participate in mathematical discourse. The RDM approach aligns with principles of a growth mindset, encouraging students to view their abilities as malleable and capable of development through effort and practice. Results also revealed the teacher plays a critical role in facilitating RDM practices effectively. PSTs and novice teachers believed adopting a nonevaluative stance, highlighting strengths in students' drafts, and inviting them to revise their thinking were key strategies for supporting meaningful mathematical discourse and learning.

However, the PSTs' and novice teachers' responses also revealed potential challenges in implementing RDM, such as engaging all students in sharing their reasoning, providing constructive feedback on incomplete work, and eliciting meaningful self-reflection from students. Practical constraints, such as time limitations and curriculum transitions, may also influence the feasibility of adopting RDM practices. Despite these challenges, the potential benefits of RDM in improving student engagement, confidence, and learning in mathematics warrant further exploration and support. Results revealed reading and discussing the full book (Jansen, 2020) enhanced novice teachers' knowledge, skills, and confidence. PSTs and novice teachers also expressed a desire for support in implementing the approach. Ongoing PD and collaboration among teachers could help address the identified challenges and facilitate the effective integration of RDM into classroom practices. Future research could examine the long-term impacts of RDM on student outcomes, such as academic achievement, mathematical confidence, and attitudes toward the subject. Investigating the strategies and classroom practices that support the successful implementation of RDM also could provide valuable insights into teacher education and PD. This study builds on prior literature by highlighting the effectiveness of tailored approaches to introducing RDM among PSTs and novice teachers while addressing challenges hindering implementation. By expanding PD to emphasize depth of understanding through texts, fostering collaborative learning experiences, and providing immediate opportunities for classroom enactment, mathematics education leaders can better support educators in adopting RDM practices.

This work contributes to an emerging vision for mathematics education—one that prioritizes teacher agency, student engagement, and equitable practices to create vibrant learning environments for all. In conclusion, RDM offers a promising approach to address the multifaceted challenges that mathematics educators face. By creating a safe and supportive learning environment, fostering mathematical discourse, and promoting a growth mindset, RDM has the potential to engage students, build their confidence, and enhance their learning experiences in mathematics classrooms. We hope the analysis of how minimal interventions supported PSTs' and novice teachers' learning provides insight for other mathematics teacher leaders who want to support teachers with enacting RDM.

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DISTRICT LEADERS IN SUPPORT OF COACHES

EXAMINING DISTRICT MATHEMATICS LEADERS' SUPPORT FOR SCHOOL-BASED MATHEMATICS COACHES

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ABSTRACT

Mathematics coaching differs significantly from mathematics teaching, and many coaches transition to the role directly from teaching with limited opportunities to learn to work effectively with teachers. Although coach professional development can provide one source of support for coaches' learning, coaches might also benefit from close work with other accomplished facilitators of teachers' learning, such as district mathematics leaders. This study analyzed interviews with 15 district mathematics leaders to understand whether and how they supported school-based mathematics coaches. We found 13 of 15 leaders worked closely with coaches to support them, and we identified seven ways they did so (e.g., classroom visits with coaches). Our findings have significance for research on district leadership and district leaders' support for coaches.

Keywords: mathematics coaching, professional development, district leadership

Teaching that supports students' attainment of rigorous mathematics learning goals is highly challenging, complex work that involves, among other things, eliciting, attending to, and making use of students' reasoning (Lampert et al., 2010; National Council of Teachers of Mathematics, 2014). This kind of teaching differs significantly from the kind of instruction often seen in many U.S. mathematics classrooms (Schoenfeld, 2022; Stigler & Hiebert, 2009), meaning many mathematics teachers will require support for their learning if they are to teach in ways that can support students' mathematics learning. Schools and districts in the United States frequently support teachers by employing mathematics coaches, who work directly with teachers to help them improve their teaching and thus students' learning (Kraft & Hill, 2020; Russell et al., 2020).

Mathematics coaches are often hired because of their experience and prior successes as teachers (Chval et al., 2010). Yet, the work of mathematics coaching differs significantly from that of mathematics teaching (Kane & Saclarides, 2023; Saclarides & Kane, 2023), and mathematics coaches often transition to the role directly from the classroom with limited opportunities to learn the coaching-specific knowledge, perspectives, and practices necessary to support teachers' learning effectively (Stein et al., 2022). Many mathematics coaches therefore require support for their *own* learning if they are to provide teachers with the quality of coaching that can support improvements in mathematics teaching and learning (Kane & Saclarides, 2023; Saclarides & Kane, 2023).

One common type of support for coaches is pull-out professional development (PD), which we consider off-site coach PD that takes coaches from classrooms and schools to participate in self-contained training sessions or courses (Kane & Saclarides, 2022; Stein et al., 2022). However, mathematics coaches might also benefit from more individualized support through collaborative work with other accomplished facilitators of mathematics teachers' learning. District mathematics leaders (DMLs) are educators who bear significant responsibility for mathematics learning and teaching in a district (Bolyard & Baker, 2024) and who often design and facilitate PD for teachers. Because of their assumed expertise in math instruction and facilitating PD for mathematics teachers, DMLs may be uniquely positioned to work closely with school-based mathematics coaches to aid coaches in supporting teachers' learning. Yet, it is unclear how common it is for DMLs to work directly with school-based mathematics coaches and what that work might look like, especially considering the wide variation in district contexts (e.g., size, demographic makeup, distance to city center) across the United States.

In this paper, we report on a study examining DMLs' perceptions regarding the support they provide—or do not provide—to mathematics coaches. We share findings related to DMLs' perceptions of the percentage of time they work directly with school-based mathematics coaches. We also report on the ways in which DMLs reported to have interacted with school-based mathematics coaches. Because, as we discuss later, such interactions could constitute coach learning opportunities, their identification marks a key step toward a broader research agenda focused on DMLs' efforts to support school-based mathematics coaches' learning.

CONCEPTUAL GROUNDING

Mathematics Coaching

Mathematics coaching is a form of job-embedded support for mathematics teachers' learning that is becoming increasingly common in U.S. schools and districts (Kraft et al., 2018). Mathematics coaches, who are intended to be accomplished mathematics educators, work closely with teachers on activities central to the work of teaching (e.g., planning for lessons, implementing instructional activities, analyzing students' work). The primary goal of mathematics coaching is to support teachers in developing the effective and equitable instructional practices necessary to support all students' mathematics learning (Kraft & Hill, 2020; Russell et al., 2020). The conceptual rationale for mathematics coaching is based on the notion that working with an accomplished colleague on activities relevant to one's work can support professional learning (Lave & Wenger, 1991). Empirically, research has shown that coaching can support teachers' development when it is sustained and coaching interactions are of high quality (Gibbons & Cobb, 2017; Russell et al., 2020; Saclarides & Munson, 2021).

Prior research on coaching has identified coaching activities that can support teachers' learning (Gibbons & Cobb, 2017). These potentially productive coaching activities include, for example, modeling instruction, coteaching, and conducting one-on-one coaching cycles with teachers (Russell et al., 2020; Saclarides & Munson, 2021). Yet, the learning potential of these activities depends on when and how coaches enact the activities with teachers (Gibbons & Cobb, 2016). Further, the learning potential of coaching writ large depends, in part, on the extent to which coaches and teachers have opportunities to engage in sustained interactions together (Blazar & Kraft, 2015). We can conclude effective coaching requires coaches to develop, among other things, expertise in facilitating potentially productive coaching activities and in navigating schooling contexts to create sustained opportunities to engage teachers in such activities.

Yet, many mathematics coaches transition to the coach role directly from the classroom with limited opportunities to develop such coaching-specific expertise before starting their work with teachers (Stein et al., 2022). The transition from teacher to coach requires a significant adjustment in professional identity, skill set, and approach (Gallucci et al., 2010). Coaches must navigate complex interpersonal dynamics, build trust and credibility, and adapt to new challenges in working with adult learners. Chval et al. (2010) emphasized that addressing these struggles requires systemic support, clear role definitions, and ongoing PD for coaches. It is therefore important for mathematics coaches to have opportunities to develop the expertise necessary to maximize coaching's potential and support mathematics teachers' learning (Kane & Saclarides, 2023; Saclarides & Kane, 2023; Stein et al., 2022).

Supporting Mathematics Coaches' Learning

Although several recent studies of coaching have examined the learning opportunities that can arise when coaches engage in traditional, pull-out PD (Kane & Saclarides, 2022; Saclarides & Kane, 2023; Stein et al., 2022), few studies have examined other types of professional learning activities that can support mathematics coaches beyond traditional pull-out PD. Coaches are likely to benefit from job-embedded supports that situate coaches' learning in their own contexts (Kochmanski & Recore, 2024), just as teachers benefit from similar forms of support (e.g., coaching and professional learning communities [PLCs]; Cobb et al., 2018). For example, mathematics coaches might benefit significantly from close work with other accomplished facilitators of mathematics teachers' learning, just as teachers can benefit greatly from working with other educators. Put another way, accomplished facilitators of mathematics *teachers'* learning could support coaches' learning, just as coaches (who are assumed to be accomplished teachers of students) serve in a similar capacity with teachers.

As noted previously, DMLs are education professionals who frequently design and facilitate PD for teachers (Jackson et al., 2015). Because many DMLs routinely facilitate PD for teachers, they likely have developed into accomplished facilitators of teachers' learning. Consequently, it is worth exploring whether and to what extent DMLs serve in a mentorship capacity for school-based coaches. However, the coaching literature provides little guidance on whether DMLs see working with coaches as a core function of their role nor on the amount of time they might work with coaches—if they do at all. Further, it is an open question as to *how* DMLs might work to support coaches' learning, if at all. Understanding whether, the extent to which, and how such leaders can support mathematics coaches' learning can provide greater clarity regarding how coaches can be supported to develop the coaching-specific expertise necessary to support mathematics teachers' learning.

Research Questions

The following questions informed our investigation of DMLs' work with school-based mathematics coaches:

1. What percentage of their time do DMLs perceive to be spent in support of school-based mathematics coaches?
2. In what ways do DMLs interact with school-based mathematics coaches, if they do at all?

METHODS

Study Context

We investigated our research questions in the context of an ongoing, larger research project funded by the National Science Foundation. The project aims to understand whether and how the design and use of professional learning resources can support large-scale improvements in mathematics teaching and learning across a state in the southeastern United States. A significant conjecture of the project is that educators at all levels of systems (e.g., teachers, school-based coaches, school-based administrators, district leaders) will benefit from collaborative efforts to design solutions to common problems of practice related to district-wide instructional improvement initiatives. In line with this conjecture, the project encourages actors at different levels of school and district systems to collaborate, making it a best case context to investigate whether and in what ways DMLs interact with school-based mathematics coaches.

As part of the broader project, researchers conducted 28 semistructured interviews with mathematics instructional leaders across the focal state. The interviewed instructional leaders included mathematics educators working in various roles (e.g., school-based mathematics coaches, teacher leaders who split their time between classroom teaching and other leadership activities, and DMLs). Interviews included questions designed to clarify with whom the instructional leaders worked in their contexts, the nature of that work, and the goals of their work. Consequently, DMLs' interview responses had the potential to provide rich information regarding their work with school-based mathematics coaches, thereby enabling us to answer our research questions.

Participants

Fifteen of the 28 instructional leader interviews were conducted with DMLs. These 15 participants accounted for our study sample. Though formal DML titles varied, all participating leaders stated they worked across schools, were employed primarily by a district, did not report to a principal, and were responsible for mathematics learning and teaching in the district. As shown in Table 1, participating DMLs worked in districts of varying sizes and locations within the focal state, with some leaders working in smaller, rural districts and others working in large, urban school districts. For this paper and to maintain participant anonymity, we considered a small district to be any district serving fewer than 15,000 students, a midsized district to be any district serving more than 15,000 students but less than 100,000 students, and a large school district to be any district serving over 100,000 students. We also included the per-student expenditures in Table 1. The per-student expenditures ranged from a low of just over $11,000 per student to a high of over $18,000 per student, and we classified them into three categories: (a) low, which was anything less than $13,000; (b) medium, which was anything greater than $13,000 and less than $15,000; and (c) high, which was anything over $15,000. Together, the 15 DMLs represent a variety of contexts in which DMLs work and enabled us to explore our research questions. All DMLs were part of a statewide initiative to bring together mathematics educators at different system levels to support large-scale instructional improvement in mathematics. Consequently, it was highly likely that the 15 participants would interact directly with school-based coaches in some capacity.

Table 1
Participants' Demographics

District leader	District type	District size	Expenditure per student
Karen	Rural	Small	Low
Jessica	Suburban	Mid-sized	Medium
Celeste	Suburban	Small	Medium
Jasmine	Urban	Mid-sized	Medium
Grace	Urban	Mid-sized	Medium
Alice	Urban	Large	Low
Greg	Urban	Large	Low
Will	Urban	Large	Low
Sasha	Urban	Mid-sized	High
Mary	Urban	Large	Low
Mabel	Rural	Small	Low
Scarlett	Rural	Small	Low
Quinn	Rural	Small	High
Mia	Rural	Small	Low
Nancy	Rural	Small	Medium

Note. Names are pseudonyms.

Data Collection

The primary data for this study were semistructured interviews with DMLs. Semistructured interviews were appropriate for this study because this type of interview enabled us to be responsive to ideas we heard from DMLs and thus press them to elaborate on and further explain their responses to the interview questions in an organic way. This approach ensured we collected rich data on their thoughts, beliefs, and perceptions with regard to their roles and work with educators in their district, including mathematics coaches. Each interview lasted roughly 60 minutes and was conducted by a research team member. Interviewers went through a 1-hour training session in which the designers of the semistructured interview protocol (see appendix) outlined the purposes of each interview question, shared sample prompts to elicit interviewees' thinking further, conducted a mock interview as a model, and reserved time for questions. Interviews were conducted virtually and in person, and we recorded all interviews for later analysis. We conducted one interview with each of the 15 DMLs. Interviews occurred over two rounds of data collection during the late fall to early winter timeframe. This timing was ideal because it meant DMLs had already begun their instructional improvement efforts in earnest; thus, they had enough time to begin working directly with school-based coaches. If we had conducted the interviews at the start of the school year, then DMLs might have had far fewer opportunities to begin their instructional improvement efforts, with far fewer types of interactions with school-based coaches on which to report. Conducting the interviews at the close of the year also may have led to DMLs forgetting the type of interactions they had with coaches due to the intense push toward statewide testing.

Data Analysis

We answered our two research questions in turn. To answer our first research question, which focused on the percentage of time DMLs spent supporting school-based mathematics coaches, we analyzed DMLs' responses to two interview questions from the semistructured interviews. The first relevant prompt was: "With whom do you work closely?" The second relevant prompt was: "What percentage of your time do you spend working with teachers/other teachers/other leaders to improve instruction?" Notably, we did not provide DMLs with types of leaders to consider or percentage ranges to choose when answering the second relevant question. However, interviewers were encouraged to ask follow-up prompts that pressed DMLs for specificity in their responses. If, for example, a DML responded to the initial question by explaining that they typically spend 50% of their time working directly with educators in schools, the interviewer might press the DML to clarify the specific role groups the DML worked with and the percentage of time for each role group. In this example, the interviewer might ask follow-up questions such as: "Can you tell me a bit more about the specific groups of educators you work with in schools?" and "About what percentage of time do you work with those specific groups?" We recorded whether DMLs reported working directly with coaches and, if so, what percentage of their time they reported doing so.

Next, we answered our second research question, which focused on the ways in which DMLs interacted directly with school-based mathematics coaches. We analyzed those interviews in which DMLs reported working closely with school-based mathematics coaches. We included all DMLs who stated they worked with coaches, regardless of the percentage of time they reported.

To identify the types of interactions DMLs had with coaches, we analyzed DMLs' responses to three loosely related interview prompts intended to clarify what they do in support of large-scale instructional improvement. The first relevant prompt was: "Please walk us through a typical day in your role/position. What does it look like?" The second relevant prompt was: "What do you spend the rest of your time doing when not working directly with teachers? What does this work look like? Are there particular activities you do?" The third prompt was: "Who would you consider to be your community, if you feel you have one? Who participates in this community? How do you work in this community? What does this work look like?" Although the three questions did not ask DMLs to report directly on their work with school-based mathematics coaches, they provided extensive opportunities for the DMLs to explain and elaborate upon their daily work. Because this second step in our analysis focused only on the DMLs who self-reported working closely with school-based mathematics coaches, we surmised that, in describing their daily work, they would articulate how they interacted with those coaches.

We were unaware of a coding scheme for district leaders' work with coaches, so we used grounded methods (Corbin & Strauss, 2014) to analyze the DMLs' responses to interview questions. We first listened to each district leader's interview and marked relevant episodes in which the DMLs reported on or described their work with school-based mathematics coaches. We considered a relevant episode to begin when the DML started describing a specific aspect of their work with school-based coaches and to end when the DML shifted the topic of conversation to something else. For example, in one interview, a DML described several activities she did regularly across the district in response to the question, "What do you spend the rest of your time doing when not working directly with teachers?" We marked a relevant episode as the beginning when this DML began to describe the classroom observations she conducted frequently with school-based coaches in her district. We considered the relevant episode to have ended when the DML changed the topic of conversation by discussing a different activity—in this case, coordinating additional support for currently struggling students.

The first and fourth authors then listened to relevant episodes in each interview and used inductive coding to characterize the types of interactions DMLs had with school-based mathematics coaches. For example, one DML said she was "in charge of the summer coaching academy," which she described as PD "for [school-based] coaches" in the district. She described setting the agenda for the academy, designing sessions, and facilitating sessions for coaches. We used the code "design and facilitate coach PD" for this interaction. This same DML reported that she "collaborates with coaches" to "design and lead PD for teachers." For this interaction, we used the code "prepare and cofacilitate teacher PD with coaches." The first and fourth authors coded all relevant episodes separately and met to reach a consensus on the codes. This process ensured consistency in our coding scheme application, which was appropriate given the limited number of cases we analyzed in the study.

Having conducted an initial round of inductive coding, we looked across codes to identify broader themes in the types of interactions DMLs had with coaches. For example, we noticed many DMLs referenced the activity of visiting classrooms to observe instruction with school-based coaches. However, they used a variety of terms to describe this type of interaction, including "learning walks," "visiting teachers' classrooms together," and "observing teachers." We classified each of these codes under the theme "classroom visits with coaches." We then applied these themes to each episode we coded, thereby accounting for the *types* of interactions each DML in our study reported with school-based mathematics coaches.

Finally, we wrote an analytic memo (Lempert, 2007) documenting the types of interactions each DML reported with their school-based coaches. In this memo, we focused on whether DMLs mentioned the type of interaction in the interview, not on the number of episodes in which each DML mentioned the type of interaction. This focus on type of interaction was because we were interested in the range of interactions DMLs might have with coaches, not how often they referred to those interactions in their interviews. This approach enabled us to see how many DMLs in our sample reported working with school-based coaches in the ways we identified over the course of our analysis. In other words, this memo enabled us to count the number of DMLs who had specific types of interactions with coaches.

Findings

We report our findings in two sections. First, we share findings regarding the percentage of time DMLs reported working with school-based mathematics coaches—if they reported to do so. In doing so, we answer our first research question. We then turn to our second research question and report on the ways in which DMLs reported interacting with school-based mathematics coaches.

Percentage of Time in Support of School-Based Mathematics Coaches

Table 2 shows that 13 of 15 interviewed DMLs self-reported working closely with school-based mathematics coaches. The two DMLs who did not work closely with school-based mathematics coaches were in small, rural districts that did not employ school-based mathematics coaches. All DMLs in districts employing school-based mathematics coaches spent some portion of their time interacting directly with those coaches.

Table 2

Percentage of Time Working With School-Based Mathematics Coaches

District leader	District type	District size	Expenditure per student	Works with mathematics coaches	Percentage of time with mathematics coaches
Karen	Rural	Small	Low	No	0
Jessica	Suburban	Mid-sized	Medium	Yes	50
Celeste	Suburban	Small	Medium	Yes	50–60
Jasmine	Urban	Mid-sized	Medium	Yes	50
Grace	Urban	Mid-sized	Medium	Yes	Not shared
Alice	Urban	Large	Low	Yes	40
Greg	Urban	Large	Low	Yes	50
Will	Urban	Large	Low	Yes	20–30
Sasha	Urban	Mid-sized	High	Yes	Not shared
Mary	Urban	Large	Low	Yes	Not shared
Mabel	Rural	Small	Low	No	0
Scarlett	Rural	Small	Low	Yes	75
Quinn	Rural	Small	High	Yes	25
Mia	Rural	Small	Low	Yes	35–40
Nancy	Rural	Small	Medium	Yes	33

DMLs reported a wide range in the percentage of their time devoted to working with coaches. For example, Will reported spending 20%–30% of his time working closely with school-based mathematics coaches. On the other hand, Scarlett reported spending nearly 75% of her time working to support school-based mathematics coaches. Interestingly, those DMLs who spent a third or more of their time working with school-based mathematics coaches stated they did so because they thought their work with school-based coaches would have a greater impact on teachers and students than working directly with individual teachers in individual schools. In other words, they viewed working closely with the coaches, who would then work closely with teachers, as important. As Scarlett put it, she cannot be in every school at once, so a major part of her job is "to build the capacity of [her] coaches," so they can "work effectively with teachers," which suggests that, for some DMLs, a significant portion of their work in schools may be devoted to supporting school-based mathematics coaches or instructional leaders in learning to support teachers better.

Types of Interactions Between DMLs and School-Based Mathematics Coaches

We identified seven ways in which DMLs in this study interacted directly with school-based mathematics coaches: (a) facilitating PD for coaches, (b) engaging in strategic planning with school-based coaches, (c) providing individualized support for coaches in conducting one-on-one coaching with teachers, (d) visiting classrooms with coaches, (e) training coaches to deliver district PD at their schools, (f) preparing and cofacilitating PD for teachers, and (g) cofacilitating PLCs with coaches. Table 3 summarizes our findings and shows the types of interactions each DML self-reported having with school-based mathematics coaches. Interestingly, no DMLs reported having all seven types of interactions with school-based mathematics coaches. The most common interactions were visiting classrooms with coaches ($n = 10$), facilitating pull-out PD for coaches ($n = 7$), and cofacilitating PLCs with coaches ($n = 7$). Next, we describe each type of interaction the DMLs in this study reported having with school-based mathematics coaches, following the order in which they are listed in Table 3. In describing each type of interaction, we also provide examples from our interviews with DMLs.

Facilitating PD for Coaches

Seven of the 15 DMLs reported facilitating traditional pull-out PD for school-based mathematics coaches in their district. As the DMLs described, this PD involved coaches leaving their school sites to attend working sessions at a centralized location, such as the district offices. DMLs cited several different goals for the coach PD. Many DMLs noted the coach PD focused on effective mathematics teaching practices. For example, Greg explained that he offered training for school-based mathematics coaches focusing on "things they should consider doing [from] a math lens as an instructional facilitator in their building." He also has offered "progression training" to coaches, where he has helped coaches understand the progression of standards and the

Table 3

Interactions With School-Based Mathematics Coaches by District Mathematics Leader

	Types of interactions with mathematics coaches						
District leader	**Facilitating PD for coaches**	**Engaging in strategic planning**	**Providing individualized support for coaches**	**Visiting classrooms with coaches**	**Training coaches to deliver district PD**	**Preparing and cofacilitating PD for teachers**	**Cofacilitating PLCs with coaches**
Karen							
Jessica	✓	✓				✓	
Celeste	✓	✓	✓	✓			
Jasmine	✓			✓			✓
Grace	✓			✓	✓		
Alice				✓	✓	✓	✓
Greg	✓						✓
Will			✓				
Sasha			✓	✓			✓
Mary			✓	✓			✓
Mabel							
Scarlett		✓		✓		✓	✓
Quinn	✓			✓	✓		✓
Mia	✓			✓		✓	
Nancy				✓		✓	
Total	7	3	4	10	3	5	7

progression of mathematical ideas students are expected to learn in certain grade bands.

Other DMLs explained that the PD they provided to coaches was intended to give them opportunities to connect and discuss common problems of practice they could then work to address collectively. Mia, for example, described the primary goal of the monthly PD she facilitated for mathematics coaches as getting the coaches to talk to one another, so they feel less alone in doing their coaching work. In her interview, she explained:

> *I meet with [the coaches] once a month...We try to get them to talk to each other, that's the big thing. Because they're almost always the only [coach] at their school. When they can reach out and talk to the other [coaches] that makes them, they can flourish...So we do problems of practice with them. So that's huge for [the coaches] because, like, meetings are hard. They don't like being pulled out of their schools. So [we ask them], bring a problem that you're having in your school, and we can all solve it together. So, sort of like brainstorming...and it doesn't have to be a fire, but what can we do to sort of like address this [problem] in a structured way, in a way that makes sense.*

Finally, two DMLs noted they led PD focused on supporting coaches in developing effective coaching practices. The relatively limited number of DMLs who focused coach PD on *coaching* practices aligns with prior research indicating PD for mathematics coaches often focuses on mathematics and the teaching of mathematics as opposed to the knowledge and practices specific to coaching (Saclarides & Kane, 2023). In both cases, DMLs reported the PD focused on how coaches can lead coaching cycles or PLCs effectively with teachers. Celeste, for example, explained that she led PD for coaches that focused on how to "go into a PLC and help a PLC plan through a launch, explore, discuss [lesson]." She explained that she has worked with the coaches to "think about what that [kind of work] looks like on a daily basis with PLCs."

Engaging in Strategic Planning With Coaches

Three of the 15 DMLs reported engaging in ongoing strategic planning with school-based mathematics coaches. For all three DMLs, this involved meeting with school-based coaches to determine which teachers in the building the coach would support directly to maximize their impact. Scarlett, for example, described how she has worked with coaches to bring together student achievement data and data on instruction to determine which teachers need direct support from coaches. Scarlett shared:

> *One visit could be that we look at student data together, and then formulate next steps based on data. One visit might be that I do learning walks with them, we try to do nonjudgmental data collection. And then we come back, we triangulate our data between the lesson plans, and what they have talked about in PLCs, with the teachers, and then we come forward with if that teacher needs more support.*

As another example, Jessica described working with coaches to identify teachers in their buildings who were likely to stay at the school longer term, so coaches could prioritize working with those teachers. Jessica argued this step was worth doing because "coaches can be more impactful" when they establish "longer standing relationships" with teachers.

Beyond thinking strategically with school-based coaches about which teachers they should support, Alice reported working with coaches to analyze student achievement data. She explained that data are a big deal in her district and are "only getting bigger" as they "head through to the end of the year." Because of this impact, she described meeting with the school-based coaches to discuss "formative assessments" and "how they can use [data]," including how the coaches "can identify what needs to happen" to get teachers where they want them. These conversations were intended to help coaches think strategically about the different teacher supports they implemented in their buildings.

Providing Individualized Support for Coaches

Four of the 15 DMLs reported providing individualized support to school-based coaches beyond strategic planning. All four DMLs explained that they provided side-by-side support to coaches as they interacted with teachers and met with coaches afterward to discuss their decisions. Nancy, for example, explained that she sometimes has worked "side-by-side" with coaches to plan for and lead PLCs. Afterward, she met with them to debrief the PLC and discuss how it went. She explained that her goal was to figure out what she could "do to further support what [the coach] is trying to do to move [the teachers] forward." Like Nancy reported providing side-by-side support during PLCs, Alice reported going to schools with coaches to conduct coaching cycles with them. Her goal in doing so was to help the coach identify what "the next steps are" and then figure out the appropriate "bite sized pieces that can move instruction forward."

Two DMLs who provided individualized support to school-based coaches explained that this support was sustained in nature. For example, Celeste noted:

> *I try to meet with [new coaches] on a weekly basis in the beginning of the year and then eventually move to just every 2 weeks. A lot of that [early work] is problem solving. Like, I sent this email [to a teacher], and it did not go very well. I'm like, "Okay, well, let's talk about why we should have reworded that." . . . So I do a lot of [early work] to help them navigate the coaching world.*

In contrast, the other two DMLs reported providing individualized support only in response to one-off requests from coaches or principals. For example, Will explained that he provides individualized support to coaches, but it usually "ends up being more one off" and a response to a "question about something" he can answer.

Visiting Classrooms With Coaches

Ten of the 15 DMLs we interviewed conducted classroom visits with coaches, making this type of interaction the most common DMLs in this study had with school-based coaches. DMLs reported that these classroom visits typically involved the DML and school-based coach doing observations of several mathematics classrooms in the school, with the goal of understanding the current state of instruction in the building. As a brief clarifying note, we distinguish classroom visits from strategic planning because of the depth of conversation described. DMLs reported that classroom visits typically resulted in brief conversations in which they supported coaches regarding potential improvement goals for the teachers they had seen. In contrast, DMLs who engaged in strategic planning with their coaches described this work as involving in-depth conversations in which the coach and DML discussed school-wide and teacher-specific improvement goals.

Jasmine's interview illustrates this type of interaction. In her interview, she reported that she would often "go to a school in the morning and a school in the afternoon" to see instruction. During these visits, she would "sit and observe some classrooms with the math coach." For Jasmine, this was a beneficial interaction because it meant she could support the mathematics coach in learning what to look for in the classroom to see whether teachers are implementing district curriculum effectively. DMLs also noted meeting with coaches frequently after conducting classrooms visits to determine next steps for teachers whose instruction they had observed.

Training Coaches to Deliver District PD

Three of the 15 DMLs also support school-based coaches by training them to deliver district-provided PD sessions at their schools. All three coaches described this work as following a train-the-trainer model, wherein they support the coaches in learning to deliver teacher PD sessions originally developed by the district. For example, Alice described leading PD that has "been a kind of train-the-trainer model" where school-based coaches learn something new about mathematics teaching, "and they take that learning back to the teachers." As another example, Quinn reported designing PD for teachers and then "training [coaches] to actually implement" PD sessions with teachers over the summer. This focus on learning to deliver specific PD sessions contrasts with designing and facilitating coach PD; the latter focuses primarily on supporting coaches to improve their capacity to work effectively with teachers, not on learning to lead a specific PD session designed for teachers.

Preparing and Cofacilitating PD for Teachers

Four DMLs reported working with coaches to support them in designing and facilitating school-based PD for teachers. Unlike the prior activity, which focuses on training school-based coaches to lead district-designed PD, this type of interaction focuses on supporting coaches in developing and leading their own PD sessions that are responsive to the teachers in coaches' current school contexts. DMLs who interacted with coaches this way noted interactions usually involved meeting with the coach to develop PD activities and then joining the PD session to provide the coach with added support. For example, Mia explained she has often worked with school-based coaches to "tailor" school-level PD experiences to teachers' current practices. As another example, Scarlett reported meeting with coaches "if they're doing any PD" so she can "support them as much as possible." She explained that this support often involved planning the PD together, and then she would attend the PD to see how it went.

Cofacilitating PLCs

Seven of the 15 DMLs joined their school-based coaches in their buildings to cofacilitate PLCs between teachers, making this one of the most reported activities. DMLs cited several reasons for cofacilitating the PLCs. Some DMLs noted that their presence in PLCs was intended to provide the coaches with a visible show of support. Others noted joining PLCs to support coaches and teachers in conducting in-depth analyses of student-level and instructional data. For example, Scarlett explained that, just a few weeks before her interview, she visited a school struggling in fifth-grade math. On this visit, she "worked with the fifth-grade math team" and led the PLC in "looking at benchmark data" by "grade level and standard." For this visit, the "coach was there 100% of the time and was engaged" in the activities. Scarlett explained that she led the PLC through an "item analysis" where they "looked at the type of problem that was most frequently missed." Others noted joining PLCs to ensure consistency in messaging and feedback from the district to the school administration to the school-based coach. Overall, all seven DMLs who mentioned this activity appeared to see the cofacilitation of PLCs as both supporting coaches and directly supporting teachers' learning, meaning it often served two parallel purposes.

Discussion

This study had two primary goals. First, we aimed to better understand whether DMLs see the support of school-based mathematics coaches as a primary component of their jobs. Of the 15 DMLs we interviewed, 13 noted that they saw the support of school-based mathematics coaches as a key component of their job function. Second, we aimed to clarify the ways in which DMLs interacted directly with school-based mathematics coaches, if they did so. Our rationale for pursuing this latter goal was that clarifying these types of interactions serves as an initial step toward a greater understanding of how DMLs might work to support school-based mathematics coaches' learning. We identified seven types of interactions that DMLs in this study had with school-based mathematics coaches.

Our findings surface several key issues of significance for research on mathematics coaching and supporting mathematics coaches. First, we found most DMLs saw the support of school-based mathematics coaches as a component of their work. This finding suggests DMLs often interact directly with school-based mathematics coaches, meaning these educators have the potential to support school-based mathematics coaches' learning. This finding is significant for research on coaches' learning (Kane & Saclarides, 2022; Saclarides & Kane, 2023; Stein et al., 2022) because it highlights an additional source of support for coaches beyond traditional, pull-out PD that could aid in coaches' development. It is also significant for research on DMLs—it clarifies an often-nebulous role by detailing a key component of DMLs' daily work. Our study indicates DMLs devote considerable time and energy to working closely with school-based coaches, in addition to other common activities (e.g., designing and facilitating PD for teachers; Jackson et al., 2015).

Second, we found considerable variation in the percentage of time DMLs reported working with school-based mathematics coaches. When we began our study, we suspected DMLs working in larger, relatively well-resourced districts might have more opportunities to work closely with school-based coaches because there might have been more available coaches with whom to work and thus more opportunities to support their learning. We also suspected DMLs working in smaller, less resourced districts might spend less time supporting coaches because there might be fewer coaches and more responsibilities for the district leader. The evidence in support of our conjecture is mixed. On one hand, the two DMLs who reported that they did not work closely with school-based mathematics coaches came from smaller, more rural school districts. Further, 4 of the 5 DMLs who reported spending over 50% of their time supporting school-based coaches worked in urban or suburban school districts. These findings lend support to our early suspicions. On the other hand, the DML who reported spending the greatest percentage of time supporting school-based mathematics coaches worked in a small, rural school district. This finding suggests other factors may influence district leaders' support of school-based coaches.

Third, by identifying the ways in which the DMLs we interviewed interacted with school-based mathematics coaches, we took steps to better understand how DMLs might support school-based mathematics coaches' learning. Because of the nature of this study, we were unable to determine the extent to which the seven types of interactions we identified supported coaches' learning. However, all seven interactions we identified appear to have the potential to support school-based mathematics coaches' learning. That said, we also recognize their potential is largely contingent on the nature of the interaction. For example, working with coaches to prepare and cofacilitate PD might constitute a significant learning opportunity for a school-based coach *if the DML supports the coach in seeing the codesign and cofacilitation experience as a case from which to learn.* This co-facilitation might involve the DML holding framing conversations before and after the collaborative experience in which the DML presses and supports the coach to identify principles of effective PD design and facilitation that the coach might then take up when developing other PDs for teachers.

In contrast, this type of interaction might have limited potential for supporting coaches' learning if the DML approaches it from a "helping hands" perspective and focuses exclusively on designing and facilitating the PD without discussing what the coach learned from the experience. Because the types of interactions we identified describe what DMLs might do when working with teachers, we suggest they can serve as the initial basis for the delineation of a topology of how DMLs can support school-based mathematics coaches' learning. Developing and validating such a topology would be a highly beneficial step forward for research examining coaches' learning (Stein et al., 2022) and the design of *systems* of support for coaches' learning (Kochmanski & Recore, 2024).

Finally, regarding implications for practice, we see the identification of the seven types of interactions as beneficial for DMLs in other districts who spend a significant percentage of their time working closely with school-based mathematics coaches. We suggest such DMLs might find the types of interactions informative for their work, as we described possible interactions DMLs might aim to have with coaches. If any types of interactions prove new or novel, DMLs might try them out with school-based coaches with whom they work.

Limitations and Directions for Future Research

Though this study provided valuable insights into how DMLs support school-based mathematics coaches, there were several limitations. First, the findings were based on interviews with 15 DMLs, which may not capture the full diversity of roles, experiences, and responsibilities of DMLs across varied districts and contexts. Further, the interviews were part of a larger study, and the interview had other foci (e.g., what DMLs perceived to be high-quality mathematics instruction). Second, although the study identified seven types of interactions between DMLs and coaches, it did not assess the impact of these interactions on the learning or professional growth of the coaches, focusing instead on potential rather than verified outcomes. Third, the study did not investigate whether the seven interaction types are exhaustive or if other significant interactions are not in this data set, which would require additional interviews in other contexts, including DMLs working in different states. Fourth, although we acknowledge the effectiveness of these interactions likely depends on their quality, this study did not attend directly to the quality of interactions due to the nature of the data we analyzed. Fifth, while we acknowledge systemic factors (e.g., district size and resources), the study did not explore how broader organizational structures or leadership practices influence DML–coach interactions, leaving the role of district-level policies and priorities underexamined. These limitations highlight the need for further research to understand comprehensively how DMLs effectively support school-based mathematics coaches and the systemic factors that shape their interactions.

Turning now to directions for future research, we suggest researchers might investigate the coach learning potential of the types of activities identified in this study. Our current work is descriptive, and due to the available data, we could only analyze interviews with DMLs in which they described how they worked with coaches. Future research might collect data on district leaders' and coaches' interactions as they engage in activities described previously to look closely at whether the activities can give rise to coach learning opportunities. Researchers also might look closely at the kinds of expertise necessary for DMLs to facilitate these activities effectively with coaches, such that they support coaches in learning to support teachers better. For example, just as it is useful to understand when and why coaches choose to enact coaching activities with teachers (Gibbons & Cobb, 2016; Kochmanski & Cobb, 2023; Witherspoon et al., 2021), it may be similarly useful to look closely at when and why DMLs choose to engage school-based coaches in particular types of support. Finally, as noted, we initially thought school districts' size and available resources might have influenced the amount of time district leaders worked with school-based coaches; however, the size of the district did not appear to explain discrepancies in the percentage of time spent working with coaches for this subset of 15 district leaders. Future research might build on this analysis by investigating explanations for the differences we observed in how much time district leaders devoted to supporting school-based coaches' learning and in how they went about working with coaches.

Conclusion

Mathematics coaching is an increasingly common strategy for supporting improvements in teaching and learning. The transition from teacher to coach is significant and requires new and novice coaches to develop new forms of knowledge and practice (Stein et al., 2022). As education professionals who often design and implement professional learning experiences for teachers, DMLs can serve as facilitators of coaches' learning. In this study, we found most DMLs we interviewed devoted at least a portion of their workday to supporting the learning of school-based mathematics coaches. We also found seven types of activities that DMLs reported enacting with coaches to support their learning. These results suggest DMLs have an essential role in the support and success of school-based mathematics coaches.

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Appendix
Relevant Section of Semistructured DML Interview Protocol

PART C - DESCRIBE YOUR WORK

In this next part of the interview, we would like to better understand what it looks like for you to do your work as a a math instructional leader

Please walk us through a typical day in your role/position? What does it look like?

IF they say there is no typical day: Please talk us through the kinds of things you often do in your role/position.

IF they say they visit schools or classrooms: How do you decide which schools/classrooms to visit? Do you consult with anyone about this decision?

What percentage of your time do you spend working with teachers/other teachers/other leaders to improve instruction?

PROBE on working with teachers: What does this work look like? Are there particular activities you do when working with teachers/other teachers/other leaders (i.e., modeling, planning with teachers, etc.)?

What do you spend the rest of your time doing?

PROBE on this by asking: What does this work look like? Are there particular activities you do? Particular expectations for this other work?

PROBE on curriculum development/planning: What role do you have in curriculum planning? What does this look like? Do you have a say in decisions around school- or district-wide curriculum? Who else do you work with to make these decisions?

PROBE on teaching students in the classroom: Do you teach students in the classroom? If so, what percentage of your time focuses on this? How does this impact or influence your work with other teachers? Your work with curriculum?

PROBE on other things: What else haven't we asked about that you actually do?

PROBE on comparison to expectations: Imagine you are one of those memes, where it shows a list of what everyone thinks you do during your day, and then there is your box saying, "This is what I actually do." What do other people *think* you do during the day? Who are your "others"? How does this compare to what you actually do?

With whom do you work closely? Note that this can include people you support, people who support you, your boss, people who you see as peers, etc.

Who would you consider to be your community, if you feel you have one?

PROBE on specific communities: Who participates in this community? How do you work in this community? What does the work look like?

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