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# NCSM JOURNAL

## OF MATHEMATICS EDUCATION LEADERSHIP

VERTICAL LESSON STUDY TO BRING COHERENCE IN PRIORITIZING STUDENT CONTRIBUTION AND VOICE

ONE CURRICULUM COMMITTEE'S PERCEPTIONS OF HIGH-QUALITY MATERIALS

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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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- Professional development efforts including how these efforts are situated in the larger context of professional development and implications for leadership practice; and
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## NCSM–LEADERSHIP IN MATHEMATICS EDUCATION



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# Table of Contents

# About NCSM

## NCMS 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.

## NCMS 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:

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- 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;
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- 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 you rest and refresh under the warm summer sun, the editorial team at the *Journal of Mathematics Education Leadership (JMEL)* invites you to immerse yourself in the latest issue of our journal. We are thrilled to present new insights and perspectives that will deepen our collective understanding of research-based practices to support mathematics education leaders.

Echoing President Katey Arrington's remarks in the May 2024 *Insider* edition, we are proud to share that *JMEL* is now an open access publication. This means that all electronically available back issues that have ever been published in JMEL, which start with Volume 7, are now freely available to anyone, anywhere in the world. This move aligns with our core values of accessibility, engagement, and collaboration. Ultimately, making *JMEL* open access ensures that our authors' thoughtful work can reach a broader audience and thus have a greater impact within and beyond our field. We encourage NCSM members and our readership to explore, share, and engage with our articles, and join us in advancing mathematics education leadership knowledge and understanding.

With our commitment to open access as a means of ensuring wider dissemination of research, we are also dedicated to maintaining rigorous review procedures to uphold the quality and integrity of the work we publish. All manuscripts should be submitted using the Google form available on the *JMEL* website. First, all submitted manuscripts undergo initial editorial screening by both editors to ensure fit with the journal. Specifically, we look to see that authors are making deep and sustained connections to mathematics education leadership literature, topics, and perspectives to appeal to our readership. Approved manuscripts then undergo double-blind peer review by two volunteer reviewers and one member of the editorial team. From start to finish, the review process can take anywhere from three to six months. Ultimately, one of the following decisions is rendered on the manuscript: (a) accept as is, (b) requires minor revisions, (c) requires moderate revisions, (d) requires major revisions, or (e) reject.

In this issue of *JMEL*, we invite you to dive into two thought-provoking articles. In our first article, "Vertical Lesson Study to Bring Coherence in Prioritizing Student Contribution and Voice," Tate and colleagues collaborated to create a vertical lesson study team in an elementary school setting. The teachers partnered with two university researchers, who helped to facilitate the lesson study. Tate and colleagues lay out their use of a Study-Plan-Teach-Reflect cycle to engage in lesson study around algebraic patterning K-6 with a goal of increasing the quality of student discourse. The author team (including both teachers and researchers) provide an exemplar of the model, as well as tools and resources that can be adapted by those wishing to replicate the model in their own setting.

In our second article, "One Curriculum Committee's Perceptions of High-Quality Materials," Mason and colleagues explored aspects of the curriculum adoption process that United States school districts often undergo. Specifically, they examined how one district's curriculum committee members considered curricular materials both in terms of their quality and appropriateness for different student groups. They also sought to understand the extent to which curriculum committee members held a coherent view with one another of what constitutes "high-quality" materials. Mason and colleagues share key insights and recommendations for district administrators, leaders, coaches, and teachers to consider as they move through the curriculum adoption process to promote an inclusive and equitable mathematics experience for all students.

In closing, as we explore the connections between lesson study and the curriculum adoption process, both practices offer valuable insights for improving the teaching and learning of mathematics. The articles featured in this issue deepen our understanding of these processes and challenge us, as mathematics education leaders and researchers, to think critically about how we can incorporate these articles' findings into our respective communities. Please consider the following questions as you reflect on the articles presented in this issue:

- How can educational leaders support the integration of both articles' findings into their unique contexts?
- How can the insights from these articles inform future research about lesson study practices and/or the curriculum adoption process?
- What are the potential synergies between vertical lesson study and the adoption of high-quality curriculum materials?

As an editorial team, we encourage our readership to grapple with these questions and consider how to: (a) implement the strategies and ideas features in these articles, and/or (b) extend the research put forth by both author teams. In doing so, we can foster a more responsive mathematics education community that centers students and teachers.

# VERTICAL LESSON STUDY

## VERTICAL LESSON STUDY TO BRING COHERENCE IN PRIORITIZING STUDENT CONTRIBUTION AND VOICE


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### ABSTRACT

This article tells the story of a team of K-6 teachers who engaged in action research through Lesson Study to build equitable classroom structures through discourse-rich vertical tasks. Founded within the key recommendations of Catalyzing Change (NCTM, 2020), our community explored ways to prioritize student voice and distribute student mathematical contributions across more students within correlated patterning tasks.



*Keywords: lesson study, equity, math discourse, vertical task.*


The National Council of Teachers of Mathematics (NCTM)'s *Catalyzing Change in Early Childhood and Elementary Mathematics: Initiating Critical Conversations* (2020) called for the mathematics teaching community to engage in a conversation to bring equitable teaching practices to the forefront of our mathematics teaching and learning. An imperative component of this work is a school's shared and coherent vision of what equitable mathematics is and, importantly, how centering equity in mathematics makes students feel. An equitable mathematics classroom is one in which "Every child is capable of learning important mathematics with depth of understanding if provided with sustained opportunities that support children in reaching their full potential in mathematics" (NCTM, 2020, p. 14) by attending to how teachers and students position one another as capable of doing mathematics. Ideally, teachers specifically heed the content and vertical progression of standards to assess where students are, build their mathematical understanding, increase their confidence, and support their mathematical identities as doers of mathematics. *Doing mathematics* involves teaching practices that maintain high levels of cognitive demand for each and every student (Smith & Stein, 2011) and are grounded in mathematical discourse (NCTM, 2014).

Lesson Study (LS), as described by Lewis et al. (2012), is a cyclical investigation within a teacher-centered inquiry that uplifts teachers as co-researchers. Teacher members develop a community of practice (Robinson & Leikin, 2012) in which professional learning is grounded in a specific lesson and centers student thinking data with particular attention to how lesson components act in tandem with what students are doing or learning. The public and collective action of Lesson Study allows a team of educators to witness the lesson firsthand while providing a reflective space for critique and refinement (Lewis et al., 2012). To improve practice, Lewis et al. (2012) stress the importance of educators having the opportunity to observe their peers and take risks trying out new instructional strategies. LS allows for this space as the cycle includes both planning and implementing an intricately designed action research lesson with a post-lesson analysis of student learning (Shimizu & Kang, 2022). Ultimately, LS makes collegial and student thinking visible (Lewis et al., 2012). Schipper et al. (2022) report on research reviews that reveal LS as a professional development model that builds individual teacher knowledge and a positive mindset for mathematics teaching. We utilize the term "co-researchers" as an embodiment of all members of the LS Team—coach, teacher, and university partner—and to represent the deep levels of learning and practitioner research as we engaged in Lesson Study.

One of the prerequisites for a vision of teaching and learning for equity is ensuring teachers understand the mathematical content and processes to better assess and leverage students' strengths to advance their learning (Kobett & Karp, 2020). The research goal of this LS was to support equitable student participation through discourse to cultivate positive mathematical identities. Aguirre et al. (2024) conceptualize *mathematics identity* as "the dispositions and deeply held beliefs that students develop about their ability to participate and perform effectively in mathematical contexts and to use mathematics in powerful ways across the contexts of their lives" (p.14). The authors stress the importance of teachers recognizing the impact of each instructional decision on a child's identity and indicate the interconnectedness of equity work and classroom cultures that expand opportunities for young children to demonstrate competence (Aguirre et al., 2024). Thus, using the key recommendations set forth by *Catalyzing Change in Early Childhood and Elementary Mathematics: Initiating Critical Conversations* (NCTM, 2020), our learning process centered on creating equitable mathematics classrooms through 1) broadening the purposes of learning math, 2) creating equitable structures in math, 3) implementing equitable mathematics instruction, and 4) developing deep mathematical understanding. NCTM (2020) expands on the notion of *doing mathematics* through the processes and practices of:

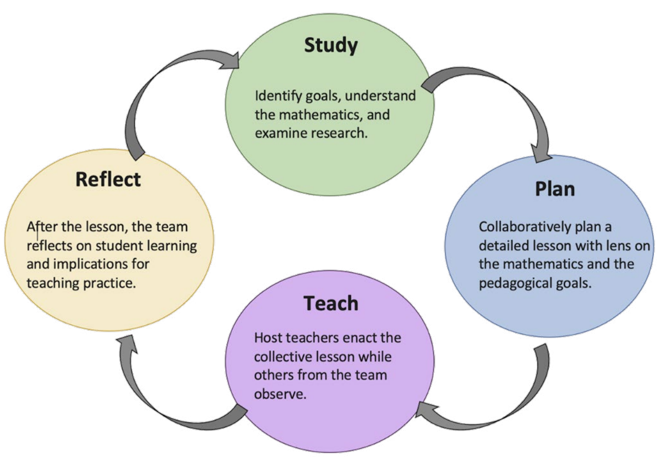
1. Representing and connecting,
2. Explaining and justifying,
3. Contextualizing and decontextualizing, and
4. Noticing and making use of mathematics structure.

This article presents a collaborative professional learning initiative endeavored by a team of kindergarten through grade six teachers. The co-authors writing this story include members of our team: a first-grade teacher (Amy), a third-grade teacher (Jenny), a fourth-grade teacher (Kaitlin), a sixth-grade teacher (Jacqueline), a mathematics coach (Holly), and a collaborating professor of mathematics education (Jennifer). Our team came together after Holly and Jennifer first discussed the idea of engaging in a vertical Lesson Study (LS). Holly reached out to teams to see if one (or more) members from each grade level might be interested in meeting after school for a few weeks to learn together and observe one another. Five teachers agreed (representing grades K, 1, 3, 4, 5, 6) to participate as a vertical learning community and spent the subsequent month using a LS model (Lewis, 2002; Suh et al., 2019) to study, plan, enact, and debrief lessons that promoted mathematical discourse and illuminated equity-centered elements to catalyze change. The LS team met after school weekly throughout the spring semester and had the opportunity to push into each host classroom to observe during the LS cycle.

## THE VERTICAL LESSON STUDY CYCLE

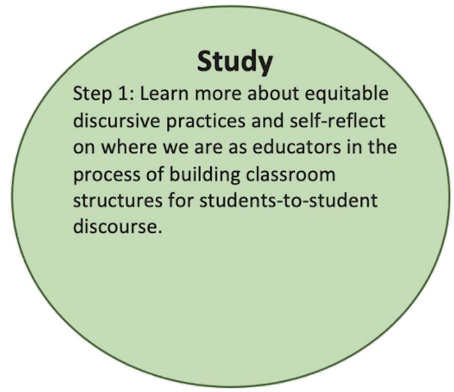
In Figure 1, we detail the protocol our vertical community used, focusing on equity and the key recommendations set forth by NCTM (2020). In the text that follows, we include detailed examples of our team's experience within each of the protocol's steps and its impact on our mathematical teaching and learning.

**Figure 1**
*Protocol for vertical lesson study grounded in discursive practices*




*Note:* Adapted from *About Lesson Study*, by The Lesson Study Group at Mills College, 2022, https://lessonresearch.net/about-lesson-study/what-is-lesson-study-2/.

### *Study*: Creating and Implementing Equitable Mathematics Instruction




The LS process creates a community of vulnerability (Suh et al., 2021), allowing teachers to anchor learning in their wonderings shared as a collective unit and to strengthen their teacher mathematical identity (Aguirre et al., 2024; NCTM, 2020). Vertical LS provides opportunities not only to deepen teachers' and coaches' understanding of the development of children's mathematical knowledge through the analysis of student work but also allows for the vertical team to work toward a common teaching practice and bring coherence school-wide collectively (Suh et al., 2019). Lewis (2015) describes LS as improvement science, in that educators "choose an improvement aim, agree on how they will recognize improvement, identify the changes that might procedure improvement and test these changes in LS cycle" (p. 57). In this way, in the "Study" phase of the Lesson Study, the team identifies a problem of practice, in this case a student goal around increasing participation through discourse and learning about discursive practices.

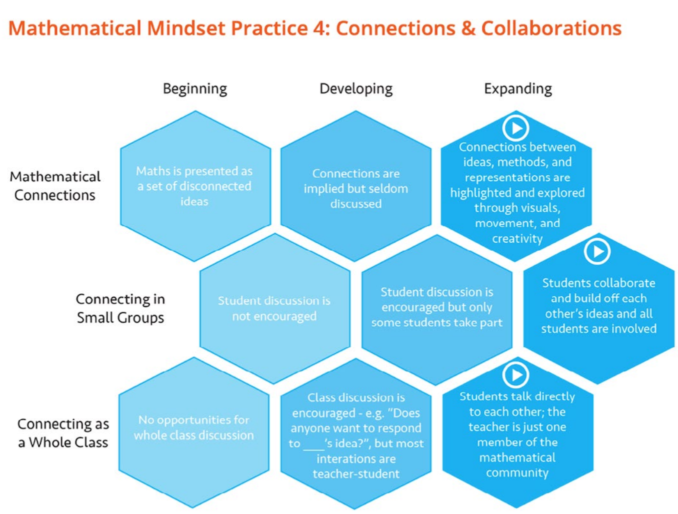
By placing the educators at the forefront of the LS "study" goals and research, they were empowered to explore areas of mathematical pedagogy that were meaningful to them as instructors of mathematics. With this model, we established a teacher community (NCTM, 2020; Robinson & Leikin, 2012) of collaborative mathematicians.

In our initial meeting, we learned collectively about the effective teaching practices outlined by NCTM, and the teachers chose to focus on, "Effective teaching of mathematics facilitates discourse among students to build shared understanding of mathematical ideas by analyzing and comparing student approaches and arguments" (2014, p. 29). Our team chose to attend to this principle because it enabled us to consider how our classrooms could construct spaces with opportunities for students to engage in sense-making and deep reasoning. This notion is central to NCTM's first key recommendation, broadening the purposes of school math by "developing deep mathematical understanding as confident and capable learners" (2020, p. 11). Positive and discourse-rich classrooms allow each student to feel successful and proud (NCTM, 2020). Strong discourse structures elicit students' ideas and strategies, creating an equitable space for students to interact with their peers and value multiple contributions. Hierarchical status among students, such as differences in "smartness" or ability perceptions, diminishes (Zavala & Aguirre, 2023). Thus, we intended the LS would highlight the use of discourse to consider how students position one another as capable mathematicians, allowing our LS team to explore routines that make discourse an expected and natural part of mathematical thinking and reasoning (Aguirre et al., 2024). Students in this space are confident enough to ask questions and engage in mathematical argumentation, which enhances their mathematical learning. In sum, our research goal was to bring intentionality in our discursive practice to prioritize student voice and distribute mathematical intellectual contributions (Aguirre et al., 2024) across more students.

After choosing the focus on discourse, teachers asked questions when considering the principle—What is mathematical discourse? What isn't it? This open dialogue led to exploring researched-informed resources. The coach and the math educator provided resources to consider, such as a chapter from the *5 Practices for Orchestrating Productive Mathematics Discussion* (Smith & Stein, 2018) and three key functions in facilitating meaningful discourse (Staples & King, 2017) in this more exploratory phase of studying.

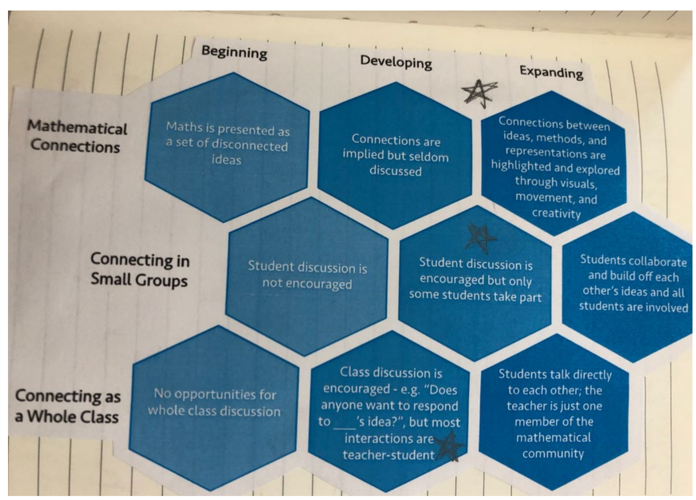
One teacher, drawing on the district's use of Jo Boaler's (2016) book *Mathematical Mindsets*, decided to further explore Youcubed (n.d.). Youcubed is a website designed for teachers, parents, and students, with many ready-to-go resources often used throughout our district-level curricula resources. Our district had recently supported teachers in taking the virtual Teacher's Course that focused on the brain, productive struggle, and how to create classroom communities that do not dichotomize children into those who "can" and "can't" (Boaler, 2016). Boaler indicates "responsibilities" of an equitable classroom, one inclusive of working on groups where "different thinkers are helped, both by going deeper and by having the opportunity to explain work, which deepens understanding (p. 138)." Within the Youcubed (n.d.) website, the teacher discovered "Hexagons for Mathematical Mindsets" rubric-like visuals designed to be reflective and non-evaluative tools (Figure 2) (Youcubed, 2018).

**Figure 2**
*Rubric used to self-assess discursive practices in the math classroom (Youcubed.org, 2018)*




The hexagon self-assessment was designed for teachers to gauge their practice using rubrics around Mathematical Mindset Practices. Our LS Team loved the idea of taking the Youcubed site's (2018) advice of using the rubrics to "understand where you are now" and "consider where you want to be" around the Mathematical Practice of "Connections and Collaboration" (p. 2), as a good fit for this practitioner study as our team examined both the literature and our current reality (Knight, 2016) of discursive practices. In the subsequent LS meeting, the coach and the math educator asked teachers to engage in self-assessment, situating their classrooms within the rubric of "Math Connections," "Connecting in Small Groups," and "Connecting as a Whole Class" (see example in Figure 3) (Youcubed, 2018, p 4). "Math connections" included a progression for the presentation of the mathematics itself, whether as a disconnected set of ideas or in a rich way that included visuals, creative strategies, and a structured experience for students to make connections. "Connecting in small groups" ranged from classroom contexts where very little discussion occurred to mathematics dependent on student collaboration and ideas in small groups. "Connecting as a whole class," similarly, focused on opportunities as a whole class for students to build off each other's ideas as monumental in a mathematical community.

**Figure 3**
*Teacher sample of self-assessment in researcher journal*




Across these categories, our context's "beginning" stages included worksheets or procedure-based games as a part of a guided math structure. Oftentimes, noted in the discussion from LS Teachers, students had very little opportunity to talk deeply about mathematics in these kinds of situations, with true understanding of the concepts through flexible and connected strategies. Further, many math centers/ stations were either silent stations or ones where students might interact to talk about their answer, but not about their strategies and how strategies connected. It seemed there were fewer spaces where teachers opened opportunities for children to build mathematical understanding *together*. Every teacher self-assessed around the range of "developing," (Figure 3) with one teacher indicating that they were mostly "beginning" this journey. We realized through the self-assessment that a focus on discursive practices was a prime way to focus our learning to create and implement equitable structures as our LS goal.

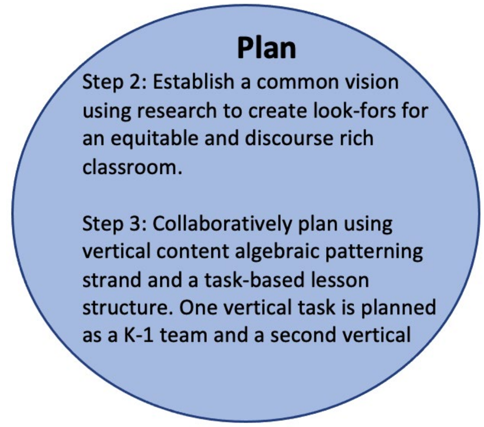
From there, teachers began unpacking their wonderings about facilitating meaningful mathematical discourse. They journaled, posing specific questions about their practice as they pondered what moving forward in the hexagon rubric would mean. For example, a teacher journaled about her wonderings and curiosities regarding student discourse sharing, "I would like to improve student-to-student discourse and ensure that all students are engaged in discussion and thinking. What happens to student learning when students are doing most of the talking? I am really curious about how I can get students to do this." As teachers enacted the other phases of the Lesson Study, this rubric acted as a way for them to reflect on their personal goals and questions within the larger LS context. Teachers continued to journal over the course of each LS meeting in response to their initial questions as they worked to move towards "expanding" discourse connections individually. In this way, the "study" of oneself occurred throughout the entirety of the Lesson Study.

During the "study" phase of LS, our vertical team continued to investigate action steps for each co-researcher's personal goals grounded around student discourse and collaboration. We spent two sessions in the "study" phase delineating how we would increase meaningful discourse in ways reflective of the themes that emerged from teacher learning goals. The conversation included discussions of equity and what it means for every student to have an opportunity to investigate mathematics deeply— Is this happening in classrooms currently? How often? What do the conversations sound like and how deep are the conversations? We considered how discourse is not just a "show and tell" but explicit in developing a shared meaning of mathematical ideas (McGatha & Bay Williams, 2018). Through our discussion "meaningful and equitable discourse" was defined as efforts to prioritize student voice and distribute mathematical contributions across more students through student to student discourse.

This notion of observing and listening to student thinking instead of relying on high-stakes assessment supported the second key recommendation from NCTM (2020), creating equitable structures, where the organization advocates assessment as a method of gathering evidence of children's mathematical thinking to inform learning and teaching. In reflecting on our next steps, teachers indicated that our school had classrooms of children who may not have seen themselves as "math people." Therefore, our plan to embed mathematical discourse needed to send the message, "You are a mathematician." In summary, our "study" phase consisted of the following learning processes, guided by the team:

1. We built common language and background knowledge around equitable and effective math pedagogy.
2. identified a target practice to explore in depth as a community.
3. continued to build common language and background knowledge about the target practice.
4. reflected on current practices and set goals for the LS.

***Plan:* Broadening the Purpose of Learning Mathematics**




In the "plan" phase of Lesson Study, teachers selected a rich task and planned for discourse using a task-structure (Smith & Stein, 2011) format. Since rich tasks were newer to several members of the LS team, the coach and math educator pulled together a bank of tasks from NCTM as a jumping off point to this selection. Since the team realized that current classroom structures were not always meeting the needs of cultivating deep mathematical discourse, as facilitators we created a lesson plan template to support teachers in thinking through planning for a task. The plan required thinking through a launch, monitoring student thinking in small groups and through purposeful questions, and selecting student groups to share their ideas in connection to the math goal (Smith & Stein, 2011; Van de Walle et al., 2019) (See Appendix B).

***Planning for Discourse***

During this phase, the LS team utilized our learning and reading from the "study" phase to create a list of crucial practices we deemed necessary as part of a mathematical community for equitable discourse. Teachers first worked in partnerships to brainstorm look-fors based on the previous sessions' readings (e.g., NCTM, 2020; Smith & Stein, 2011; Staples & King, 2017; Youcubed, 2018), investigations, and self-assessments. We then looked across the lists for themes, grouping ideas together and narrowing down to five important look-fors, which we called "Key Practices to Create an Equitable Discourse-Rich Classroom": (1) Opportunities for student-to-student discourse (2) students explaining their own mathematical thinking (3) students commenting on the mathematical thinking of their peers, (4) students using sentence frames to support their discourse and (5) students asking each other questions. As a team, we embedded these look-fors into a checklist, deciding it was also necessary to include a space for anecdotal evidence (see Appendix A). The anecdotal space not only encouraged LS members to take detailed notes, but it also gave our debrief sessions a more vibrant and evidence-based approach as teachers were able to draw on specific instances that stood out in classrooms. We utilized the discourse monitoring tool from Appendix A in all our LS classrooms, K-6, as a learning tool for our team.

While monitoring student discourse was an essential learning component across all grade levels, facilitation of student discourse based on the mathematical content varied in our kindergarten and first-grade classrooms compared to our upper-level classrooms as seen across the vertical progression of standards. In the primary grades, patterning started with repeating patterns and simple growing patterns, then progressed to connecting multiplicative patterns to linear functions by sixth grade. Thus, our next steps included making two important decisions: first, collaboratively planning instruction around a rich task; and second, making sense of student engagement with vertical mathematical content.

NCTM (2020) expresses the urgency for catalyzing change by broadening the purpose of learning mathematics. Students should recognize mathematics as a beautiful and creative study through the real-world discovery of concepts in meaningful instruction. To aid in the planning for a classroom grounded in students' creation of mathematical ideas, a general task-based plan, adapted from Smith et al. (2020), assisted teachers in orchestrating classroom discussions by posing questions of how they might introduce a task, allow for independent think-time, consider purposeful partnering for sharing ideas, and connect student strategies to culminate the task (Figure 4). Grade-level bands planned within this cycle together, in tandem with the task-based lesson planning template, while also explicitly considering the discourse monitoring tool.

As we considered the purposeful partnerships, manipulatives and purposeful questions that encourage students to describe their strategies and ideas, we considered questions to discover children's thinking. The teams developed open-ended questions to embed in the tasks, such as:

- What did you do to start the problem?
- Can you tell me more about that?
- Why did you choose to…?
- Is this a pattern? How do you know?
- How does your pattern relate to the multiplication table?
- How is your pattern growing?
- How are these connected?

Our team also considered how we might purposefully partner students based on their strategies and solutions to enhance peer discussions. Here, teams brainstormed sentence frames to support the necessary peer connections that students would need to make if partnered with someone strategically based on their strategy. Several classrooms began using the sentence frames before our LS implementation so that students would be familiar with the stems. Examples of the sentence frames included:

- I agree with _____ because…
- ______'s is connected to ______'s because…
- I see the pattern growing by….

**Figure 4**
*Process of planning and implementing mathematical tasks*


*Note:* Adapted from *5 Practices for Orchestrating Productive Mathematics Discussion,* (Smith & Stein, 2011).

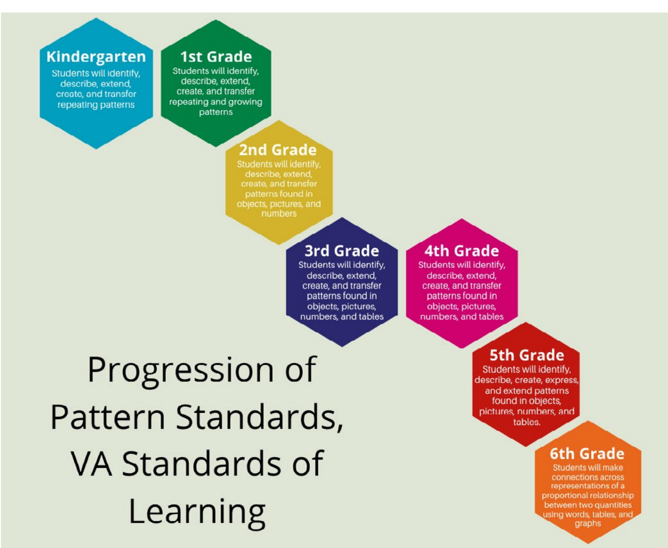
Anticipating student responses (Smith & Stein, 2011) allowed us to be intentional in the connections between strategies and mathematical ideas. For example, knowing how a kindergartener or first grader might build a pattern created an opportunity for teachers to recognize relationships among different strategies to understand what kinds of big mathematical ideas might arise from the chosen tasks to structure possible partnerships and whole class reflections. This type of planning was different for teachers than other kinds of instruction they had done in the past as they shifted from delivering procedural skills to noticing and naming various strategies and emphasizing the discourse of connections between strategies. For several of the teachers, this was the first time centering the students as the doers of mathematics, where students would not be working towards a single solution. Instead, the heart of the task would be in student thinking, analyzing, discourse, and reflecting while the teacher facilitated this open space.

### *Planning for Vertical Mathematics Concepts*

An additional key recommendation for catalyzing change in early childhood and elementary classrooms includes the development of deep mathematical understanding (NCTM, 2020). To determine the best content strand for a vertical LS in tandem with the focus on discourse for meaning-making, the team looked across the standards in the district pacing for the semester to find content commonalities across the pacing timelines, landing on the strand of Patterns, Functions, and Algebra (PFA). PFA also worked for the team as the choice of vertical articulation because we felt that it had access points for us as mathematics educators to understand the mathematics in a cohesive manner from kindergarten to 6th grade because of the connections within patterning that could be seen as students moved from repeating patterns, to growing patterns, to multiplicative reasoning in patterns in different forms, to ratio tables and proportional reasoning. The learning progression was examined from kindergarten through sixth grade, as seen in Figure 5.

**Figure 5**

*Progression of pattern standards from kindergarten to sixth-grade, Virginia Standards of Learning (2016)*




Next, our collective broke into grade-band teams to examine their specific standards more closely: a kindergarten and first-grade team and a 3rd through 6th-grade team. Choosing a task that targeted our learning goal of providing students with many opportunities for discourse allowed for deep discussions about the nature of the problems chosen by the grade bands. To have discourse we, inherently, would need a mathematical space where students could talk about mathematical ideas and strategies. We wondered:

- What kinds of tasks provide opportunities for access and scaffolds but also for extension to even deeper levels?
- How can we best adapt a task to meet each grade's patterns, functions, and algebra learning targets?
- What do we anticipate students doing with the task, and how will that help us better understand their mathematical understanding?

**Primary task.** Figure 6 shows the kindergarten and first-grade task, created by the team to highlight the many kinds of repeating patterns children could make. Using the Kindergarten and First Grade pattern standards (see Figure 5), the team hoped to open a range of possibilities for creating a repeating pattern, but also connected to real world context. The team wondered about where in real-life primary students might see patterns, and what might excite them to create a pattern and decided on a task that had students create a bulletin board border. Kindergarten and first graders could create any repeating pattern they wished, as long as it repeated at least three times to create the border The task also included a "missing part" as an extension, with the hopes of extending student thinking to consider what a possible core of the pattern could be to fix a "torn-down" part of a bulletin board. The team was very intentional in putting in the purple shaded box to increase the level of complexity of the pattern and to open possible solution strategies.

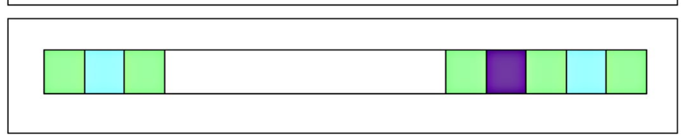
**Figure 6**

*Kindergarten and first-grade task*

It's time to make a new border for our classroom bulletin board! Your pattern must repeat at least 3 times! Choose any tool you'd like to create your border.

Can you create another border with at least three attributes?

Some of the bulletin board border has been torn down! Can you figure out what parts of the pattern are missing?



The kindergarten and first-grade team anticipated an initial default to ABC patterns and students having difficulty identifying a different type of pattern that still had three attributes, but brainstormed others such as AABC, ABAC, and ABCC as potential cores students might explore. Additionally, teachers wondered about students' creation of patterns outside of using colors for the core of the repeating pattern. We extensively discussed what part of the pattern we might "tear down" from the bulletin board. Do we cover one complete repetition? Ultimately, we decided that it might lead to more interesting conversations and student use of strategies if we "tore down" part of the bulletin board pattern that started mid-core, where students might not be able to see the whole core of the pattern from the first term, instead determining a potential core in later terms. After making final adjustments to our planning process and considering the intersection of the task, patterning content, and student mathematical discourse, the kindergarten and first-grade teachers were ready to implement.

**Intermediate task.** The third through sixth-grade team chose a task that connected the third-grade content of multiplication and growing patterns with sixth-grade content of linear functions and proportionality (see Figure 7). As mentioned in the "study" phase, our school district had begun to embed several task resources into our curriculum and schools, so the intermediate team began with Boaler's (2018) Mathematical Mindset task books. In the third-grade version, Jenny noticed that a task called "Tile and Table Patterns" (Boaler, 2018, p. 222-230) connected growing patterns to multiplication, which would be beneficial to the third graders in her classroom. The task required students to connect a growing "tower pattern" to a hundreds chart by drawing arrays, extending the pattern and using creative color-coding to investigate the relationships between rectangles and numbers on the chart. Jacqueline pointed out that this type of growing pattern was also a linear function, and that the linear relationship could actually be seen as students connected multiplication arrays with a hundreds chart. The vertical team recognized the transition from "repeating pattern" foci in kindergarten, to "growing pattern" foci in the older grades. We also had interesting planning discussions about what actually "repeats" in growing patterns and linear functions, as there is a common repetition of a rule that causes a multiplicative relationship to occur. Teachers were curious to see how an eight-year-old might access or think about this task similarly or differently from an eleven-year-old.

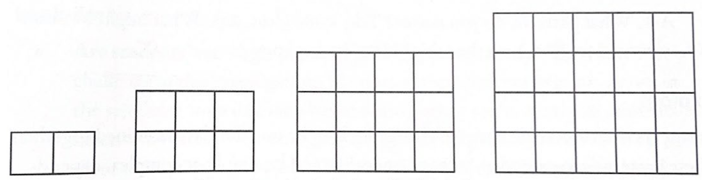
The intermediate team anticipated that students would begin to create patterns that grow in multiples, for example, 3 x 1, 3 x 2, etc., and grow by doubling. The sixth-grade teacher noted that students may have a misconception about connecting this type of thinking to a ratio table and considered the types of additive thinking that might develop instead. For example, a student might create a ratio table that adds up by threes and also create sums of numbers representing what should be the number of rectangles (see Figure 7), indicating a disconnect between the student's understanding of ratio tables and multiplicative reasoning. We also wondered about students drawing their patterns starting in different places in the multiplication table and how that would impact their understanding of the connection between the two. Further, the team discussed the language students might use when considering their growing patterns: Do they use multiplicative or additive language? Are they beginning to generalize an overall rule or describing from term to term? Anticipating student responses to the chosen low-floor, high-ceiling task allowed our intermediate LS group to take the next step in collaboration to reach their professional learning goal for student discourse, particularly in the moment of teacher. Now, they would know what to look for in order to elevate student-to-student discourse opportunities in small and whole-groups.

**Figure 7**
*Third, fourth, and sixth-grade task*

**Tile and Table Patterns** (Boaler et al., 2018)

**Snapshot**
Students create growing patterns with rectangles and then locate those rectangles on the multiplication table to see what new patterns this reveals.

| Activity | Time | Description/Prompt | Materials |
|---|---|---|---|
| Launch | 10–15 min | Show students the tower pattern and ask what patterns they see. Discuss how the pattern grows. Then ask them to locate these rectangles on the multiplication table. Discuss what patterns they see now, and predict where the next rectangle in the pattern will be in the table. | • Tower Pattern sheet, to display<br>• Multiplication Table sheet, to display |
| Explore | 30–40+ min | Partners create their own growing rectangle patterns on grid or dot paper and then locate their rectangles on the multiplication table, extending the pattern as far as it goes on the table. Partners try this with different patterns, color-coding them on the multiplication table and making observations. | • Grid or dot paper (see appendix), multiple sheets per partnership<br>• Square tiles<br>• Multiplication Table sheet, at least one per partnership<br>• Colors |
| Discuss | 20 min | Partners present the most interesting pattern they created, along with where it is located on the multiplication table. Discuss the patterns student see in the multiplication table, and generate questions that students are wondering about now. | • Multiplication Table sheet, to display<br>• Colors |



Tower pattern showing horizontal and vertical growth

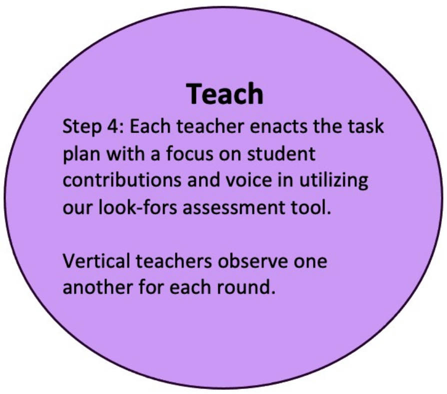
| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| 9 | 9 | 18 | 27 | 36 | 45 | 54 | 63 | 72 | 81 | 90 |
| 8 | 8 | 16 | 24 | 32 | 40 | 48 | 56 | 64 | 72 | 80 |
| 7 | 7 | 14 | 21 | 28 | 35 | 42 | 49 | 56 | 63 | 70 |
| 6 | 6 | 12 | 18 | 24 | 30 | 36 | 42 | 48 | 54 | 60 |
| 5 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
| 4 | 4 | 8 | 12 | 16 | 20 | 24 | 28 | 32 | 36 | 40 |
| 3 | 3 | 6 | 9 | 12 | 15 | 18 | 21 | 24 | 27 | 30 |
| 2 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 |
| 1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| x | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

A 2 x 3 rectangle is shown with a point representing the area at the number 6. A 5 x 6 rectangle is shown to have an area of 30.

In planning for discourse paralleled with vertical mathematical content, the LS team created task-based lessons that would offer rich opportunities for students to participate in mathematics in ways they may not have had before. In summary, our "plan" phase consisted of the following learning processes, guided by the team:

1. We used our research from the "study" phase to plan a monitoring look-for chart;
2. Identified and adapted tasks from a bank of resources, including those from the district;
3. Anticipated student responses to the tasks to better understand the mathematics; and
4. Created a task-based lesson plan for implementation.

***Teach:* Connecting Deeply with Mathematical Understanding**




In the "teach" phase of LS, teachers enacted their selected tasks while the co-researcher team observed, utilizing the discourse monitoring tool. Each member of the team used the monitoring tool, focused on children's actions and language, while in the host-teacher's classroom. Each teacher from the LS team received an invitation to observe the other teachers on the LS team. So, in our model, every teacher was an observer and every teacher was a host.

Across the enactments of the lessons, we noticed the ways that students were doing mathematics across NCTM's (2020) key recommendations. The co-design team noticed that our observations of the ways students engaged in *doing mathematics* aligned with NCTM's (2020) vision in that students engaged in 1), representing and connecting, 2) explaining and justifying, 3) contextualizing and decontextualizing, and 4) noticing and using mathematical structures. In the following sections we utilize these practices as a way to frame what our LS team noticed within the "teach" phase. We employ these processes and practices to structure discussion of the discursive practices that our LS team noticed within the "teach" phase.

***Representing and Connecting***

We observed students engaged in *doing* mathematics in various ways beyond simply solving an "extend this pattern" problem. Students represented their work with multiple representations and connected the different models of patterns. When given a variety of tools to use, we saw students' thinking and solutions in different ways. For example, Figure 8 shows a kindergarten student working on transferring patterns. By using the manipulatives, they made a direct transfer of this pattern, first using the same colors as is seen on the paper pattern. Importantly, teachers created a manipulative-rich environment, and because students had access to a variety of tools they were able to transfer the pattern in a new way. We see the child using the same ABCD core, but now with new manipulatives and then colors. On the bottom row, the student recreates the blue, purple, green, orange core as orange, red, yellow, tan. It's also clear that this student focused on the color as a pattern, rather than the type of manipulative being important because they used a red square and a red trapezoid to both represent the "red" part of the core which indicates their focus on the attribute of colors.

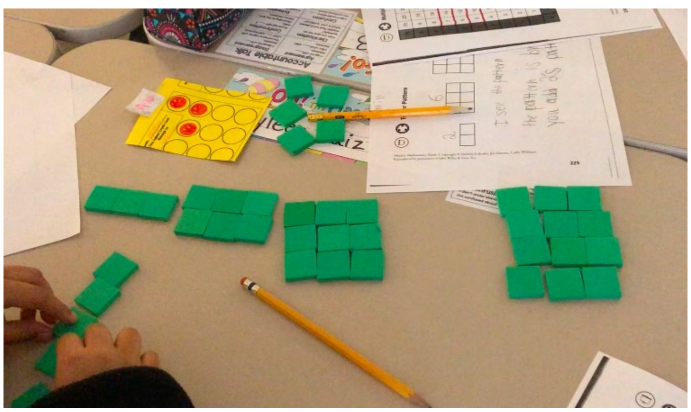
**Figure 8**

*Kindergartener transfer of patterns across mediums*

The openness of the task instilled mathematical agency as students chose strategies that made sense while justifying their reasoning to their peers. The variety of strategies allowed the teacher to purposefully partner students who were solving in different ways so that they could learn from one another through discussing how their representations of the bulletin board border were the same or different In the moment, the host teacher decided to partner students who had similar cores but used different materials to make the core. Kaitlin indicated in her anecdotal notes that it was powerful to see how this student justified the ABCD core to another child who was not sure that the mix of manipulatives still represented the pattern because in their pattern, they used all unifix cubes. By noticing that his partner's pattern was different than his through the connecting prompts, mathematical questions occurred: Do you have to always use all the same materials to represent a pattern? Or can we still see the core? It also provided space for the teacher to connect the small group discussions with the whole group's reflection on mathematical thinking and strategies to move beyond just "extending" the pattern to thinking deeply about the core and what exactly is repeating by facilitating conversation around several student representations and continuing to ask, how are these the same? How are they different? How do they all show us a repeating core?

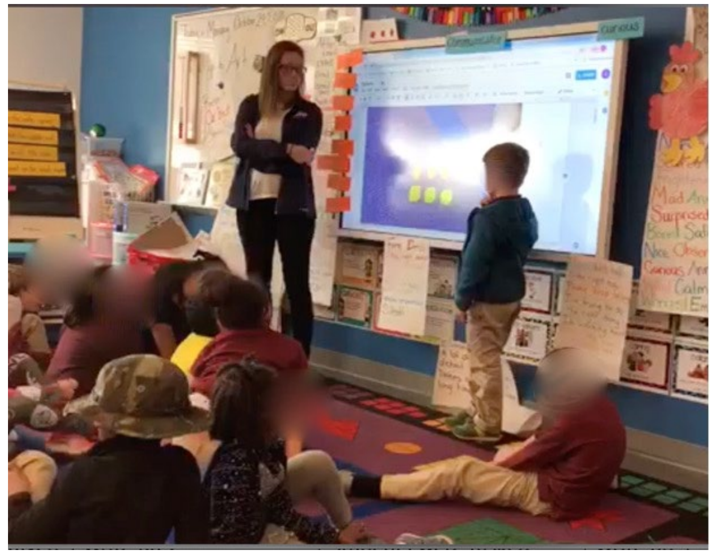
When students can choose to represent their math thinking with different tools, children make essential connections and generalizations. In the third-grade classroom, children used tiles to recreate the growing tower pattern (Figure 9). After creating this pattern with tiles, collaborative pairs worked to transfer their growing patterns to a multiplication table, which allowed students to make important connections between the physical tool of tiles and the abstract drawings of the representations. As students connected these two different representations, conceptual understanding developed as students were able to understand how the numbers in the multiplication chart connected to the total number of physical tiles and the equal rows and columns indicative of the multiplicative relationship.

**Figure 9**
*Third grade students recreate tower pattern with tile*



***Explaining and Justifying***
Much of our notes and discussions during the "teach" phase focused on the ways students moved between explaining and justifying to figure out the *mathematics* with a partner, to then explaining and justifying their group's mathematical models and ideas in a whole-group setting. A first-grade child, for example, shared how he and his partner saw a unique pattern representation with the class (Figure 10). He said, "We saw blue-blue-blue, orange-orange-orange, yellow-yellow-yellow." The teacher asked a very purposeful and pre-planned question from the lesson plan, "does that make this a pattern?" The student thought about his reasoning during a whole-class turn-and-talk and decided, no, it does not after bouncing some ideas off of his turn-and-talk partner. Then, he looked at the pattern from another angle and said, "I changed my mind. I see it this way: yellow-orange-blue, yellow-orange-blue." Because he explained his thinking and had to follow up to justify it, he was able to revise his mathematical ideas alongside his peers and express with more precision where to find the core of the pattern.

**Figure 10**
*First grade student explains a unique mathematical noticing to his class*



Similarly, a fourth-grade child in Figure 11 justified her mathematical ideas to her classmates by explaining her thinking about the growing pattern in the intermediate tiling task. Other students made connections, asked clarifying questions, and added to her thinking. As this student explained and justified her thinking, she represented the pattern in different colors, stating, "I noticed a pattern with the numbers in yellow. Those numbers are how many tiles are in each figure of the pattern." What she was noticing was that the entire quantity of the arrays could be captured by the upper right hand number in the multiplication table because of the relationship between the row number and column number. She also indicated that each square that she built was inside the larger the squares because the highlighted yellow number fell diagonally below the larger square number. The host teacher decided to open the conversation to the students listening from the carpet. The teacher asked, "What ideas do you have about her mathematical noticing and how she represented the diagonal?" After a turn-and-talk to reflect on the representation, comments from other students included, "I didn't see it that way. Now I understand why those numbers are important to the pattern." This student was doing mathematics while justifying her thinking through explanation and representation.

**Figure 11**
*Fourth grade student justifying what she noticed about the growing pattern to the class*

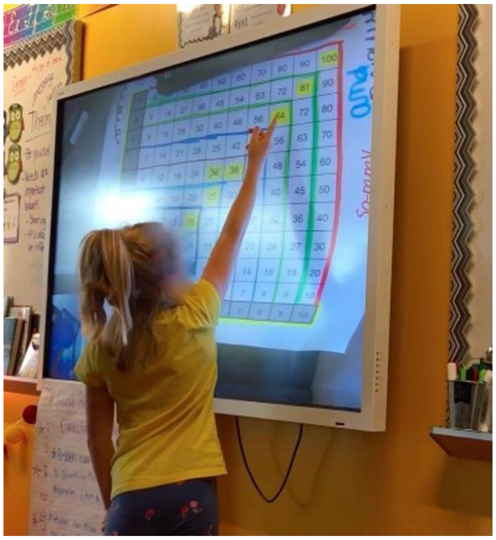
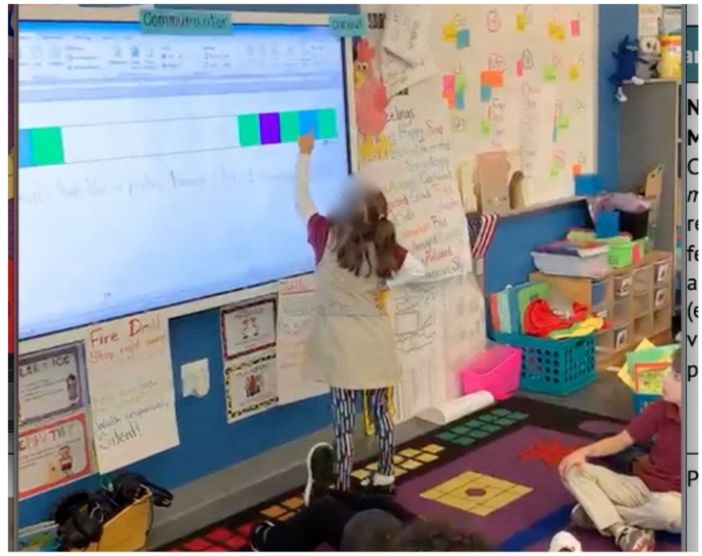


**Figure 12**
*First-grade student explaining what would make the most sense for a bulletin board border*



***Contextualizing and Decontextualizing***
We often noticed that students explained the ways that they were fluidly moving between the contexts, representations, and sense-making. In a first-grade class, the host teacher prompted partners to discuss their patterns by noting, "I noticed you both decided on different patterns for the missing part of the bulletin border. Could you all talk about that? Can they both work?" One partner explained what she thought the "hidden" pattern might be, while another student countered her ideas (see Figure 12). An observing teacher recorded the peer conversation on their monitoring tool.

*Student A: The pattern could be blue, green, blue, green, then change in the middle to include the purple.*

*Student B: I don't think so. Normally bulletin boards have the same paper all the way across the bottom. I don't think it would change.*

They likely engaged in mathematical argumentation because of their interest in the concept of the problem--- not simply identifying cores of given patterns in a low-level task, but instead were interested in solving the "mystery" of the torn down bulletin board. Because they were using the context of a bulletin board border to make sense of patterning, they were able to use this type of reasoning to better make sense of the mathematics and the core of a pattern. The students recognized that, most often, a bulletin board pattern has the "same paper across the bottom," which pushed them to have conversation about what would make the most sense as the continuing pattern.

Providing students with tasks where they can make mathematical connections (such as between a growing pattern and a multiplication table) and are interested in solving the problem creates high student engagement and collaboration. For example, a fourth-grade partnership engaged in mathematical discourse about the problem while questioning ideas and building a shared understanding of the pattern while connecting to the more familiar context of multiplication (see Figure 13). The fourth grade host teacher noticed that Leo was shading just the growing number pattern for counting by 2s (i.e. 2, 4, 6, 8), while Max was creating the rectangle arrays for the pattern. She wondered about these two ideas and decided to partner them together so they could discuss.

*Max (pointing to the hundreds chart): So this is like multiplication. Like when we count by twos or fives. You know when we skip count and that's multiplying?*

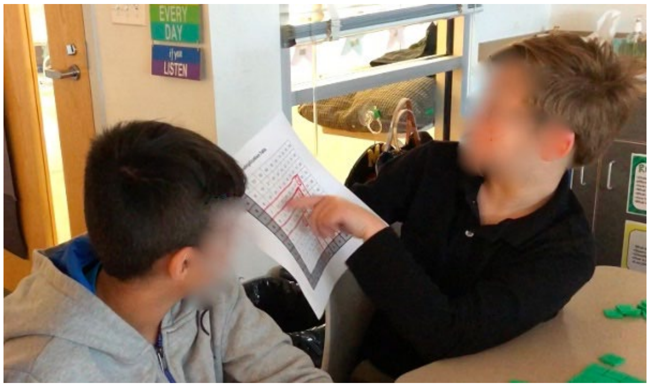
*Leo: Wait. But I see 2, 4, 6, and 8 on this chart. But I don't see the multiplication.*

*Max: See how I made these rectangles. That shows the 2 x 4 which is the 8. But it's getting bigger and following this pattern.*

*Leo: So there's the two more (points to the larger rectangle which represented the array for 10).*
*Max: Yeah and it equals 10, so it makes this line across.*

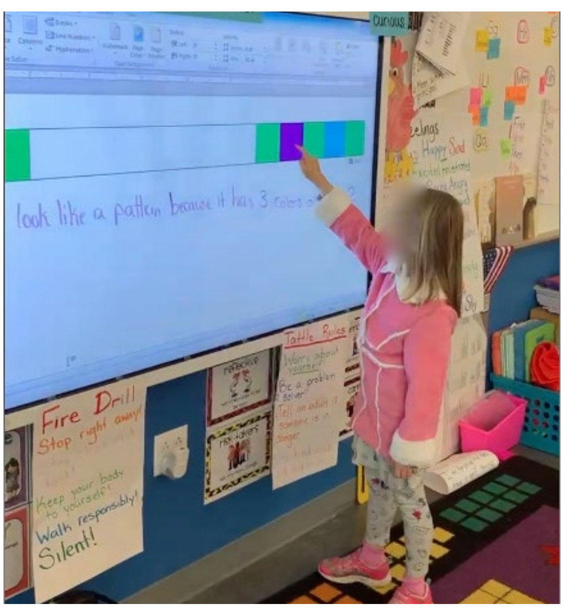
With further conversations, the multiplication chart, a common tool for the students, acted as the vessel for the partnership to notice the "line" created if you follow the diagonal up the page when exploring different square arrays. The group noticed that it seemed to stretch one row "up" and one column "out" to create the diagonal line.

**Figure 13**
*Fourth-grade students used the hundreds chart pattern to recognize a diagonal line*




***Noticing and Using Mathematical Structures***
Across our observations, we noted how children from kindergarten to sixth grade discussed mathematical structures and used them to justify strategic thinking. For example, a first-grade student used her math vocabulary to explain her thinking (Figure 14). She acknowledged that the core of the torn-down pattern appeared unfinished but applied her knowledge of patterns to develop a solution. "I see that green-blue-green is at the beginning, and I see it again over here. I think that this purple comes at the end of the core." She used the structure of patterns to establish her solution. Another child incorporated math vocabulary into her explanation, noticing that there *had* to be a core for it to be a repeating pattern, stating that the class needed to "decide what the core is." The class debated what that extra purple box meant for the core and how it might play out with the space missing in the pattern, using their understanding of repeating cores to make sense of this new and challenging situation.

**Figure 14**
*A first-grade student used her understanding of "core" to decide where the purple might fall*



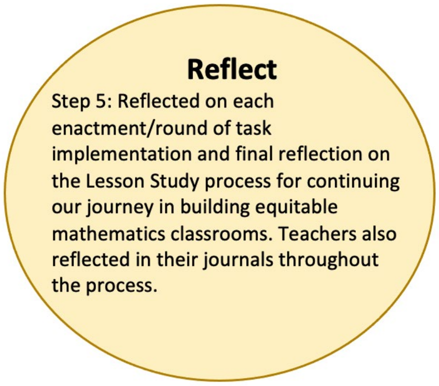

During the whole-group reflection on the growing patterns task, fourth-grade students also came together to discuss key mathematical ideas. An important part of the LS team's collective lesson was specifically choosing student work to compare mathematical ideas with the whole class. The fourth grade teacher invited several students to share how they figured out what kinds of growing patterns existed on the multiplication table. One student explained how her model was different from another group's model because they created the towers horizontally, while the partnership she worked in represented the towers vertically on the hundreds chart (Figure 15). The teacher elevated this moment in the conversation as a noticing of mathematical structures asking, "Can we represent the growing pattern either way? Why or why not? What does this help us to understand about multiplication?" This student's noticing led to conversation revealing early conceptualizations of the commutative property through array models.

**Figure 15**
*Fourth-grade child noticed that a group created a horizontal model of the pattern, which contrasted with her vertical representation*

Across these examples from the "teach" part of our Lesson Study, students represented patterns while connecting models to deeper conceptualizations of patterning all related to the opportunities for small group and whole group discourse. Discursive practices emerged in sense-making around how models connected to the core of the pattern or how much each figure grew, and children generalized their thinking to find ways to extend the pattern. With a wide range of strategies and ideas discussed during small group thinking, the teacher facilitated a whole group discussion with diverse strategies and focused on the math context of connecting patterns to the multiplication chart. As students began to explore patterns within a real-world context, they looked at the problem as a whole and isolated the needed information, noticing and using pattern structures, which stood out to our LS team. As host teachers facilitated our group lesson plan, we collected much information that helped us to see that *how* we implement a task or lesson is just as important to *what* is in the lesson itself. Our "teach" phase consisted of the following processes:

1. Each grade level teacher (K, 1, 3, 4, 5, 6) hosted an enactment of the lesson in their classroom while other members of the LS team observed;
2. The observation team utilized the discourse observation tool to notice and note how students engaged in discursive practices.

***Reflect:* Valuing Student Contributions and Promoting Discourse**




A critical component of our vertical LS learning was continual observation, reflection, and revision of our educator perspectives and mathematical pedagogies. While the K-1 and 3-6 grade bands initially planned independently of each other (though collaboratively within the bands), our observations happened across all grade levels. Kindergarten and first-grade teachers had the opportunity to observe upper-grade instruction, and vice versa. We were able to gain a deeper understanding of the progression of the pattern standards by seeing student engagement, discourse, and problem-solving in action. After observations, the group engaged in a collective reflection. In the "reflect' phase, teachers discussed their collaborative work and evaluated ways to enhance their lesson and approach.

We followed the "reflect" protocol proposed by The LS Group at Mills College (2022) which began with taking time to look over data. Data artifacts included student work samples from the tasks and the discourse monitoring tool with anecdotal notes, along with any other notes that the team felt was important to our learning. We used this data in conducting our post-observation discussion, letting the host teacher speak first, then the rest of the team, to talk about what stood out about our collective lesson plan and the facilitation in the classroom. We ended our reflective sessions by consolidating our learning to think about what we wanted to tweak before the next iteration of LS observation and what we wanted to carry into our daily practice. Looking back on the process, teachers had a chance to recognize their growth and how the process impacted their own practice as mathematics teachers, both through the structure of LS itself in becoming reflective practitioners committed to growing and in the process of building discourse-based, equity centered classrooms.

***Lesson Study as a Chance to Become a Reflective Educator***
Teachers indicated throughout our reflective sessions and within their journal entries that the actual process of engaging in a vertical LS grew them as reflective and learning-centered practitioners. When asked how LS impacted her learning, Jacqueline shared how observing lessons and peers across different grade levels was powerful in helping her to recognize teacher moves that might elicit student strategies and ideas,

*I was amazed at the valuable insight I gained about my own practice by observing another teacher in action from a grade level two years below mine. By focusing on student discourse and the strategies used, I was able to watch other teachers implement strategies in their own unique ways and contemplate ways in which I could implement/adapt those strategies with my own students at the sixth-grade level.*

Further, the consistent journaling throughout the LS process helped teachers reflect on how their planned questions enhanced student discourse. Jacqueline acknowledged how writing down questions about her own practice helped to guide the things she looked for in classrooms,

*First, writing down my questions of how I could implement strategies to increase student discourse, get students sharing their strategies/thoughts, and have students responding and reflecting on their peers' strategies helped me to hone in on these ideas and create a solid plan for implementing them.*

Jacqueline went on to explain how journaling immediately following a lesson or debrief helped her to make visible the negotiation of teacher facilitation and children's discourse in mathematics. Embedded in the Lesson Study, teachers journaled both in the moment as they were observing and as part of our debriefing. One shared, "Reflecting in my journal after a lesson helped in recording my immediate thoughts-what worked well, what helped students to talk, and what steps I needed to take next so that they weren't lost in the shuffle of all the other teacher tasks." Not only did journaling as a reflective practice carry on in Jacqueline's teaching, she also found it beneficial for her students.

*I felt the benefit of writing my thoughts, questions, and summaries of the lessons so greatly that it is actually a practice I implement for my students as well, giving them time at the end of a lesson or activity to write in their interactive notebooks about their own reflections of the math learning taking place.*

Interactive writing and journaling, a form of written discourse, provided time and space for both teachers and students to make sense of their learning stemming from an emphasis on mathematics discourse during the task.

## LESSON STUDY AS A CHANCE TO PRIORITIZE STUDENT VOICE AND DISTRIBUTE MATHEMATICAL CONTRIBUTION THROUGH STUDENT TO STUDENT DISCOURSE

Keeping a focus on the common vision of creating an equitable discourse-rich classroom from the planning stage allowed for teachers engaged in the Lesson study to work on prioritizing student voice and contribution through student to student discourse. Jacqueline looked back on her journal entries to see how the notion of her role as a mathematics learning facilitator shifted over the course of the lesson study. She indicates how, as LS "teach" and "reflect" sessions progressed, she witnessed the transfer of students moving from passive receivers of math knowledge, to creators and contributors of math knowledge. This captures a huge goal of our LS as we grew as a team to create spaces where children could contribute and have a voice that brings more ownership in their learning there by developing positive mathematical identities (Aguirre et al., 2024),

> *In one journal entry I wrote, 'the best part is that my students are formulating conceptual ideas for themselves!' I witnessed (and continue to witness) students developing a deeper understanding of concepts through engaging with one another, sharing strategies, being able to talk through and then building upon their own understanding. My role, as a facilitator, is to showcase student thinking to help students conceptualize, connect, and discover math. The impact this had in my classroom is seen in the increased level of engagement in my students, students' confidence in their math abilities rise, and my favorite part, the noise level in my classroom.*

Jenny also explained how observations of vertical classrooms impacted her mathematical knowledge for building a discourse-rich community. Jenny noted the need for student-to-student discourse, especially as children built models to represent their thinking, and discussed how she went even further to create more scaffolds to access peer discourse.

> *Following each of my observations, I was able to revisit, adjust and improve my planning of the lesson and eventually the delivery. I saw the benefit of conversation in connection with building a model. I decided to create sentence starters that would provide students ways to tell about their thinking. I also had sentences starters of ways to ask questions in response. This created a conversation about each pattern. My goal was to hear the students not just share their own ideas, but to really challenge their classmates to talk through their thinking. This influenced students to talk more and to reach a level of mindfulness of their why.*

Through the probing questions and sentence stems, she allowed for students to work on their explanations and justification and to orient students towards other students' thinking. In this way, the discourse moved beyond just increasing student voice to distributing intellectual ownership across multiple students. LS not only led to reflection within the moment, but propelled teachers into thinking about their daily practice and what might come next within their specific contexts and future tasks. Further, Jenny noted,

> *My classroom is a place that fosters conversations. I find myself speaking more with questioning sentences and less with telling sentences. I encourage my students to also use questioning sentences to learn from each other. I purposefully plan to observe my students and encourage cognitive self-awareness.*

As teachers reflected both within and after the LS sessions, they became increasingly aware of not only the benefit in creating discourse-rich environments, but also the ways students learned mathematics deeply--- pivotal shifts towards creating and implementing equitable structures and reaching towards NCTM's (2020) key recommendations.
In summary, we found two major benefits of LS as a professional learning experience and efforts in increasing student discourse. First, LS is a way for teachers and teacher leaders to hone their practice by learning from the community. Teachers observed and integrated new to them strategies such as sentence frames, and consistently reflected on their growth as educators through the process. Second, LS allowed teachers to really focus on their goal of creating discourse rich environments. Highlight the various takeaways they had about HOW they learned to do this through the reflection process. I think the idea of "forward thinking" and planning is a really important success to highlight as you close this section. We cannot always do lesson study, so we want the impact to go beyond the single lesson itself and to create a ripple effect.

**Next Steps and Implication for Lesson Study Implementation to Catalyze Change**

Lesson Study and the learning process around student discourse documented shifts in teachers' practice and thinking that reflect more equitable mathematics experiences by increasing student voice as well as distributing intellectual contributions across more students. Together, we were able to practice forming discourse-rich classroom communities and employed our new knowledge to determine the next steps for the classrooms in our school. Our individual and collective reflections allowed us to refine the tasks for other iterations to deepen our knowledge of what it means for students to *do mathematics* through the lens of NCTM's key recommendations (2020). One of the prerequisites for creating a more equitable learning space where student math thinking is honored and mathematics learning is distributed and experienced by each and every student is ensuring teachers better understand notions of "doing mathematics" and "student discourse," which is what the vertical LS structure afforded to teachers. Teachers who understand both the mathematics and discursive structures for topics they teach are better able to provide rich opportunities in which students can engage. Our patterns task gave every student an entry point to engage in mathematics at their own level, but everyone's thinking was elevated due to learning as a collective. Creating space to connect the ideas that emerged in small groups with the whole group discussion allowed the teacher to assign competence in mathematical ideas. The robust array of strategies and diversity of thinking allowed the class to explore the mathematical concept's intricacies further, engage in one another's mathematical knowledge, and empower them with access as the knowers and doers of mathematics.

Without the LS opportunity, entrenched with peer observation, reflecting questioning, planning, and revising, teachers may not have had such a robust and job-embedded learning experience. LS provided a safe professional learning opportunity to bring the essential effective PD components (Desimone, 2009) which include 1) content focus—activities that are focused on algebraic thinking and how students learn that content 2) active learning: opportunities for teachers to observe, receive feedback, analyze student work 3) coherence: content, goals, and activities that are consistent with the school curriculum and goals, teacher knowledge and beliefs, the needs of students, and school 4) sustained duration: PD activities that are ongoing and 5) collective participation: groups of teachers across grades to participate in PD activities together to build an interactive learning community.

Engaging in a vertical LS gave us the opportunity to think beyond the learning targets of our particular grade levels, providing a vision of what a mathematical concept looks like across multiple grade-levels. Knowing what comes in the future, and what students learned previously, can establish a more holistic understanding of mathematical teaching and learning for teachers and, consequently, the students in their classrooms. Looking along a vertical content progression of patterns, functions, and algebra allowed us to connect students' mathematical knowledge to equitable discursive practices to find strength in student sense-making and understanding. The possibility of a vertical LS requires a commitment to teacher development and professional learning, as well as the continued opportunity for collective planning, observation, and reflection.

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## Appendix A

Checklist Used for Lesson Study Assessment of Student Discourse

### Evidence of Student-to-Student Discourse

| Evidence | Y/N | Notes |
|---|---|---|
| Opportunities during task and whole-class reflection for students to engage in meaningful discourse. | | |
| Students explaining their mathematical thinking. | | |
| Students commenting on their peers' mathematical thinking. | | |
| Students using sentence frames to talk about their peers' thinking (e.g.):<br>● I agree because…<br>● I disagree because…<br>● Their thinking is similar to mine because…<br>● I wonder about…<br>● I notice that… | | |
| Students asking each other questions. | | |

## Appendix B

Lesson Study Lesson Plan Template (adapted from Van de Walle, et al., 2019)

| | |
|---|---|
| **Team Members:** | |
| **Lesson Date:** | |
| **Grade Levels:** | |
| **Title of Lesson:** | |
| **Research Theme:** | |
| **Rationale for choosing the topic:** | |

**Task Lesson Plan**

Title of lesson:

| **PART 1: PRIOR TO IMPLEMENTING THE MATHEMATICAL TASK; Van de Walle et al., "Before Phase" (10-15 min)** | |
|---|---|
| **Essential Knowledge and Skills: Content and Cognitive level of standard(s)** | |
| **Essential Question** | |
| **What are your mathematical learning goal(s) for the task?**<br>**Include behavior and conditions.** | |
| **Criteria for mastery and formative assessment tool—how will you monitor student understanding as they engage in the task?** | |
| **What task will you use for the lesson?**<br><br>Provide a short description of the task.<br>● What tools will students have available to them?<br>● What additional scaffolds might you provide? | |
| **Anticipating:**<br>*Work through the problem yourself.*<br><br>Describe possible **anticipated student solutions and strategies** that may occur during the task, as well as **possible misconceptions**.<br>*-What will students do or say that lets you know how students are thinking about the mathematical ideas?*<br>*-What will children be doing or saying if they understand or if they do not understand?* | |

| | |
|---|---|
| **Launching the task/lesson (activator):**<br><br>Address each of the teacher actions for the Before Phase of the lesson plan. How will you:<br>● activate prior knowledge?<br>● be sure the problem is understood?<br>● establish clear expectations? | |

<table>
<tr><th colspan="2">PART 2: DURING TASK IMPLEMENTATION; Van de Walle et al., “During Phase” (30-50 min)</th></tr>
<tr><td>Monitoring<br>How will you monitor and keep track of key strategies used by students during the task? Which strategies will you monitor? (This will connect with your selecting plan below.) Create an observation chart or checklist or other monitoring tool that is connected to the EKS (formative assessment).<br>-What should the observer pay attention to as the children work and talk?<br>-What is the evidence that students understand the mathematics?<br><br>What questions will you ask to—<ul><li>help students be organized to work on the task while you are free to confer?</li><li>help a student get started or make progress on the task?</li><li>focus students’ thinking on the key mathematical ideas in the task?</li><li>informally assess students’ understanding of key mathematical ideas, problem- solving strategies, or the representations?</li><li>move students to think deeply about the mathematics and advance students’ understanding of the mathematical ideas?</li><li>provide appropriate support without taking over student thinking?</li><li>provide appropriate extensions?</li></ul></td><td></td></tr>
</table>

| PART 3: SHARING AND DISCUSSING THE TASK; Van de Walle et al., "After Phase" (10-20 min) | |
|---|---|
| **Selecting**<br>What possible solutions do you want shared during discussion? Explain. (These are the strategies you monitored.) | |
| **Sequencing**<br>In what order do you want to present the student work samples? Consider your mathematical goals and learning trajectories.<br><br>How will:<br>● students share their work?<br>● you listen actively without evaluation?<br>● you sequence who will share to highlight your mathematical goals of the lesson? | |
| **Connecting (Summarizer):**<br>What specific questions will you ask so that students will:<br>● make sense of the mathematical ideas that you want them to learn?<br>● expand on, debate, and question the solutions being shared?<br>● make mathematical connections among different strategies that are presented?<br>● summarize main ideas and identify connections to future mathematics problems? | |

# ONE CURRICULUM COMMITTEE'S PERCEPTIONS OF HIGH-QUALITY MATERIALS

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## ABSTRACT

This paper highlights aspects of the curriculum adoption process that may have previously been overlooked—the degree to which the curriculum committee has a shared view with one another of material quality, including committee members' views about material appropriateness and the alternatives they would recommend for students. We highlight one curriculum committee's perspectives, which were generally coherent with one another with respect to their views of material quality and appropriateness. In addition to describing details of the project, we share key insights and make recommendations for how other districts might attend to these aspects of a curriculum series adoption that promote more inclusive mathematics experiences for all students.

*Keywords: mathematics curriculum, interdisciplinary perspectives, high-quality materials, appropriate materials.*

Many school districts undergo curricular reforms with the hopes of creating coherent mathematics learning opportunities for PreK-12 students (Hirsch & Reys, 2009). Although it is important for the curricular materials themselves to have coherence, or a logical sequence of topics (Confrey et al., 2017), it may be similarly important that the people selecting those materials achieve two kinds of coherence—a shared view of material quality within the group and that the group's views align with existing research about what constitutes high-quality curricular materials. Personnel coherence is necessary for sustained instructional improvement, requiring effort from people invested in mathematics education across a school district (Cobb et al., 2020). After uncovering the degree to which personnel coherence exists, a district could examine the degree to which the group's perspective aligns with professional guidance.

Achieving personnel coherence may be challenging because often, invested persons are brought together to form a multi-disciplinary committee, charged with finding, evaluating, and piloting materials. Committee members from various disciplines may hold divergent views about mathematics teaching (e.g., van Garderen et al., 2009), which if left unaddressed could disrupt the process of selecting a series that reflects the personnel coherence needed for instructional change. Conversely, working with a multi-disciplinary committee has affordances for those engaged in the work, some of which include innovative thinking (Hardré et al., 2013), programmatic improvement (Goos & Bennison, 2018), and opportunities for people to develop cross-disciplinary empathy (Mason & Thomas, 2021). This suggests that perceptions about material quality are not neutral and that disciplinary differences could either hinder or enhance the curriculum selection process.

It is further necessary to investigate these views since high-quality materials alone will not ensure robust opportunities for students to learn. The National Council of Teachers of Mathematics (NCTM; 2014) clarifies:

> *Administrators should recognize that pacing guides, textbooks, and other instructional materials can guide the planning process but should never take the place of the teacher in determining how to meet the needs of students in a particular class most effectively (p. 77).*

This excerpt highlights the teacher's role in making use of curricular materials by deciding that particular materials are or are not appropriate to meet their students' needs. Because curricular materials are strongly linked to students' opportunities to learn (Choppin et al., 2021; Choppin et al., 2022; Stein et al., 2007), it seems especially important to understand how practitioners might, through their role on a curriculum committee, make similar decisions when considering the students in their district.

We note here that existing literature about mathematics materials does not regularly include perspectives from curriculum committees, evidenced by the lack of empirical citations to which we can reference. What little discussion we did find about the experience of being on a curriculum committee was not empirical but was one person's editorial account of their experience (e.g., Newman, 2004). Despite this lack of attention, we contend that the decision curriculum committees are tasked to make—determi ning which materials are appropriate for the district to adopt—parallels the decisions classroom teachers make each day when using materials with students. That is, curriculum committees shape what materials are available to and sanctioned by the district (Hirsch & Reys, 2009), thereby placing boundaries around teachers' choices about what to teach. Similarly, when a teacher selects something to teach from or outside of the district-provided curriculum, they are placing boundaries around what students have the opportunity to learn (Choppin et al., 2021; Choppin et al., 2022; Stein et al., 2007).

Unlike other investigations that describe teachers' attention to or use of particular features within a specific curricular series (e.g., Fuentes & Ma, 2018; McDuffie et al., 2018) or teachers' perceptions and use of materials (e.g., Remillard & Bryans, 2004), we were working with a district that did not yet have specific materials to analyze. Because our partners were in the process of choosing materials, we were interested in eliciting views that could indicate the features to which this multi-disciplinary committee might be drawn, specifically noticing the degree to which those views were congruent with one another. We recognize that beliefs about what counts as appropriate and high-quality likely vary amongst teachers and could, under different circumstances, be conceptualized differently. Thus, we are careful not to suggest there is universal agreement about these constructs. This article describes one district's curriculum committee and their views of high-quality mathematics materials, including their perceptions about the appropriateness of particular material features for a range of students. Before describing the data, we first reiterate the link between curricular materials and opportunities to learn, unpack what professional organizations identify as features of high-quality materials, and highlight groups of students for whom access to high-quality materials has been sporadically or scarcely afforded. We then share the findings from our study and conclude with a set of implications for curriculum committees and district leaders who may be embarking on a district-wide series adoption.

## HOW ARE CURRICULAR MATERIALS RELATED TO MATHEMATICS LEARNING?

As Hiebert et al. (2007) suggested, the curriculum plays a part in shaping the learning opportunities afforded to students. Curriculum use can be considered in three phases: the written curriculum, the intended curriculum (i.e., what teachers plan to do), and the enacted curriculum (i.e., what teachers *actually* do; Stein et al., 2007). The written curriculum, the focus of this study, consists of mathematical tasks that vary in terms of rigor. Mathematical tasks can be considered to have lower- or higher-levels of cognitive demand with lower-level tasks characterized as *memorization* or *procedures without connections* (Smith & Stein, 1998). Mathematical tasks at these levels are disconnected from concepts, unambiguous, and aimed at producing correct answers, absent of conceptual understanding. Higher-level tasks are characterized as *procedures with connections* and *doing mathematics* (Smith & Stein, 1998). Mathematical tasks at these levels are conceptually oriented, ambiguous, and require non-routine thinking. Thus, such tasks can be represented and solved in multiple ways. The nature of mathematical tasks is, therefore, inextricably linked to the types of learning opportunities possible within the task (Stein et al., 2007). Professional organizations have thus articulated the kinds of learning opportunities they associate with high-quality materials.

## EXISTING GUIDANCE FOR EVALUATING THE QUALITY OF CURRICULAR MATERIALS

The NCTM and the Association of Mathematics Teacher Educators (AMTE) offer consistent guidance about the features of curricular materials that especially warrant the attention of prospective and in-service teachers. The message from both organizations is clear: the materials do not shape the curriculum, rather the materials are a tool for teachers; high-quality materials should align with the goals of and support student learning. One recommendation from multiple professional organizations is that teachers should use materials that facilitate coherent learning experiences for students within and across grade levels (AMTE, 2017; NCTM, 2014). Specifically, the NCTM (2014) indicates that materials should reflect everyday life and promote mathematical problem solving and reasoning. Further, the AMTE (2017) specifies that materials should include tasks that are meaningful, specifically that contexts and examples are related to what students would consider their real world (and not just what teachers may perceive as students' real world).

In addition to these specific features, both organizations foreground the role of the teacher in interacting with the materials and ultimately making instructional decisions. The AMTE (2017) promotes the idea that beginning mathematics teachers are prepared to adeptly read, interpret, and enact lessons. Specifically:

> *They have the content preparation and the dispositions to analyze instructional resources, including those provided by textbook publishers and those available from sources online, to determine whether these resources fully address the content expectations described in standards and curriculum documents (p. 10).*

This indicates that in addition to the skills needed to analyze a variety of curricular materials, teachers also need a particular disposition or attitude to make such instructional decisions. This professional disposition likely entails, in part, using an equity lens when evaluating and using curricular materials. With respect to materials, the NCTM's Equity Principle advocates that equity is achieved when teachers tailor their supports to facilitate mathematical success for students. This suggests that we would expect practitioners to view different materials as more or less appropriate for various learners. If something is deemed less appropriate for some learners, the question then becomes, what next? Or what instead? That is, if a curricular feature was determined inappropriate for some students, what would the practitioner turn to instead, and what impact would such a pivot have on the learning opportunity afforded to those students? Relatedly, the AMTE's (2017) indicator, Understand Power and Privilege in the History of Mathematics Education, also calls for well-prepared beginning mathematics teachers to ask questions about the type of instructional materials to which students have access. Given that both organizations indicate the need for practitioners to develop equity-oriented dispositions to evaluate the quality of instructional materials, it seems important to investigate whether and to what degree a district's curriculum committee—those uniquely positioned to make a crucial decision—may reflect this stance.

## (IN)EQUITABLE ACCESS TO HIGH-QUALITY CURRICULAR MATERIALS

Despite the importance of the written curriculum in affording learning opportunities, researchers agree that some students have disproportionate opportunities to access high-quality materials, which likely relates to their disproportionate opportunities to learn. It is well documented that students who face persistent marginalization are excluded from opportunities to engage in high-quality mathematics learning opportunities, specifically students of color (e.g., Battey, 2013; Berry et al., 2014), multilingual students (e.g., Callahan, 2018), and students with disabilities (e.g., Lewis & Fisher, 2016). One factor persistently linked to the learning opportunities afforded to students is teachers' views about who they perceive to be mathematically capable. That is, general education mathematics teachers have reported making instructional adjustments that vary in quality (e.g., Jackson et al., 2017), specifically in relation to students' disability status (e.g., Mason, 2023). Teachers' views have also been related to diminished learning opportunities for racially and linguistically diverse students (e.g., Wilhelm et al., 2017). Given the relation between teachers' views of students' mathematical capabilities and students' opportunities to learn, it would seem important to investigate whether such views were also related to the process of adopting a new curricular series. Beyond individual editorials about their experiences on a curriculum committee (e.g., Newman, 2004), this idea has been minimally explored. Yet, if teachers' views have been linked to differing articulated and enacted learning opportunities, those same views could reasonably surface amongst curriculum committee members. More pointedly, other curriculum researchers (e.g., Choppin et al., 2022) have identified the need to consider the context and demographics of the research site as important factors for understanding curriculum selection and use.

The purpose of the current study was to understand how the members of one district's curriculum committee thought about curricular materials in terms of their quality and their appropriateness for different groups of students. The following research questions guided our investigation:

1. How do curriculum committee members characterize high-quality materials?
2. How do curriculum committee members talk about material appropriateness with respect to different groups of students?
3. To what degree do curriculum committee members have a coherent view with one another of high-quality materials?

## BACKGROUND AND CONTEXT

Unity School District (a pseudonym) is in a small city in the Midwestern U.S. The largest percentage of students in this district identify as White (46%), followed by Hispanic (27%), and Black (17%), with the majority of students identified as low-income (69%). The district also serves students identified as English Learners (18%) and students with disabilities (18%).

Motivated by several persistent issues discussed here, Unity was in the process of adopting a new mathematics curricular series. After evaluating the district's standardized test data, district leaders found that a low number of students were meeting benchmark proficiency levels in math. As a result of this and other factors, they determined that the core math curriculum did not adequately support student math performance across the district. Other factors included high rates of students who were failing Algebra 1 by the time they got to high school. These poor outcomes were attributed to an incoherent mathematics learning experience across grade bands. Until this adoption, each grade band used their own curricular series. In response to these concerns, the district formed an ad hoc committee whose purpose was to select the new series that would be used PreK–12. To ensure the committee was representative of the district, one of the district's Assistant Superintendents and the Curriculum Director elicited interest in joining the committee from early childhood teachers, elementary teachers, building-level leadership, and district leadership, selecting committee members who represented a variety of buildings and grade bands. The district's one high school and one middle school mathematics department chairs were included on the committee, as well as representation from middle grades and secondary special education. This committee had not worked together previously and included individuals from a range of district roles and grade bands (see Table 1). They were tasked with choosing a curricular series that would support students PreK–12 and be used consistently across teachers and buildings.

Given the district's disjointed curricular history in mathematics, district leaders emphasized the importance of fidelity to whatever series was adopted. District leaders recognized the importance of teachers' agency in the instructional process, but because previous efforts were so uncoordinated leaders prioritized fidelity at the onset of adoption, highlighting the need for a district-wide structure. At the time of this project, the Curriculum Director expressed an interest in understanding how curriculum committee members perceived the experience of being on the committee, so in addition to the research questions addressed, we also collected data about participants' experiences on the committee. That information was not considered data and is therefore not shared here. The authors played no role in the district's series adoption process.

**Recruitment and Participants**

The Unity school district's Mathematics Curriculum Committee met regularly throughout the 2021–2022 school year, though the authors did not observe nor collect data during any of those meetings. In the fall of 2021, the first and second authors attended a single meeting to introduce the project to the committee members. During the meeting, we provided information about the level of participation, compensation, and safety measures in place to protect the participants' identities. After the meeting, all committee members ($N$ = 25) received an email with a link to a consent form; 13 participants (52%) consented to participate. Participants included five district-level administrators (39%), five building-level administrators (39%), and three classroom teachers (23%). The majority of participants identified as women ($n$ = 11; 85%); the majority of participants identified as White ($n$ = 11; 85%). Table 1 contains a list of participant information.

The participants in this study held a range of professional roles in their district. The Curriculum Director oversaw all curricular efforts, PreK–12. This person also supervised the two Curriculum Coordinators, whose work was focused in either elementary or secondary schools throughout the district. The district had one Grants Coordinator who, because of their prior experience with mathematics curriculum and instruction in another school district, was included on this committee. The Grants Coordinator was responsible for applying for and carrying out work in the district that was funded by external grants (e.g., afterschool programming). The Dual Language Coordinator supported the district's robust dual language program, which at the time of this study, was prevalent at the elementary (Grades K–5) and middle school (Grades 6–8) levels. The Building Principal oversaw the day-to-day operations of one elementary school in the district. Every school was assigned a Mathematics Instructional Coach (and an English Language Arts Instructional Coach counterpart) and supported mathematics instruction, including curriculum enactment, at their respective buildings. This committee also included general and special education teachers who were responsible for delivering mathematics instruction to students.

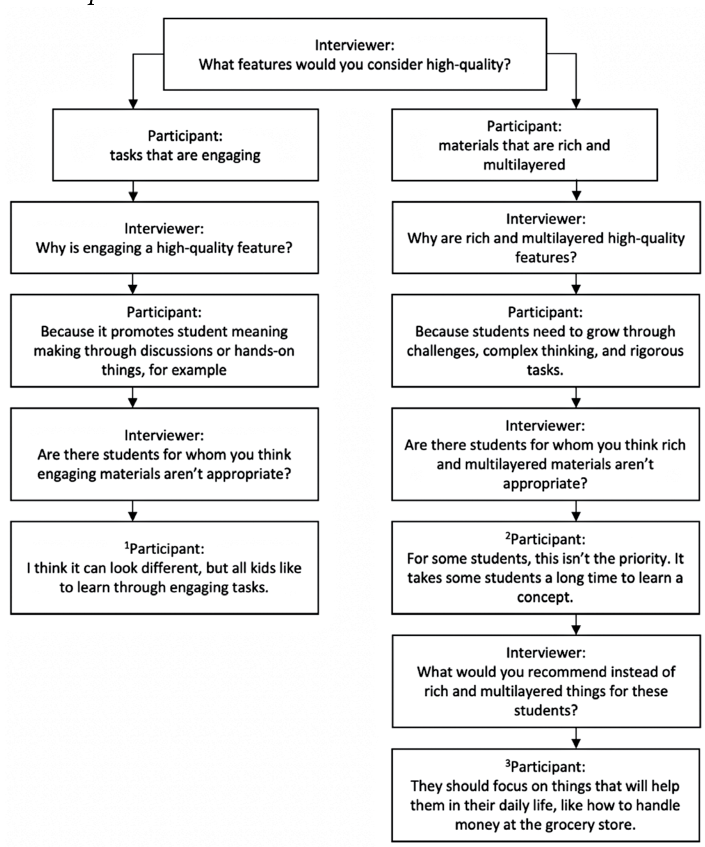
**Table 1**
*Participant Information*

| Participant Name | Participant Role | Grade Level/Area |
|---|---|---|
| Alex | Curriculum Director | District |
| Amanda | Curriculum Coordinator | Secondary |
| Erin | Curriculum Coordinator | Elementary |
| Jocelyn | Grants Coordinator | District |
| Lucia | Dual Language Coordinator | Early Childhood |
| Beatriz | Building Principal | Elementary School |
| Margaret | Mathematics Instructional Coach | Middle School |
| Sam | Mathematics Instructional Coach | Elementary School |
| Tina | Mathematics Instructional Coach | Elementary School |
| Marie | Mathematics Instructional Coach | Elementary School |
| Joe | General Education Teacher | High School |
| Elizabeth | Special Education Teacher | Middle School |
| Tiffany | General Education Teacher | Elementary School |

*Note*. Participants' names are pseudonyms.

**Data Collection**
During the 2021–2022 school year, we conducted two one-on-one interviews with each participant, for a total of 26 interviews in the whole data corpus. This paper shares findings from a subset of that corpus, 13 interviews conducted in fall 2021, which were, on average 39 minutes long (ranging from 22:28–55:45 minutes). We focused this analysis on the fall 2021 interview responses because the second interview protocol addressed content that falls outside the scope of these research questions and analysis. Participants had the choice to complete the interview in person or via Zoom. The first author conducted all the interviews using a semi-structured interview protocol which consisted of nine questions: (a) two questions about participants' views of high-quality mathematics materials, (b) one question about their views of material appropriateness and recommended alternatives, and (c) six questions about their experiences on the committee; Figure 1 provides an example of how the interview flowed between parts (a) and (b). Questions in part (c) were synthesized and shared with the Curriculum Director, participating members of the curriculum committee, and the Assistant Superintendent for Curriculum and Instruction. All interviews were audio recorded and transcribed.

**Figure 1**
*Example Interview Flow*




*Note.* See Analysis section for an explanation of the superscripts.

A member of the research team created a one-page summary of the interview and emailed the summary to participants as a member check. The majority of participants responded to those emails ($n$ = 11; 85%) and either confirmed that the summary reflected their views or provided minor edits. If participants provided edits about the content of the interview, the participant-edited summary was attached to the end of the transcript; if participants provided edits about diction, syntax, or other aspects of structure, the original transcript was retained.

**Analysis**

To answer the first research question (How do curriculum committee members characterize high-quality materials?), we used Saxe et al.'s (1999) form-function distinction to foreground the rationales participants gave (function) with respect to curricular features they considered high-quality (form). Because we thought the term *form* would be confusing for participants, we used the term *feature* when asking participants to talk about the components of materials they considered high-quality. However, during analyses, we understood that the features named were the forms. We emphasized participants' rationales (i.e., the functions they articulated) because, in conversation with Unity's Curriculum Director, she expressed concern committee members might get stuck on whether a series included a particular feature and overlook the possible outcome of that feature. Prioritizing the outcome of a feature over the feature itself mirrors professional guidance around material quality (AMTE, 2017; NCTM, 2014). So instead of looking for particular features, the Director was more interested in choosing a series that created certain kinds of learning experiences for students. To our knowledge, this message was not necessarily made explicit to curriculum committee members. Given this focus, we asked participants to name the curricular features they would consider high-quality and articulate *why* they would consider that feature an indicator of quality. We assigned concept codes (Saldaña, 2021) to segments of each transcript where a participant stated a function. Our concept codes came from participants' words. For example, Curriculum Coordinator, Erin stated that authors of curricular materials should "actually have taken the time to think about who materials are written for, maybe not their own experience, but a broader scope because we don't just teach one kind of student." Hence, this excerpt was labeled with the function code "reflect a broader scope." We then collapsed like concept codes into broader thematic codes, which included a range of forms, but all articulated as having a common function. For example, the function codes "reflect a broader scope," "support a range of students," "reach a wide population," and "reach more students" were collapsed into the thematic code, *reach a range of students.* Finally, thematic codes were collapsed into over-arching themes intended to characterize similar responses (see Table 2 for all thematic codes and overarching themes; see Appendix A for a complete list of forms).

To address the second research question (How do curriculum committee members talk about material appropriateness with respect to different groups of students?), we examined participants' talk about for whom particular curricular features were viewed as more or less appropriate. This part of the interview protocol followed a series of questions that, depending on the participant's response, elicited specific follow-up questions; Figure 1 illustrates the possible flow of the interview depending on a participant's response. After asking about their rationale for why the features they named were considered high-quality, we asked participants to talk through each feature they named with respect to the appropriateness of that feature for different groups of students and the alternatives to that feature they might employ. We asked participants if there were groups of students for whom they thought a particular feature was or was not considered appropriate. If the participant said the feature was appropriate for all students, we assigned the descriptive code *everyone* and proceeded with the interview (see Figure 1, superscript 1). If, however, the participant said a particular feature was not appropriate for all students, we generated a descriptive code that characterized the response (e.g., *long time to learn*; see Figure 1, superscript 2). This then prompted us to ask participants to suggest what they would recommend instead of the feature being discussed. Based on participants' responses we assigned another descriptive code (e.g., *decrease rigor*; see Figure 1, superscript 3). Then, we collapsed like codes to generate broader thematic codes (see Table 2 for all thematic codes and overarching themes).

Finally, to answer the third research question (To what degree do curriculum committee members have a coherent view with one another of high-quality materials?), we looked across the dataset and evaluated whether committee members' responses were coherent. Responses were considered coherent if participants (a) identified curricular features that served similar functions, (b) expressed similar views about the appropriateness of particular curricular features for different groups of students, and (c) suggested alternatives that served similar purposes.

## FINDINGS

Participants in this project largely characterized high-quality mathematics materials within three themes. They articulated a variety of rationales for the appropriateness of material features for certain students and alternative options. Our results suggest that curriculum committee members generally identified similar high-quality material features and considered those features appropriate for a range of students, thus reflecting a high degree of coherence across this committee.

**How do Curriculum Committee Members Characterize High-Quality Materials?**

We asked participants what features (i.e., forms) of mathematics materials they would consider high-quality and, using Saxe et al.'s (1999) form-function distinction, our analysis revealed that curriculum committee members named 60 unique curricular features (i.e., forms) they considered to be high-quality and articulated a range of rationales (i.e., functions) for why those features were considered high-quality (see Appendix A for our codebook). Eleven of these rationales were excluded from our final analysis because they were articulated in terms of supporting teachers, for example, materials that included a comprehensive teacher's guide. Although a teacher could use a teacher's guide to improve instruction for students and could articulate how a teacher's guide would facilitate this, if the participant framed the feature only in terms of supporting adults instead of students, we excluded it from our analysis. Across the articulated rationales, we identified three themes: *to reflect and reach a range of students; to foster a sensical and meaningful learning experience;* and *to yield multiple learning outcomes, especially student thinking and understanding*. The results of our first research question are listed in Table 2.

**Table 2**

*Themes and Thematic Codes Across Articulated Rationales*

| To reflect and reach a range of students | To foster a sensical and meaningful learning experience | To yield multiple learning outcomes, especially student thinking and understanding |
|---|---|---|
| • reflect a range of students (4)<br>• reach a range of students (4)<br>• meet students' needs (3) | • increase content continuity and comprehension (6)<br>• accurately assess student knowledge (6)<br>• increase engagement and motivation (6)<br>• promote independence and choice (5) | • attend to student understanding, reasoning, and meaning making (11)<br>• promote learning and thinking (9)<br>• considering the future or "real world" (3)<br>• promote procedural knowledge toward solving (3) |

*Note.* Numbers in parentheses represent the number of features (i.e., forms) participants named to meet that function. For example, participants named six features that were related to the rationale (i.e., function) "increase content continuity and comprehension."

***To Reflect and Reach a Range of Students***

Participants expressed the importance of using materials that reflected the students in their school district, specifically students seeing themselves in the materials and seeing mathematics as important to their lives. Erin, the Elementary Curriculum Coordinator, said, "I look at a lot of curriculums and there's not humanity in it […] [They] are designing for a broad mass of one level of people and [they're] not taking into consideration the people that [we're] teaching." Relatedly, she emphasized that a curriculum that reflected her students would also reflect how students learned best, saying:

> *If my student is somebody who makes more meaning out of concrete and kinesthetic [activities] then that's the method I'm going to teach them, so maybe Touch Math, or…some kids are more musically inclined and they remember their math facts because they can sing a song. You know, it just depends on what works for kids.*

A few participants gave rationales that framed *reaching a range of students* as meeting students' "needs," but more often, participants talked about the importance of material features that allowed the greatest number of students to be reached. Tiffany, an elementary general education teacher, described valuing materials that included opportunities for peer collaboration and said:

> *I think students learn by doing, not necessarily listening to what the teacher says…I think students grow more when they work together. They feed off of each other. So if another student is able to explain it. I think you hit more kids that way.*

***To Foster a Sensical and Meaningful Learning Experience***

Participants named features that were intended to make learning sensical and meaningful. Some participants talked about the role curricular materials and their features can play in allowing the content to have continuity across contexts. Tina, an elementary instructional coach, described a feature of high-quality materials as their alignment with the Common Core's Eight Mathematical Practices and said, "If you have that continuity and you have that common language, and you have that common focus, [everything is] still all connected. And there's that continuity for students."

Meaningful learning experiences were characterized in terms of student engagement and motivation, student independence and choice, and features that allowed for accurate assessment. Several participants named rationales that talked about the importance of students having buy-in in the learning process. Tina, an elementary instructional coach, promoted materials that embedded multiple curricular areas (e.g., mathematics and science), stating that in addition to increasing learning opportunities for students, engaging with multi-content materials creates "a context and a reason for learning it." Independence and choice were also important aspects of how participants talked about creating meaningful learning experiences for students. Marie, another elementary instructional coach, said:

> *We need to have something else that I can use in place of [tape diagrams[1]], or some student choice…so that if you like tape diagrams you can represent it that way. And if I like number lines, I can use a number line instead.*

Similarly, other participants gave rationales that emphasized the importance of student power and agency, specifically opportunities for students to learn independent of the teacher. For example, Sam, an elementary instructional coach, said:

> *Inquiry is such a powerful space for student ownership…'I have some control and I have some power in this space and I have some agency in the space and what I wonder [and] the way I see the world is valued in this space'…*

Finally, participants described meaningful experiences as also being about assessment opportunities. Marie, an elementary instructional coach, emphasized that materials that were flexible and adaptable served the purpose of

1 A tape diagram, or strip diagram, is a rectangular visual model resembling a segment of tape and is used to illustrate the number of parts in a whole and support understanding of number relationships and proportionality (Beckman, 2004).

allowing teachers to elicit students' background knowledge, which then allowed students to show their learning beyond standardized tools. Another participant, Elizabeth, a special education teacher, described the importance of informal opportunities to assess learning when introducing a new topic. She said, "I also think it's just interesting to kinda like take away the borders of math and to see what students do and how they figure out things." Elizabeth compared this more exploratory approach with more traditional approaches to teaching mathematics to students with disabilities where the teacher likely directs the learning. To her, it was meaningful to center student thinking by seeing how they informally "figure out things" instead of simply responding to a teacher's prompt or model.

#### *To Yield Multiple Learning Outcomes, Especially Student Thinking and Understanding*

Participants named features aimed at students' learning outcomes with a range of rationales. A few participants named focusing on procedural knowledge, with the goal of solving and considering students' future or the "real world" as evidence of material quality. However, the majority of features within this theme were focused on features that would promote and center students' thinking and understanding. Elizabeth, a special education teacher, articulated that an exploratory approach to mathematics "just really allows the students to create and think." She juxtaposed this to a more traditional teacher-guided model of instruction for students with disabilities. Beatriz, an elementary school principal, highlighted the importance of giving students the opportunity to become problem solvers: "We're teaching kids to be thinkers, we're teaching kids to be problem solvers. And when a child can't explain their thinking, then we're not growing them and their problem-solving skills."

Many participants articulated rationales that extended these ideas by talking about the importance of students making conceptual connections between mathematical ideas. Others talked about the effects of broadening their perspective about who was capable of engaging in rigorous mathematical activity and how that allowed them to see a feature as being beneficial for different students across time. One notable idea about this theme was the emphasis on student activity with respect to learning outcomes. For example, Erin, an Elementary Curriculum Coordinator, gave an example from a curricular series she had used in the past, explaining that a major component of the series was a teacher script, which resulted in students doing:

> *[A] lot of sitting and listening. That's not very engaging. It makes it very difficult for students to make meaning out of it…It's not engaging their brain in a meaningful way, and they aren't having to own it.*

Here, Erin contrasts something she observed in the past with the importance of attending to the nature of student activity to promote students' mathematical thinking and understanding.

### How do Curriculum Committee Members Talk About Material Appropriateness with Respect to Different Groups of Students?

Participants in this sample generally viewed material features as appropriate for all students. In instances where participants questioned the appropriateness of a feature for particular groups of students, their rationales for feature alternatives were generally aimed at supporting students by increasing access or allowing for different approaches to the same content, activity, or task as other peers (see Figure 1 for an example of the questioning flow). We should note that some participants responded in such a way that asking the follow-up question about appropriateness would have prompted potentially problematic responses. For example, Amanda, the Secondary Curriculum Coordinator, said she would look for materials that employed a "cultural lens" so that students could "see themselves" in the materials. To follow-up this response by asking, "Do you think there are students for whom 'seeing themselves' is not appropriate?" would have reflected an over-adherence to the interview protocol and would not have generated useful information to address the questions posed in this project. Of all the curricular features named in this study ($N = 60$), we coded 24 (40%) instances where participants named a feature about which the interviewer determined it was inappropriate to ask the follow-up questions from our semi-structured protocol.

When participants questioned whether a feature would be appropriate for particular groups of students, their reasons for this belief were coded as *stating a fact*, *expressing authentic care*, or *external*. For the first category, many participants explained that a curricular feature may not be appropriate for a group of students and offered a reason that simply stated a fact about a student or group. For example, Elizabeth, a special educator, said that real world problems were an important feature, in part because those types of problems help students see the importance of mathematics. When asked about the appropriateness of real world problems for students, she named students with Autism as a group who may struggle with these types of problems if students interpret the problem literally, stating, "Due to […] the disability and […] things that were difficult, I had a hard time making some of those connections sometimes. [The student is] like, 'Well, I don't like, I'm never going to run a race.'"

We coded *expressing authentic care* when participants gave a reason that was framed as concerned with students' growth (Noddings, 1995) and not conveyed with judgment. Such concern might appear as a statement of fact or an honest description of a circumstance, but without language that assigned value. For example, Marie, an elementary instructional coach, described how some students might feel overstimulated by highly engaging activities, explaining:

> *Sometimes, there are students who are overstimulated by too much. And it might just be that there's too many materials to choose from…If that seems to be the engagement of this curriculum is too much [for] them, we look at that skill and concept and how I can still convey that to you in a way that isn't too much for you and build your capacity to be able to accept what I'm offering over here at some point in time.*

They expressed care for students by saying that being overstimulated may cause the student anxiety and, therefore, highly engaging activities may not be appropriate. Others may have characterized the situation by describing the student as anxious and thus judging the student for struggling to regulate their emotions. Finally, there were many instances (*n* = 8) in which participants named factors external to students as the reason some features may not be appropriate. For example, elementary instructional coach Marie recognized that materials that are flexible and adaptable may not be appropriate for multilingual learners. She says, "We've had some materials that are not serving our [English Learners], our dual language students […] they could just be better written as far as the directions or the number of steps or the amount that's on the page." We coded the accessibility of materials in students' home languages as a reason external to the student.

With respect to alternatives to the features named, most participants suggested making adjustments that maintained the rigor of the activity or otherwise gave access to the same activity that others in the class would also be doing (*n* = 23). Joe, a high school general education teacher, named "the opportunity to participate in group work" as a feature of high-quality mathematics materials. From Joe's perspective, opportunities for group work de-centered the teacher, which distributed mathematical authority, and allowed students to construct arguments and critique the reasoning of others. Joe explained this saying:

> *I do not want the students to see me as the only source of knowledge…I really want the students to get a flavor of the fact that they can learn from each other,…constructing arguments and critiquing the reasoning of others…It's not a thing that I have to teach; it happens naturally when they have that opportunity to talk to each other.*

When asked if there were students for whom group work was not appropriate, Joe said students with "math anxiety" might feel especially uncomfortable working in a small group. When asked about alternatives to group work, he said he would assign partner work instead, clarifying "there's a lot of think-pair-share types of situations also that happen, which does decrease the anxiety level of certain students." Here, the student who could be feeling anxious would still get to work with a peer, and arguably derive the same benefits but in a context that was aimed at decreasing the student's anxiety.

We coded very few features (*n* = 3, 4%) as inappropriate for students based on participants' rationales. In all instances, our codes reflected the participants' deficit framing in response to why a particular feature would not be appropriate for some students. Both Erin, the Elementary Curriculum Coordinator, and Tina, an elementary instructional coach, described particular features that may not be a priority for some students. When describing materials that included rich and multilayered tasks, Erin described these features as inappropriate for students who would, according to her, benefit from a greater focus on functional life skills (e.g., banking, grocery shopping). She says:

> *I'm just thinking about some students that I've had that have a hard time retaining information, retaining processes, so that kind of thinking [related to complex or multi-layered materials] might not be the priority. Maybe the priority is just making sure you're successful with some of the things that you're gonna run into in your daily life, like how to do your banking, how to add at the grocery store, how to handle money. That sort of thing.*

Tina had the same rationale, but for materials that included higher-order thinking problems. Erin also described opportunities for practice as inappropriate for some students because they had emotional challenges and that, no matter how many times a student practiced a skill, it was not going to stick.

### To What Degree Did the Curriculum Committee Have a Coherent View with One Another of High-Quality Materials?

Despite their different disciplinary perspectives, we were able to categorize all of the curricular features participants named into three over-arching themes, suggesting this curriculum committee had a coherent view with one another of what features they considered high-quality. Beyond the coherency of their views about what constitutes material quality, they were also consistent in how they described for whom particular features would be appropriate and the nature of suggested alternatives. Although generally coherent, we also noticed there was not perfect agreement across committee members with respect to either the features they considered high-quality or for whom they considered particular features appropriate. This raises questions around the degree of coherence desired during a curriculum adoption and which we unpack further in the Discussion.

## LIMITATIONS

Several limitations should be considered when interpreting the findings of this study. First, the study was conducted with one school district located in a small city. Findings of this study might reflect experiences and perspectives that are unique to the district and may not be representative of curriculum identification and adoption processes or perspectives at larger districts. Second, the results represent participants' perceptions about the process, with no evidence of how these perceptions may or may not have manifested in committee meetings and the actual decision of which series to adopt. This is not necessarily a limitation, per se, but warrants consideration from readers. Finally, participants reported inconsistent participation in committee meetings due to schedule complexity and other responsibilities related to their roles. This perhaps reflects the reality of many district-wide committees but should also be considered.

## DISCUSSION AND RECOMMENDATIONS

This study aimed to illustrate how one district's curriculum adoption committee characterized high-quality curricular materials, broadly, and also with respect to a range of learners. Aligned with the three research questions guiding this study, we reported three main findings. Based on these findings, we offer key insights and recommendations that others can consider when navigating a similar process. We also suggest existing resources and activities with which committees may engage (see Table 3 for a summary of recommendations).

**Table 3**

*Key Insights, Recommendations, and Resources for Curriculum Adoption*

| Key insights | Recommendation |
|---|---|
| Viewing curricular features as appropriate for a wide-range of students can support a diverse range of students, including students who have been historically underserved in mathematics. | Engage in self-reflection and conversation to interrogate perceptions about student capability.[1, 3, 6, 8] |
| Identifying alternatives that maintain rigor and increase access may be important for ensuring all students get to engage with high-quality materials. | Learn about how the principles of Universal Design for Learning can be applied in mathematics and other approaches to making materials accessible.[2, 4, 7] |
| Individuals from different disciplines can have a coherent view of what constitutes high-quality materials. | Multi-disciplinary teams should invest time in understanding individual committee members' perspectives, foster dialogue, share resources, and broker differences between disciplines before the decision-making process begins.[5] |
| Resources | |
| [1]DeMatthews (2020)<br>[2]Lambert (2021)<br>[3]Lewis (2016, Feb 5)<br>[4]Lynch et al. (2018)<br>[5]Mason & Thomas (2021)<br>[6]Matthews et al. (2022)<br>[7]Yeh et al. (2020)<br>[8]Zhao & Lapuk (2019) | |

### Viewing Curricular Features as Appropriate for a Wide Range of Students Can Support a Diverse Range of Students

Our second research finding revealed that this curriculum committee generally identified materials as being appropriate for all students in their district. Because of the racial, ethnic, and cultural diversity in this district, this finding reflects the equity lens promoted by leading mathematics professional organizations (AMTE, 2017; NCTM, 2014) which advocates for centering and supporting a diverse student population, including students of color, multilingual students, and students with disabilities. Because students from marginalized identities often face persistent stereotyping and diminished opportunities to learn (e.g., Battey, 2013; Berry et al., 2014; Callahan, 2018; Lewis & Fisher, 2016), we would encourage committees to avoid the assumption that selecting and utilizing curricular materials is a neutral activity and instead recognize and interrogate committee members' perceptions about who is capable of engaging in particular kinds of mathematical activity.

We echo DeMatthews' (2020) recommendations to school leaders about attending to issues of racism and ableism that, if unaddressed, could contribute to viewing some students as not mathematically capable. A curriculum committee might explicitly reject notions of normalcy (e.g., discuss the ways in which some social identities–being White, not having a disability, being an English speaker–are considered "normal"), emphasize multidimensional identities (e.g., problematize labels and the disaggregation of data by labels that reinforce singular identities), invite an interdisciplinary lens (e.g., create district family-community input structures), and engage in activism and resistance (e.g., tap into local affiliates working to address injustice). For example, a curriculum committee might watch the video "Difference Not Deficit" (Lewis, 2016, Feb 5) in which Dr. Katie Lewis rejects the idea of normalcy surrounding how people "should," for example, solve and make sense of the problem 8 x 3. A committee might also look for supplemental resources, like Matthews et al.'s (2022) book about culturally relevant math tasks. Committees might use these and other resources to generate honest conversation about the assumptions and biases that shape how we think about which materials are and are not appropriate for particular students and generate actionable recommendations for how to meaningfully adapt curricular materials. When looking for information about teaching mathematics to students from historically marginalized groups, avoid resources that suggest some student groups need particular kinds of instructional approaches and therefore particular types of curricular materials (e.g., Codding et al., 2022). Instead, we encourage practitioners to seek out resources that present a nuanced view of an instructional practice or approach so that they can understand the benefits and drawbacks and make decisions accordingly (e.g., Lynch et al., 2018; Zhao & Lapuk, 2019).

### Identifying Alternatives That Maintain Rigor and Increase Access May be Important for Ensuring All Students Get to Engage with High-Quality Materials

Another aspect of our second research finding was the importance of maintaining the rigor of mathematical activity and ensuring access for students when working with materials that were not, in the original form, considered appropriate for students. Because curricular materials are related to the kinds of learning opportunities afforded to students (Choppin et al., 2021; Choppin et al., 2022; Stein et al., 2007), it is essential that the work of a curriculum committee is not taken lightly, including how those committee members conceptualize curricular alternatives. As curriculum committee members and others consider alternatives to curricular features or material resources, we emphasize the idea that material alternatives or efforts to individualize materials do not necessitate removing students from the whole-group context nor providing them with materials that significantly diverge from the whole-group lesson. Instead, alternatives can consider ways to increase accessibility and also maintain rigor. There are multiple frameworks available that promote increasing accessibility. Universal Design for Learning (UDL; CAST, 2018) is one framework that suggests implementing proactive and universal supports so that learning experiences are accessible to all students from the onset of instruction. This might mean, for example, reading the context of a problem aloud so everyone can hear, even if there are some students who could access the problem without hearing it read aloud. Treating supports as universal minimizes the need to identify unique alternatives that could reinforce stigma or unintentionally prevent students from using a needed resource. As a curriculum committee, perhaps a small group of committee members decides to read an article about how UDL might look in mathematics classrooms specifically (e.g., Lambert, 2021). Using the information and examples in the article, the small group might then create a matrix based on the three principles of UDL Math–Engagement, Representation, and Strategic Action. The matrix could include references to specific curricular materials and describe uses or adjustments that could increase accessibility. This matrix and other committee-developed resources could become meaningful supplements that aid enactment beyond the series adoption.

Another small group of committee members might read about strategies for maintaining the rigor of a task, while ensuring its accessibility. They might read about how learning opportunities, as posed via the curricular materials, have been historically limited for marginalized students, like students with disabilities, (e.g., Yeh et al., 2020). The small group might also investigate the specific mechanisms teachers can employ that decrease, maintain, or increase the rigor of a task (e.g., Lynch et al., 2018). Although focused on supporting students with disabilities, both readings provide actionable ways for teachers to adjust materials that honor the intent of the original task while ensuring that all students participate in grade-level lessons.

**A Coherent View of What Constitutes High-Quality Materials May Foster Productive Committee Work**

Our first and third research findings highlight the importance of committee coherence in selecting a series for use across a school district. In creating a multi-disciplinary curriculum committee, research indicates that understanding different perspectives can facilitate connections between disciplines in productive pursuit of a common objective (Choutou & Potari, 2024). The current study involved participants from different disciplines and roles within one school district, and yet they all had coherent perspectives about high-quality mathematics materials. This aligns with existing research on multi-disciplinary community collaboration, which suggests that people collaborating across disciplines should take the time to understand each other's perspectives, engage in dialogue, share resources, and address differences between disciplines (Hardré et al, 2013). Given the importance of there being shared ideas about what constitutes high-quality materials when adopting new curricular materials, we recommended that committee members establish a community of practice with shared understandings, perspectives, and purpose before the decision-making process begins (Wenger, 1998).

The Curriculum Director may play a crucial role in guiding the committee through the curriculum adoption process. As an introductory activity, the Director might ask the committee to complete a t-chart with a left-column heading that says, "It is important that materials are/have …" and a right-column heading that says, "... so that students can …" Sharing such views may spark conversation and press committee members to articulate what they value and why and, more importantly, identify points of convergence amongst the committee. The goal of this conversation would be to establish that the committee is working toward a shared vision and that future committee efforts will be grounded in common language and meaning. The Curriculum Director, acting as a broker between disciplines, can guide the team to hybridize practices from the varied disciplines towards a coherent view (Gleason, 2020), the importance of which is central to carrying out and sustaining instructional improvement (Cobb et al., 2020).

In such ongoing conversations, it is also important to recognize that different districts and contexts may require differing degrees of coherence or perhaps there are topics around which the district prioritizes higher degrees of coherence. For Unity School District, with respect to mathematics instruction, it was important that a representative contingency of educators had a part in selecting and implementing a common curriculum. Since previous norms in the district allowed individual teachers and schools to use a range of materials (which were not necessarily aligned to a shared set of curricular goals), it was important to this district to achieve the highest degree of coherence possible.

## CONCLUSION

When districts go through the process of adopting a new curricular series, they have the opportunity to ensure that students in their district have access to materials that reflect rigorous and meaningful mathematics learning. Beyond material coherence, a committee's personnel coherence may be important for ensuring students who have been historically underserved also have access to rigorous and meaningful mathematics learning. This paper examines how one district's multi-disciplinary curriculum committee characterized high-quality curricular materials, including their perspectives about for whom those materials were considered appropriate and what alternative recommendations they would make. Our findings indicate that committee members can converge around a shared understanding of quality and material appropriateness, and ensure curricular alternatives increase accessibility while maintaining rigor. Each member of the committee brings an important personal and disciplinary perspective to the initiative. The group endeavor must begin with communication and the opportunity to identify points of convergence. Reflective engagement with the tasks and frameworks we recommend may support collective reimagining and generate previously unseen pathways for rich mathematical learning opportunities for all students.

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## Appendix A

Codebook

| Theme | Thematic Code | Concept Code | |
|---|---|---|---|
| | | Curricular **form or feature** considered to be high-quality | **Function or rationale** for why curricular form was considered high-quality |
| To reflect and reach a range of students (7) | Reach a range of students | adaptable | reflects a range of students |
| | | appropriate for students | reach a wide population of students |
| | | concrete and abstract reasoning | support a range of students, including those who are behind |
| | | student collaboration | having students collaborate and so there's instruction from the teacher, more students can be reached |
| | Reflect a range of students | appropriate for students | connects students with materials |
| | | connections to the real world | seeing math as important to their (students') lives |
| | | cultural lens | seeing oneself |
| | | engaging and interesting | related to students' lives |
| | Meet students' needs | adaptable | meet the needs of all students within the zone of proximal development |
| | | differentiation | recognizing that every student is not the same, they have different learning styles so it's what students need |
| | | standards-based | give students what they need to learn and be successful |
| To foster a sensical and meaningful learning experience (9) | Increase content continuity and comprehension | age-appropriate language of written materials | align the complexity of the text with students' age |
| | | aligned with 8 mathematical practices | create continuity for students |
| | | emphasis on vocabulary | start with a shared understanding of math terms |
| | | hands-on/manipulatives | making the content more comprehensible |
| | | supports for English learners | promote a shared understanding between people who speak different languages |
| | | supports for English learners | decrease language demand |
| | Accurately assess student knowledge | age-appropriate language of written materials | ensure materials are assessing what they were intended to assess |
| | | alternative assessments | demonstrate mastery in different ways |
| | | flexible/adaptable | allows for multiple ways to assess what students know |
| | | independent solving | demonstrate what students know |
| | | materials that build on students' background knowledge | accurately assess what students know or don't know as they're learning new concepts |
| | | opportunities for exploratory learning | get a baseline for what students know or (don't know) at the beginning of a unit |
| | Increase engagement and motivation | appropriate for students | take learning seriously, to buy in |
| | | connections to the real world | make learning more exciting |
| | | cross curricular | having fun |
| | | cross curricular | create a context and reason for learning |
| | | manipulatives | provide a tangible, memorable, and engaging way to represent concepts |
| | | opportunities for student inquiry | affirms the way the student sees the world |

| | | | |
|---|---|---|---|
| | | | is valuable and that motivates them |
| | Promote independence and choice | engaging and interesting | promote student choice |
| | | group work | de-center the teacher |
| | | opportunities for student inquiry | promotes student ownership; students have control, power, and agency in the space |
| | | present another way to understand the same concept | align with how students prefer to learn |
| | | readable | students can learn independent of the teacher |
| To yield multiple learning outcomes, especially student thinking and understanding (12) | Attend to student understanding, reasoning, and meaning making | connect to students' backgrounds | making a concept concrete allows students to tap into their prior knowledge |
| | | engaging | make meaning, actively |
| | | engaging and interesting | support student understanding |
| | | group work | promotes argumentation / reasoning |
| | | hands-on | make connections, add layers to understanding, support the concept |
| | | include common misconceptions | strengthen understanding |
| | | manipulatives | make connections, understand the big concept |
| | | manipulatives | understanding concretely is a prerequisite to abstract understanding |
| | | multiple representations | children learn (using a variety of tools) and understand content better |
| | | opportunities for collaboration | apply and solidify concepts |
| | | scaffolding | support the student in making connections to prior material |
| | Promote learning and thinking | cross curricular | using different areas of the brain; increase learning |
| | | group work | broaden notions of competence |
| | | opportunities for enrichment | expand (not just add to) learning so different students could benefit at different times |
| | | opportunities for exploratory learning | allows students to create and think |
| | | opportunity to explain, think outside of the box | allows kids to be thinkers and problem solvers |
| | | play | active learning through play |
| | | rich/multilayered | demonstrating skills and application in a real-world context; student growth and thinking |
| | | student collaboration | growth for students |
| | | student discovery | use their (students') own brains |
| | Considering the future or "real world" | higher-order problems and fluency practice | what we needed for real life |
| | | integrated | prepare students for the real world |
| | | rich/multilayered | need jobs for the future (students) |
| | Promote procedural knowledge toward solving | cultural lens | knowing the context of what the problem is describing helps a student solve the problem (without first having to "solve" or make sense of the concept) |
| | | opportunities for practice | drill and kill |
| | | spiraling | go back to the basic skills and prepare for the next step |

*Note.* In the Theme column, the number in parenthesis indicates the number of participants who articulated that theme.

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