



Madison
Education
Partnership



Mathematize Your CLASS:

How Educators and Researchers Co-developed a
Professional Development Series for 4K Teachers

Authors*

Jill Hoiting

Kathryn Boonstra

Julianne Snyder

Elizabeth Graue

Eric Grodsky

University of Wisconsin - Madison

Culleen Witthuhn

Elizabeth Vaade

Madison Metropolitan School District

Madison Education Partnership

The [Madison Education Partnership](#) (MEP) is a research-practice partnership between the University of Wisconsin (UW) – Madison School of Education’s Wisconsin Center for Education Research and the Madison Metropolitan School District (MMSD). MEP provides a context for collaborative problem identification, jointly designed empirical research to address problems of practice, development of educational interventions, and the creation of mutually beneficial lasting relationships across the UW and MMSD. The partnership serves as a conduit to establish new research within the district, enhances research use for the district, and creates mechanisms for the dissemination of new knowledge in Madison and beyond.

Suggested Citation

Hoiting, J., Boonstra, K., Snyder, J., Graue, E., Grodsky, E., Witthuhn, C., & Vaade, E. (2020) *Mathematize Your CLASS: How Educators and Researchers Co-developed a Professional Development Series for 4K Teachers*. Madison, WI: Madison Education Partnership. pp. 1-53.

We gratefully acknowledge the assistance of Amanda Venske, Mason Gauthier, Ian Lawson, Lauren Padgett, Rebecca Bier, and Rosie Miesner. We would like to thank the participants and design team who generously shared their time, experience, and ideas for the purposes of this project. We would also like to thank Courtney Bell and Richard McGregory for their comments on an earlier draft of this report.

The research reported here was supported by a grant from the Institute of Education Sciences (R305H180053). Opinions expressed do not represent the views of the U.S. Department of Education.

Executive Summary

This report documents the design, development, and implementation of *Mathematize Your CLASS*, a professional development series the Madison Education Partnership (MEP) offered to 27 teachers of four-year-old kindergarten (4K) in the Madison Metropolitan School District with additional support from the Center for Research on Early Childhood Education (CRECE). The report outlines our collaborative and research-based design process, describes the series’ objectives and pedagogical strategies, and summarizes feedback and reflections from participants, leaders, and members of our design team.

Findings from our [prior study](#) of 4K instructional quality informed the central objectives for *Mathematize Your CLASS*: **to improve mathematics teaching in 4K and strengthen educators’ use of effective instructional support strategies**, as conceptualized by the Classroom Assessment Scoring System (CLASS). This report outlines how we leveraged evidence-based principles for professional development design, including content focus; sustained duration; active learning; support for collaboration; models of effective practice; coaching and expert support; and feedback and reflection. The report also describes the obstacles we encountered, the resources we leveraged, and the pedagogical tools we developed. This report further details the content goals and instructional components that comprised Mathematize Your CLASS, summarized below:

Mathematics Content	Instructional Support Domains	Professional Development Components
<ul style="list-style-type: none"> • Counting & Number • Spatial Relationships & Shape • Measurement & Data Analysis • Operations & Relations 	<ul style="list-style-type: none"> • Concept Development • Instructional Learning Formats • Language Modeling • Quality of Feedback 	<ul style="list-style-type: none"> • In-person & virtual meetings • Professional learning communities led by mentor teachers • Peer classroom observations • Online learning platform • Curated set of high-quality instructional resources

In the report, we highlight educators’ perspectives on their participation in *Mathematize Your CLASS*. Teachers appreciated that the series focused exclusively on the learning and development of four-year-olds, foregrounded mathematics instruction, included educators from all 4K site types, fostered collaboration and networking, and offered sustained, well-executed professional development. While participants were very satisfied with the series, they shared some concerns related to clarity of expectations and the temporal demands made by the project. Teachers demonstrated moderate gains in their mathematics attitudes, confidence, and pedagogical content knowledge, as evidenced by pre-post-surveys and participant self-reports.

Mathematize required considerable resources in the form of staff time, payments for substitute teachers, and direct compensation for teachers’ out-of-contract time. While we are optimistic about the benefits of the component parts of *Mathematize*, we are most confident in the program’s benefit as a whole. Thus, **our first recommendation is to repeat the series with fidelity, including each of the elements outlined in this report.** In addition, we recommend:

- Continuing support for existing Mathematize professional learning communities
- Replicating individual components of Mathematize
- Leveraging key structural elements from Mathematize
- Extending the leadership opportunities available to MMSD educators

Mathematize Your CLASS

The Madison Education Partnership ([MEP](#)) set out to co-design a professional development program for four-year-old kindergarten (4K) teachers within the Madison Metropolitan School District (MMSD). Using findings from observations, discussions with teachers and the guidance of a design team of 4K teachers, we created a year-long program focused on early mathematics and quality instructional support. We aimed to implement professional development with twenty teachers and to study the process and experience of the program in order to improve its quality and impact on teacher learning. The ultimate goal of our work was to enhance mathematics learning in 4K.

I. Opportunities for Professional Development in Madison's 4K Program

The Madison Education Partnership ([MEP](#)), a research collaboration between the University of Wisconsin-Madison's Wisconsin Center for Education Research and MMSD, has worked closely with MMSD's 4K program since MEP's first project in 2016. With funding from the U.S. Department of Education's Institute of Education Sciences (R305H180053), MEP partnered with Beth Graue (UW-Madison and the Center for Research on Early Childhood Education) and Culleen Witthuhn (MMSD) to first measure and then improve the quality of the 4K instruction teachers delivered to over 1,700 MMSD students in 2019-20.

We took a three-pronged approach to assessing the quality of instruction in Madison's 4K program across school, early care and education and Head Start sites. In the first year of the study we completed:

1. 63 formal observations using the Classroom Assessment Scoring System (CLASS) Pre-K to evaluate the quality of interactions across the domains of emotional support, classroom organization and instructional support
2. Semi-structured observations in 29 classrooms focused on instructional practices, content and formats related to early math and literacy
3. A combination of focus groups and interviews engaging 24 4K teachers in discussions about their instructional strengths, opportunities for growth, resources and professional development needs and preferences.

We sampled classrooms and teachers from all three types of 4K sites and sought to include both sites serving mostly families with lower incomes and those serving mainly families with higher incomes.

[Findings from this research](#) indicated both strengths of 4K instructional practice, as well as opportunities for growth. 4K teachers were well equipped to effectively manage classrooms and support students in their social emotional development. 4K teachers also demonstrated their ability to integrate literacy instruction, as well as a sound understanding of curriculum planning. Further, 4K teachers reported strong relationships with families. Our findings also indicated areas for growth. We found teachers could further support their students in reasoning and analysis skills, particularly through the use of feedback and the extension of language. We also found teachers could improve on the variety, depth, and integration of mathematics instruction. Teachers also reported a desire for additional engagement with families and collaboration with other teachers.

Based on the opportunities for growth identified through observations, we selected mathematics and instructional supports as the focus for the PD. The teacher feedback gathered through focus groups informed the selection of design elements, including Professional Learning Communities (PLCs), classroom observations and a schedule that would make the PD accessible to all 4K site types.

Project Roles

Our research team consisted of MEP leadership and staff, MMSD's Director of Early Learning and a UW Professor of Early Childhood Education, as well as a post-doctoral researcher, two graduate assistants and an undergraduate student. For a full list of team members, see Appendix H.

Parameters for the Professional Development Design

In designing this professional development series, we followed research-based principles of PD design, built on the findings from Young et al. (2019), and abided by a set of design principles to which we committed at the outset of the project. These parameters defined the scope and direction of the professional development design for what became *Mathematize Your CLASS* (or simply "*Mathematize*").

Co-led by Beth Graue (UW) and Culleen Witthuhn (MMSD), the project team established a set of "non-negotiable" elements that served as a foundation for the professional development. The non-negotiables were that our professional development would:

- (1) Be a single, cohesive program in which participants committed to the entire course versus a menu of options for selection;
- (2) Engage 4K teachers across school, ECE and Head Start sites;
- (3) Produce tools, resources, and products that 4K teachers would take back to their classrooms and use with students;
- (4) Reflect the literature on best practices for professional development;
- (5) Be active and engaging rather than an experience to "sit and git";
- (6) Focus on specific content and strategies across different instructional contexts;
- (7) Adopt three to five overarching teacher learning goals to span the entire course.

In addition, we committed in the initial proposal for this project to be an authentic collaboration with 4K teacher leaders who would contribute to the PD design based upon their experiences and expertise. This collaboration served as a keystone throughout the project.

Darling-Hammond, Hyler and Gardner (2017) outline critical attributes that shaped our pedagogical strategies. They find seven common components of effective professional development: (1) content focus, (2) active learning, (3) collaboration, (4) models of effective practice, (5) coaching and expert support, (6) feedback and reflection, and (7) sustained duration. We shared this summary of effective professional development elements with the teacher leaders who formed the design team for the professional development series. The final design of *Mathematize* interwove each element of effectiveness in different ways. Table 1 gives examples of how the design team incorporated each element into our PD.

Table 1. Pedagogical Objectives from Darling-Hammond, Hyler and Gardner (2017) & Examples of Implementation

Professional Development...	<i>Mathematize Your CLASS</i> Examples
(1) Is Content Focused	<ul style="list-style-type: none"> ● early mathematics: <ul style="list-style-type: none"> ○ number & counting ○ spatial relationships & shape ○ measurement & data analysis ○ operations & relations
(2) Incorporates Active Learning	<ul style="list-style-type: none"> ● classroom observations and post-observations discussion ● pre-session work activities implemented in the classroom ● early math activity matrix & templates ● model video analyses
(3) Supports Collaboration	<ul style="list-style-type: none"> ● professional learning communities (PLCs) ● Saturday session group activities
(4) Uses Models of Effective Practice	<ul style="list-style-type: none"> ● model early math video clips ● local instructional support video clips ● teaching vignettes
(5) Provides Coaching and Expert Support	<ul style="list-style-type: none"> ● mentor-facilitated PLCs ● curated early math activities
(6) Offers Feedback and Reflection	<ul style="list-style-type: none"> ● final summary project ● classroom observations ● online discussion threads and exchanges
(7) Is of Sustained Duration	<ul style="list-style-type: none"> ● October through June ● four five-hour sessions ● two sets of classroom observations ● assigned pre-session work

In addition to these best practices, local research with the MMSD 4K program informed the content and format of the professional development design. We selected design elements that responded to the needs and preferences that we identified through the observations, focus groups and interviews. Table 2 presents key findings from that research, PD strategies identified to address each finding, and the final design element we adopted to respond to our research.

Table 2. Application of Local Research in the PD Design

Finding	Strategy	Design Element
Teachers feel isolated	Create collaborative professional learning communities (PLCs)	A cohort design encouraged professionals to collaborate on a series of content, materials, activities and practices
Teachers want to visit other classrooms	Include classroom observations in the PD	Teachers had the opportunity to visit and be visited multiple times during the year
Teachers would like time for brainstorming	Allocate time in instructional round schedules and PD sessions, and structure into online exchanges	Planned time for professional discussions was a core element of the classroom observations and PD sessions and was incorporated in the design of an online resource
Teachers are interested in new practices and content	Include in design	The design team identified new practices and content to address needs identified in the 4K study.
Teachers have the opportunity to develop stronger use of instructional support strategies	Deeply embed the CLASS instructional support dimensions and indicators into the PD	CLASS and specifically the domain of instructional support was central to the development of PD. Instructional support elements were embedded in tools provided for PD.
Teachers have the opportunity to develop stronger mathematics learning opportunities for students and expand beyond low levels of early math content	Identify critical math content for 4K and work to integrate it with Creative Curriculum, Teaching Strategies GOLD, the WI Model Early Learning Standards and PD learning. Consult DREME I TE, the Erikson Institute and Carpenter et al.	The design team used these resources to create a learning plan for the PD that a) included teachers' reflection of practices and student learning; b) steered the development of activities and assessments; and c) guided observations
Teachers have the opportunity to more strongly connect activities to one another and to teacher-student interactions	Design for <i>ideas</i> not <i>activities</i> , linking ideas to build skills and knowledge of 4K teachers	The design team identified both content and strategies they wanted to reinforce, and structure related and interlocking units of activities that built the knowledge and skills of 4K teachers

These research-based design principles, coupled with our earlier observational study of 4K instruction in MMSD, provided the design team with a clear direction for professional development. However, to ensure success, we addressed several logistical constraints.

Scheduling was one such constraint. With the non-negotiable principle of engaging 4K teachers across all types of sites, it was challenging to coordinate meetings for the small group of teachers serving as the design team, for the full-group PD and for classroom observations. 4K teachers in school sites teach four days a week with Monday used for planning and/or professional development. Community based ECE and Head Start sites, however, have differing schedules for teachers to integrate with their other early childhood programming.

Continuity of the PD experience was another logistical constraint. With a mixed approach to offering 4K, teachers experience different expectations and requirements in their work and have access to different resources to use in their teaching, depending on their site. For example, school sites use Creative Curriculum with Teaching Strategies GOLD, but ECE sites may use the WI Model Early Learning Standards (WMELS) to guide their curriculum and instruction. An effective PD design had to meet the unique needs of teachers across sites to assure continuity in experience, applicability of teacher learning and minimize the risk of attrition.

II. The Process of Designing Professional Development

The Design Team

To inform the content and delivery for this professional development, the core research team chose a design team of leadership and teachers across 4K sites. The design team included one Head Start administrator, one ECE administrator, one MMSD lead teacher/coach, three 4K teachers from school sites, two 4K teachers from ECE sites and one 4K teacher from a Head Start site. All members of the design team were paid for their work. Initially, we kept the role of the design team open so that we could collaboratively identify the ways in which they could best contribute given their knowledge, experience and availability. This design team consulted on aspects of the PD design and shaped many facets of the PD series. Additionally, the insights and expertise of design team members informed how we addressed constraints and concerns related to scheduling and continuity.

The full design team met three times prior to the launch of the PD series (see project timeline in Appendix A). We describe the activities and outputs of these meetings in Table 3.

Table 3: Activities and outputs of each planning meeting

Meeting 1: July 30, 2019	
Activities	Outputs
Introduction of foundational design principles and previous research	Design team understood best practices and local context.

Discussion of the design team’s role in developing the PD	<p>The activities discussed included:</p> <ul style="list-style-type: none"> • Selecting mathematics content and sequencing • Developing instructional support strategies that linked to 4K mathematics • Developing assessment tools to support mathematics teaching • Developing tools to support the mastery of key 4K math content, practice of instructional support strategies and observation of practice • Evaluating the use of an online learning platform • Giving ongoing feedback • Acting as a mentor to a PLC
Gallery walk on application of research to PD	<p>Revealed design team perspectives including:</p> <ul style="list-style-type: none"> • Using research to choose a topic for the PD • Identifying and examining exemplary classrooms, making connections between early math and CLASS instructional supports • Understanding how to build on and extend teachers’ knowledge
Discussion on early math	<p>Members reflected on:</p> <ul style="list-style-type: none"> • math content for students • instructional formats • their own use of concept development • quality of feedback and language modeling in teaching math • characteristics of instructional interactions that result in deepest and most sustained mathematical thinking for students • roadblocks and challenges for teaching math, as well as for 4K students as they learn math.
Meeting 2: August 12, 2019	
Activities	Outputs
Gallery walk on the goals of <i>Mathematize</i>	<p>Decided that the <i>Mathematize</i> professional development would:</p> <ul style="list-style-type: none"> • align with best practice • incorporate play-based methods • strengthen early math content • improve instructional support strategie
Definition of audience for <i>Mathematize</i>	<p>The team prioritized a heterogenous group of 4K teachers from different types of 4K sites, integrated a survey of educators’ attitudes and confidence around early mathematics into the application, and finalized the PD schedule. The team prioritized participants:</p> <ul style="list-style-type: none"> • who were able to commit to all elements of the PD series • had a moderate amount of teaching experience • had minimal early math professional development in. the past <p>Four design team members also agreed to be mentors for the PLCs and the team made plans to identify a fifth mentor.</p>

<p>Discussion on content for <i>Mathematize</i></p>	<p>The team identified key content areas for early math: counting and number</p> <ul style="list-style-type: none"> • geometry and spatial relations • measurement and data analysis • operations and relations <p>The team also discussed instructional support dimensions and decided that they:</p> <ul style="list-style-type: none"> • would add a fourth dimension, Instructional Learning Format, to the existing Instructional Support Dimensions (Instructional Support+) • would introduce instructional supports early in the sessions to allow teachers time to implement and practice these strategies
<p>Agenda design</p>	<p>Agenda for Saturday session included:</p> <ul style="list-style-type: none"> • whole group formats to review developmental trajectories for early math learning • examples of videos of children at different stages and activities to teach these skills • as well as the deep dive into Instructional Support+
<p>Meeting 3: September 24th, 2019</p>	
<p>Activities</p>	<p>Outputs</p>
<p>Gallery walk on principles for PLCs</p>	<p>The team decided:</p> <ul style="list-style-type: none"> • PLCs need to be safe spaces where voices of teachers are heard, experiences can be shared, and the work is relevant • PLC activities should be cyclical to include prep work, time to reflect with one another, share both in person and electronically and visit one another's classroom • the role of the mentor should be flexible to consider teacher preference and so that facilitation can occur without tensions of being in control; the mentor should also be willing to try things first and model for others, as well as be willing to help structure experiences for teachers • a shared format or outline and expectations with the flexibility to adapt to specific preferences will be important for successful PLCs, as will adequate communication and content knowledge for successful mentors • Effectively planning PLCs will require considerations of time and location and the identification of prep work • PLCs should comprise of a mixture of school-based and community-based sites based on geographical groupings

Review of tools and supports for PLCs	<p>The team most strongly endorsed:</p> <ul style="list-style-type: none"> ● reflecting on lessons and activity implementation ● analyzing and critiquing activities ● reflecting on instructional supports ● using vignettes and case studies
---------------------------------------	--

After the first session of *Mathematize*, the design team narrowed to the five teacher mentors who each led a PLC. Immediately following each of the first three Saturday PD sessions, the design team convened for a debrief and met in the interim months between PD sessions. In these meetings, mentors shared their perspectives on session content and format and continuously guided the refinement of *Mathematize*. The mentors on the design team gave feedback on:

- Making the pre-session work assigned to participants meaningful
 - *"...the pre-session work needs to be brought into our session, because if not, we're going to start getting people not even doing it, because we aren't talking about it here."*
- Ensuring that participants were gaining a deeper understanding of the CLASS instructional supports
 - *"So, when we had that rubric out in front of us and those cards, I want to dive more into what does this look like, sound like, feel like, hear like within our classrooms."*
- Reframing the final reflection activity to inspire reflection and alleviate apprehensions
 - *"Posing it more as a reflection for how this class has impacted your teaching. Change it from storyboard to end of year reflection."*
- Developing meaningful tools and artifacts for PD sessions and classroom observations
- Structuring PLC time that occurs during the Saturday PD sessions
- Transitioning to an online format for the final session due to the pandemic

The design team served a vital role in developing PD that was meaningful to 4K teachers as they work to improve their instructional practice with respect to early math and instructional supports. These reflections from the mentors capture the achievements in collaborating with teachers to develop meaningful PD:

"I would say, like, along those same lines of being someone who gets zero PD at all through the school year, just being able to, 1) be part of the team that's building that PD and have my opinion heard on what I want to learn about; and then 2) have the option to do it on a Saturday and then on the evenings, for there to be a PD that I can attend, since I can't attend any during the week. So, that was awesome."

"Which I think is why [Mathematize Your CLASS] was relevant; you could take it back to your classroom right then and there. You know, because we are live teachers, and you guys study this, and so it was nice that it was relevant..."

"And I hope that it would be available for more people to participate, and that they would want to participate, because this really is unlike any other PD that 4K teachers get on a regular

basis. So, I remember when I worked for the district, going to those Monday PD's and talking about third-grade writing samples! You know, and that's valuable in some ways, you know what you're aiming for, but to have that specific 4K structure available to 4K teachers is invaluable! So, my dream would be that it would be available for our 4K program; so, for everyone."

Recruitment of participants

All 4K teachers within MMSD received email invitations to apply for the PD opportunity (approximately 90 teachers). Invitations included information on the expected commitment and compensation (\$200 for each PD session and related assignments). A total of 26 4K teachers initially applied for 20 available seats, excluding the five teachers who we recruited to be mentors. The co-facilitators of the PD aimed to select participants according to criteria prioritized by the design team: three to five years of experience teaching; no previous experience in a PD opportunity specific to 4K math; and the ability to commit to full attendance and participation. The pool of applicants constrained the degree to which we could strictly adhere to these criteria.

We sought to enroll a diverse cohort of teachers serving more and less economically advantaged students across the three types of 4K sites that serve MMSD (schools, ECEs and Head Starts). We conducted additional recruitment efforts throughout the pilot year to address participant attrition, focusing on underrepresented sites in our initial roster: Head Start programs, sites on the east side of Madison, and ECE programs serving families with lower incomes. Through individual outreach that leveraged existing relationships with Head Start and ECE programs, we recruited several additional 4K teachers over time. Due to external obligations, however, only one of these teachers could participate in the series.

Based on the selection criteria and the final make up of participants, there are limits to the generalizability of our estimates of how *Mathematize* may have changed teacher practice. The PD series engaged teachers motivated to apply and intentionally recruited those with a moderate amount of experience teaching. Understanding the characteristics and needs of 4K teachers who did not apply for the opportunity, as well as understanding the unique needs of new 4K teachers is important to expanding *Mathematize* in adaptable ways that are meaningful and effective for all 4K teachers.

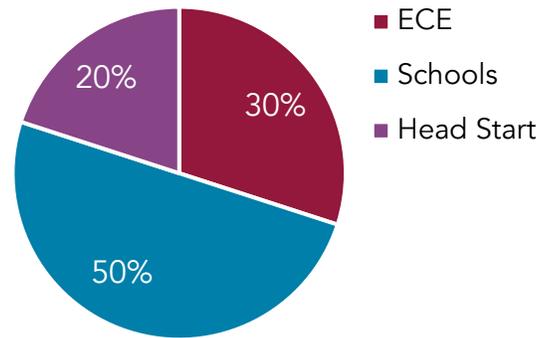
III. The Structure of Professional Development

Participants

Prior to the first session of the PD series, 25 teachers committed to participate in the PD, with five of those teachers also filling the role of mentor. Two teachers withdrew before the first session and we were able to recruit replacements prior to the first session. A third teacher who had intended to be a mentor withdrew due to a conflict with the first session but rejoined the PD series as a participant for subsequent sessions. Four more teachers withdrew over the course of the year due to changes in employment or challenges with time commitments. We were able to fill three of these open seats with additional 4K teachers. A total of 27 teachers participated in some portion of *Mathematize*, while twenty teachers, including the five mentors, completed the PD.

Among those who completed *Mathematize*, teachers held their current position between one and 22 years, with a median of 6 years. As shown in Figure 1, half of the participants who completed *Mathematize* teach 4K in a school site, almost one-third teach in early care and education centers and one in five teach in Head Start programs. All but one of the participants were female.

Figure 1. Percentage of Teachers by Type of 4K Site



In their applications, participating teachers most commonly cited the content focus of mathematics, the 4K-specific and play-based approach, and the focus on peer learning as the reasons they were interested in *Mathematize*. A few teachers also referenced their pre-existing relationship with MEP or interest in research-based practice as a reason for their interest. While many teachers discussed their desire to improve their practices, only one teacher called out the CLASS component as being a driver of their interest. Also, only one teacher mentioned the compensation among other reasons. This teacher called it “enticing.”

Professional Learning Communities (PLCs)

PLCs were a pivotal part of the PD design for *Mathematize*. PLCs served to reduce teacher feelings of isolation and present the opportunity to embed effective professional development strategies, such as collaboration, reflection and feedback. We aimed to facilitate networking and relationship building among teachers across the multiple types of 4K sites through the PLCs, as shown in Table 3.

We formed five PLCs, each with five members, including a teacher mentor. We organized the PLCs to include teachers from a mix of 4K program types and clustered teachers geographically to facilitate in-person meetings and classroom observations. Three PLCs experienced changes in membership over the course of the year due to participant attrition. While two PLCs gained members in the last rounds of outreach and recruitment, the Green PLC completed the PD series with only three members.

PLC	Geographic Cluster	Site Types	No. of Members	Final Member Total
Blue	North/East Madison	ECE	1	5
		Head Start	1	
		School	3	
Green	Central Madison	ECE	1	3
		Head Start	1	
		School	1	
Purple	West Madison	ECE	2	5
		Head Start	1	
		School	2	
Red	North/East Madison	ECE	1	5
		Head Start	1	
		School	3	
Yellow	West Madison	ECE	3	5
		Head Start	0	
		School	2	

PLCs served several functions. First, PLCs met for working lunches during in-person sessions. Based on guidance from the design team, mentors retained flexibility in how they structured these meetings during the first, second and third PD sessions so they could best meet the preferences and needs of the PLC membership. Second, PLCs formed small groups for discussion and planning activities during in-person sessions.

Finally, we organized classroom observation cycles around PLC groups. Each cycle included a pre-observation meeting, paired visits to two classrooms, and a post-observation meeting. We encouraged participants to determine a focus for each observation, and several mentors supported their PLCs by developing their own observation tools (See Appendix B). We planned for teachers to participate in two rounds of classroom observations with their PLCs, though only three of five PLCs were able to complete both due to COVID-19-related school closures.

Scheduling observations proved to be challenging. Although we budgeted the cost of substitute teachers for those doing observations, ECE, Head Start and school sites all have their own processes and policies related to substitute coverage. Additionally, 4K class times vary by site type. As one mentor said, "*I still am amazed at how those observation schedules were put together. That seems like calculus to me.*" This task required a substantial investment of time from our project manager.

Online Learning Platform

In addition to in-person meetings, we designed an online platform to support teacher learning in between PD sessions. We wanted to facilitate ongoing discussions and communication and share resources such as classroom activities, planning tools, and family engagement materials. After reviewing several options, we selected Canvas as our platform. The UW System currently uses Canvas as the main learning management system and UW-Madison provides ongoing technical support. Despite technical challenges confronted by some teachers, all participants accessed the online component of the course within three weeks of the first Saturday session.

We organized the online component of *Mathematize* around six modules: 1) Early Math Resources, 2) Number & Counting, 3) Spatial Relationships & Shape, 4) Measurement & Data Analysis, 5) Operations & Relations, and 6) About *Mathematize Your CLASS*. In Module 1, we provided early math resources related to literacy, play-based instruction and family engagement. This module also housed an updated version of the Early Math Matrix and Activities. Modules 2-5 focused on the key early math content for each of the Saturday sessions. As shown in Figure 2, we posted pre-session work, including PDFs of handouts, links to videos clips, descriptions of activities to implement in the classroom and discussion posts for reflections, as well as presentation slides and supplemental resources. Canvas modules provided easy, continued access to course material and extended teacher learning beyond the in-person session.

Finally, in Module 6, we provided general information about the course, MEP, and the Canvas website, including project summaries, research findings, the course syllabus. We also included tools to support participants in accessing and navigating the Canvas Platform, including visual

instructions with screen shots and videos for navigating the online course component and the Early Math Matrix and Activities.

We required participants to engage more with Canvas as the series progressed, specifically through pre-session assignments, make up work for those who missed the second in-person session (rescheduled due to weather), and ultimately the final session which was offered entirely remotely due to COVID-19. We noted increased Canvas engagement from participants over the course of the year, specifically in the form of more page views and more content interactions. As we used more features, including analytics, discussions and quizzes, we also consulted School of Education library staff with expertise in Canvas.

Based upon the experience of implementing *Mathematize* and the feedback shared by teachers, we identified three different functions for online professional development. Mentors reported needing a quicker and more easily accessed social platform for continued communication and peer learning among their PLCs. Canvas did not facilitate these types of communications well. We learned that video conferencing platforms can effectively foster peer learning and reflection by structuring time appropriately and using breakout or small group features. Lastly, Canvas proved to be essential to in-depth content exploration once our circumstances required remote professional development. The tools and features of Canvas allowed for a variety of modalities in adult learning, such as readings, video viewings, small and large group discussions and quizzes and surveys. In such uses, universal design is essential to ensure maximum accessibility for all professional development participants.

Early Math Matrix of Activities & Other Resources

We developed the early math matrix of activities to help equip teachers with tools and resources to implement high-quality instruction in early math. The matrix consists of two resources: 1) a curated package of early math activities encompassing number and counting, spatial relationships and shape, measurement and data analysis and operations and relations, and 2) a searchable matrix of those activities with keywords taken from the Wisconsin Model Early Learning Standards and Teaching Strategies GOLD (the assessment platform that accompanies Creative Curriculum,

Figure 2. Example of a Module Outline: Measurement & Data Analysis

Measurement & Data Analysis	
Pre-Work	
	Book Chapters: Big Ideas for Early Mathematics
	Handout: Quality of Feedback
	Handout: Language Modeling
	Video: Building Towers - Measurement & Quality of Feedback ↗
	Video: Magnatiles Play - Measurement & Quality of Feedback ↗
	Video: Graphing on Shoes - Data Analysis & Language Development ↗
	Classroom Activity: Measurement, Quality of Feedback, Data Analysis & Language Modeling
	Video: A View of Language Modeling through the Classroom
Saturday Session	
	Presentation: Session 3 Measurement & Data Analysis
Supplemental Resources	
	Actual Size Storybook Guide ↗
	Balancing Act Storybook Guide ↗
	Crash! Boom! A Math Tale ↗

the 4K curriculum for MMSD and some other sites). To be used together, the first component is a PDF and the second is an Excel file.

For each of the curated activities, we generated a lesson plan (see Appendix C for the template) highlighting important information about math concepts, developmental trajectories, and instructional support strategies. Specifically, each lesson plan included:

- The main math concept of interest;
- Mathematics developmental progressions, including the preceding developmental milestone(s), the focus skill(s);
- The Wisconsin Model Early Learning Standards (WMELS) the activity addresses;
- The Teaching Strategies GOLD Objectives the activity addresses;
- Appropriate assessment protocols;
- The materials teachers will need to complete the activity;
- An in-depth description of the format, preparation, instructional introduction and activity;
- Instructional support prompts for things to observe and questions to ask related to Concept Development, Instructional Learning Formats, Quality of Feedback and Language Modeling (from CLASS); and
- Ways to extend learning through interest areas or centers.

We curated activities from four primary sources:

- *Where's the Math? Books, Games, and Routines to Spark Children's Thinking*
- DREME I TE
- The Erikson Institute Early Math Collaborative
- Learning Trajectories
- other texts, websites and teacher blogs.

We drew most activities from the first three sources. We reviewed and selected activities to 1) create a balance in the format of the activity, such as small group and whole group activities and those that could be easily adapted to fit multiple formats, including child-directed formats, 2) engage an assortment of modalities for learning, such as using picture books or integrating body movement, and 3) address the range of WI Model Early Learning Standards and Teaching Strategies GOLD Objectives related to each early math content area. For example, when selecting activities related to spatial relationships and shape, we ensured that not all activities were simply shape identification, but also covered composition and decomposition of shapes, three-dimensional shapes and recognizing shapes in real world experiences.

Initially, we planned for the design team to provide feedback on the activities and help narrow down the content of the matrix from about 20 activities selected by graduate assistants to 10 activities per early math content area covered across the four sessions. To do so, each member of the design team assumed responsibility for two math domains. This plan evolved as teachers began the school year. We received input for several of the content areas early in the design process and applied the feedback as we developed the tools. However, we did not prune the number of activities. Instead, we included a minimum of 20 activities to share prior to each PD session for a total of 87 activities as of June 2020.

Once we had curated activities to align with the priorities of *Mathematize*, we developed the early math matrix of activities to help teachers identify activities that met their instructional goals. We created search filters to allow educators to select lessons based on instructional priorities, including overarching math domain, specific math concepts, instructional format, and the WMELS or Teaching Strategies GOLD objective that the activity supported. We also included the original source of the activity. We introduced the matrix during the first Saturday session and continued to revise its format in response to feedback from participants. The final matrix included more user-friendly navigation buttons rather than standard column filters, as well as brief instructions for its use, as shown in Appendix D.

We presented this updated version of the matrix to participants during the second session and demonstrated how to access and use the matrix. Following the second session, we created a video version of this demonstration and posted it to the Canvas course page. We repeated the overview in the third session to support familiarity. Graue and Witthuhn also intentionally integrated the use of the matrix in the PD sessions and encouraged teachers to use it. For example, in the second session, participants accessed the matrix through Canvas and searched for a specific activity based on specific standards and objectives. Prior to each session, we updated the matrix with activities related to the featured early math domains.

Pre-session work

Prior to each Saturday session, we assigned a set of pre-session tasks, including handouts summarizing CLASS instructional support dimensions and chapters from the book, *Big Ideas of Early Mathematics*. We selected *Big Ideas* as the core text for the course because of its readability, its teaching examples and the simplicity of its framing of the main principles of early math content. Other pre-session tasks included video clips featuring children completing math tasks in a one-on-one cognitive interview and demonstrating early math instruction in whole- or small-group formats. For each session, we also assigned teachers with an activity to implement in their classrooms. Finally, we created Canvas discussion threads for some pre-session assignments and instructed participants to post their reflections to an assigned video or classroom activity. Table 4 outlines the pre-session assignments.

Table 4. Pre-session work components

	Readings from <i>Big Ideas of Early Mathematics</i>	Example Videos of Teaching & Student Learning	Early Math & Instructional Support Handouts	Classroom Implementation Activity
Session One: <i>Counting & Number</i>	<ul style="list-style-type: none"> Chapter 3 – Counting: More than Just 1, 2, 3 	<ul style="list-style-type: none"> The Progression of Early Number & Counting Anna Counts 	<ul style="list-style-type: none"> Big Ideas of Number and Counting Instructional Supports+ 	<ul style="list-style-type: none"> Preschool Number Sense Routine Perfect for Transitions
Session Two: <i>Spatial Relationships & Shape*</i>	<ul style="list-style-type: none"> Chapter 8 – Spatial Relationships: Mapping the World Around Us Chapter 9 – Shape: Developing Definitions 	<ul style="list-style-type: none"> Betsy and the Three Magical Bears Sawyer’s Shapes A View of Concept Development Through the Classroom 	<ul style="list-style-type: none"> What Children Know and Need to Learn About Shape and Space Concept Development Instructional Learning Formats 	<ul style="list-style-type: none"> Describe, Draw, Describe with Online Discussion Follow Up
Session Three: <i>Measurement & Data Analysis</i>	<ul style="list-style-type: none"> Chapter 6 – Measurement: Making Fair Comparisons Chapter 7 – Data Analysis: Asking Questions & Finding Answers 	<ul style="list-style-type: none"> Building Towers Magna-tiles Play Graphing Shoes A View of Language Modeling Through the Classroom 	<ul style="list-style-type: none"> Quality of Feedback Language Modeling 	<ul style="list-style-type: none"> Measurement, Quality of Feedback, Data Analysis & Language Modeling
Session Four: <i>Operations & Relations</i>	<ul style="list-style-type: none"> Chapter 4 – Number Operations: Every Operation Tells a Story 	<ul style="list-style-type: none"> Operations for Breakfast Discussing Monkey Bars During Transition Time Small Group Discussions Online 	<ul style="list-style-type: none"> CLASS Dimension Rubrics 	<ul style="list-style-type: none"> Creative Curriculum + Data Questions OR Building Blocks and Measures†

* We used a pre-assessment prior to Session 2 to determine content focus, but we did not repeat this strategy in preparation for other sessions.

† Most teachers did not have the opportunity to implement these activities in their classroom prior to school closures due to COVID-19.

We developed two videos used in pre-session work for sessions two and three: A View of Concept Development Through the Classroom and A View of Language Modeling Through the Classroom. These videos each feature a local 4K teacher who served as a mentor for *Mathematize*, as they discuss and show examples of their practice. Drawing upon their 8 and 9 years of respective experience in their current classroom, these two teachers hosted us in their classroom and shared their thoughts on a series of questions. The questions we asked aligned with the indicators of the

corresponding Instruction Support dimension, concept development and language modeling. We list the questions in Appendix E. In addition to the interview, the 4K teachers gave us a tour of their classroom pointing out how their environmental design supports them in concept development and language modeling. After editing the video footage, we posted both videos to Canvas and PLCs discussed the videos during session lunches.

Saturday Sessions

The design team chose to structure *Mathematize* around four in-person sessions scheduled for Saturdays from 9:30am to 2:30pm. We chose Saturdays to accommodate the teaching schedules for 4K in ECE, Head Start and school sites. Each session focused on one early math domain. We introduced the Instructional Support+ dimensions in session one, elaborated on two dimensions of the four dimensions in sessions two and three, and reviewed all dimensions in session four.

Appendix F provides a list of resources we used in developing the Saturday sessions and Table 5 outlines the objectives defined for each of the four sessions. We began each session with an early math activity that engaged educators in learning experiences that they could implement in their classrooms and to build relationships among participants. Next, Graue and Witthuhn facilitated content-specific small and whole group sections and PLCs met for a working lunch.

In the first session, Graue introduced the main principles and ideas related to number and counting, gave an overview of Instructional Support+, and used interactive strategies—such as video-based discussions and reflections on classroom scenarios—to teach both early math content and instructional strategies. PLCs also met for the first time. Witthuhn was unable to attend this session due to a personal conflict.

Session two focused on two CLASS dimensions—instructional learning formats and concept development—and the math domains of spatial relations in shape. In this session, Graue and Witthuhn each facilitated segments of the session. Early in the day, Witthuhn covered through a group instructional planning process and discussion questions. Next, Graue led a series of activities centered on how young children learn about spatial relations and shape, including video-based discussions and a small group activity related to classroom transitions.

The third session focused on measurement and data analysis and the instructional support dimensions of quality of feedback and language modeling. In this session, Graue and Witthuhn co-facilitated, adopting a suggestion from design team members to integrate math and instructional support content. During the session, teachers reflected upon instructional videos and collaborated with their PLCs to select and plan a measurement or data analysis activity.

In response to COVID-19, we converted the fourth and final session into a remote format, using more asynchronous features and a shortened synchronous segment. This session focused on the math domain of operations and relations and included a final review of Instructional Support+. The asynchronous component consisted of a counting principles review, the discussion of vignettes and video examples regarding operations and relations, as well as the four instructional support strategies covered in the series. For the synchronous component, participants met via Zoom, a platform for video communications which we selected for its ease in access, higher quality

video and audio, recording abilities and most importantly, its breakout rooms feature. The breakout rooms facilitated continued collaboration among the PLCs in this final remote session. Witthuhn introduced a small group reflection focused on instructional supports in the context of operations and relations and Graue presented key concepts related to operations and relations through videos, visuals and vignettes.

Table 5. Session Objectives

Session	Objectives
Session One: <i>Counting & Number</i>	<ul style="list-style-type: none"> • Identify and explain key principles of number and counting • Understand developmental progressions of number and counting skills • Understand the importance of classroom quality and its connection to teacher-child interactions • Recognize and identify the characteristics of Instructional Support+ • Understand how math, development, and learning are linked and how teachers can support learning through the use of instructional support strategies • Meet new colleagues and have fun!
Session Two: <i>Spatial Relationships & Shape</i>	<ul style="list-style-type: none"> • Reflect on planning processes using the CLASS dimensions of Concept Development and Instructional Learning Formats • Practice maximizing students' interest, engagement and ability to learn from lessons and activities • Identify the benefit of graphic organizers as a teaching tool • Plan for higher-order thinking skills and cognition to focus on understanding rather than rote instruction • Understand why supporting children's spatial reasoning is so important • Recognize that mathematics is all about precise language so that we are much more precise about how we talk about shapes • Identify and explain key principles of spatial relationships and shape • Keep building strong relationships with colleagues and have fun!
Session Three: <i>Measurement & Data Analysis</i>	<ul style="list-style-type: none"> • Think about pairing what we teach with how we teach it • Bring together measurement & quality of feedback for powerful teaching • Use language modeling to learn about data • Challenge themselves, support their colleagues, and have fun!
Session Four: <i>Operations & Relations</i>	<ul style="list-style-type: none"> • Review the power of instructional support strategies • Learn about supporting learning of Operations & Relations • Celebrate the learning and connections made in <i>Mathematize Your CLASS</i> • Discuss next steps

Teachers left each PD session with concrete resources to take back to their classrooms. These resources included a set of quantity cards for number and counting, a copy of *The Secret Birthday Message*, pattern puzzles for spatial relationships and shape, a loaned children's book related to measurement and data analysis from MMSD's 4K lending library, and a copy of *Exploring Mathematics through Play in the Early Childhood Classroom* (Parks, 2015). We also distributed the following resources in sessions one, two and three to teachers chose via lottery:

- *Learning and Teaching Early Math: The Learning Trajectories Approach*
- *Really Seeing Children: A Collection of Teaching and Learning Stories*

- *Growing Mathematical Minds: Conversations Between Developmental Psychologists and Early Childhood Teachers*
- *Big Questions for Young Minds: Extending Children's Thinking*

Final Reflection Project

After the first session, we began thinking about a final project to allow teachers to document their learning during the PD. The story that a teacher told during a PLC meeting about her infusion of early math into her previous art-focused lessons sparked the idea of supporting teachers in reflecting on their own practice as a summative component of *Mathematize*. Having created the two videos focused on instructional support, we first designed the final project as the creation of a storyboard that could be made into a video, at the choice of the teacher. While the storyboard concept served as a framework, we intended for teachers to have flexibility in their creations. We also originally planned to have teachers complete their final project prior to the final session so that teachers could discuss their reflections with their PLCs during the session.

We introduced the project at the second session, which had low attendance because of the snowstorm and rescheduling. Teachers requested a sample to go along with the instructions. In creating the make-up materials for session two, we put together a Canvas page dedicated to the final project with examples. We presented the final project again at session three. Between and after these sessions, we received feedback and questions from mentors and teachers. For some, the storyboard concept was still unfamiliar, unclear and felt overwhelming. With the fourth session changing to a remote format due to COVID-19, we made significant modifications to the final project guidance and timeline. We left the storyboard as an option for teachers to use, but also expanded to include options like learning stories and illustrated journals. We also more strongly emphasized the goal of reflection and gave until the end of the school year, about a month and a half after the fourth session to post projects on the Canvas discussion board. See Appendix G for the final guidance provided for the project.

Teachers began posting their final reflection projects the week following the final session of *Mathematize*. In the Canvas discussion post prompt, we encouraged teachers to explore the projects of their colleagues and post their reflections. Teachers posted twenty projects to the Canvas discussion and made 31 additional comments and reflections on the projects of others.

Following the open-ended format of this project, teachers selected a variety of formats to reflect on their learning during *Mathematize*. Seventeen teachers created slides including pictures and/or descriptions of activities or interactions from their classrooms. Three participants used alternative formats. One submission featured a hand-written and illustrated children's story to support children's engagement with operations, along with a reflection from the teacher. Another participant completed a video journal describing what she learned through *Mathematize* and her goals for continued professional growth. Finally, one participant completed her project in the form of a written narrative reflection with accompanying pictures.

Final projects varied in focus, specificity, and depth of reflection. Five participants focused on multiple math domains or general mathematics instruction; three participants reflected on their

teaching of a single mathematics concept or domain; and twelve teachers addressed both mathematics and Instructional Supports+ in their final projects. In Canvas, participants highlighted elements of their colleagues' work that they found interesting, compelling, or insightful, and several teachers noted ideas or strategies that they planned to implement. Many teachers offered praise, validation, or appreciation of their colleagues and commented positively on their experience in *Mathematize*.

Guests and Consultants

Over the course of the year, two consultants with expertise in play-based learning consulted with *Mathematize*, meeting with the research team, design team and participating teachers. Amy Parks, Associate Professor of Teacher Education at Michigan State University, visited in December 2019. Parks, who has expertise in young children's mathematical learning, met with the research team and with the design team to share her insights into the curation and packaging of resources, the exploration of how teachers change, telling the story of how early math and CLASS instructional supports come together, and the ways in which the cognitive science perspective of math and the early childhood teaching and learning contend with one another.

Our second guest, Angela Pyle, is an Assistant Professor with the Department of Applied Psychology and Human Development with the University of Toronto with expertise in early childhood play and play-based learning. In her February 2020 visit, Pyle met with members of the research team and facilitated an interactive lecture for members of the Madison early childhood community. In her session, Pyle outlined her research on different levels of educator involvement in play-based teaching. She presented her continuum of play-based learning, which includes free-play, inquiry play, collaboratively designed play, playful learning, and learning through games. Graue invited *Mathematize* participants at the conclusion of the second PD session and described the meaning and relevance of the event to 4K teachers, as well as kindergarten teachers. Of the early learning professionals who attended the event, four participated in *Mathematize*. One *Mathematize* teacher summarized the visit as eye-opening in its description of play on a trajectory and attributed her attendance to the fact that she learned the background from her involvement in *Mathematize*.

IV. Obstacles to Implementation

Two major events prevented us from offering the full PD series as we had intended. The day before our second PD session, weather forecasts showed a significant storm hitting Madison overnight and into the morning. We made the decision to postpone the session by one week. Unfortunately, another snow storm hit the night before the rescheduled PD. Between the pre-existing conflicts or teachers had with the new date and the snow, 11 participants could not attend the session, either in part or in whole. Drawing upon the resources available within the Wisconsin Center for Education Research, we acquired higher quality video-recording hardware in plans to provide a make-up option for these participants.

We developed a make-up option for the session in Canvas, attempting to mirror the experiences of the in-person session as much as possible. We created a checklist to guide participants in the asynchronous work to ensure they completed all the requirements for the session. We were able to

split the recorded lectures and discussions that occurred during the synchronous section into smaller segments. Interspersed among the videos, we added instructions for activities that participants completed in-person and sorting exercises that introduced participants to the CLASS rubrics for Instructional Learning Formats and Concept Development. We also collected reflections from participants as they completed the work. The most difficult part to re-create was the collaboration among teachers, as the in-person session featured a collaborative lesson planning effort, which the online version could not easily replicate in ways that accommodated the busy lives of 4K teachers. Teachers provided mixed feedback about the remote make-up session. Some shared difficulties in accessing and taking in the online materials, while others expressed appreciation for the time it took to make the options available so that they did not miss the content.

The snowstorm ended up serving as an important test run for what was to come. Less than two weeks after offering the third Saturday session, Wisconsin's COVID-19 safer-at-home order went into effect. This significantly changed the direction of the professional development in several ways. First, teachers had to manage drastic changes in pedagogy as they transitioned to teaching four-year-old children remotely. The demands this shift placed on teachers, coupled with the fact that they were no longer meeting with students in-person, inhibited their ability to continue implementing PD content immediately into their practice. Second, although three PLCs had completed their second round of classroom observations, two PLCs could not complete their second round of classroom observations as planned. Finally, we could not hold the fourth Saturday session in person and, like the teachers with whom we worked, had to shift gear quickly to an online instructional format.

In moving the fourth session online, we attempted to preserve as much of the original structure, objectives, and materials as possible and to support teachers during a time of change and uncertainty. We reduced our in-person meeting time from five to two hours in recognition of the additional challenge of holding the attention of participants unable to gather in person. We also chose to begin the session later in the day so that teachers could use the morning, which they had already reserved, to complete assigned asynchronous work. The breakout room feature of Zoom, which worked seamlessly, was a critical tool in maintaining the quality of our PD. It supported PLCs in maintaining their connection, increased engagement throughout the session and helped to structure the two hours of content. While we had planned to watch videos synchronously to then discuss in PLCs, we found in our test run that the audio was inconsistent. Instead, we shared the links for participants to watch individually before joining their breakout group. Here are a few thoughts from participants on the organization and use of time in this final session:

"I thought that the organization of group work and large group time was perfect. I also enjoyed revisiting what we learned during this course. It was great to refresh the awesome activities we have already done. Many I can change a bit and use during a class zoom meeting."

"I really like utilizing what I have learned in my classroom so I will challenge myself to be more creative. I think considering the circumstances and the fact that we are all still teaching

virtually, it would have been helpful to share virtual ideas with one another. Then, just like past sessions, we leave MEP with some cool ideas to utilize with our students.”

The classroom observations may have suffered the most from the required changes due to COVID-19. The two PLCs that had not been able to complete observations prior to the safer-at-home order viewed a series of 4-8 minute video clips featuring two local 4K teachers in their classrooms, shared written reflections and met via Zoom with their PLCs—once in advance and once to debrief. Three teachers who joined the series later did not have the opportunity to complete any in-person classroom observations.

In an exaggerated time of isolation, *Mathematize* offered support and a source of connection for 4K teachers who already felt isolated in their teaching. Reinforcing the purpose of creating PLCs, this participant describes how she activated this resource to adapt to the pandemic:

“I think that really helped to have a PLC that I could reach out to. And I probably did that more than they may have. But, like, I know when we first had this whole safer at home measure and people were staying home. I know I reached out to both Michelle and Viviane [two PLC peers] and said, now, what are you guys doing? How are you implementing? What are some strategies you're trying to do with your kids? And so, I used, I utilized that resource of having them.”

V. Impacts of Mathematize

Throughout *Mathematize*, teachers reported changes in their thought processes, understanding of math content and instructional support strategies, and their teaching practices. Teachers completed the Attitudes, Beliefs and Confidence – Preschool Math Survey (ABC-PM) and the Preschool Math Pedagogical Content Knowledge Survey (PMPCK) during the first session and after the last session. The ABC-PM includes two subscales, one specific to math confidence and the other about teaching confidence. At both points in time, participants were more confident in their early math teaching abilities than their own personal math abilities.

We standardized confidence scores on a 100-point scale. In the fall, participants' mean score was 63.5 with a standard deviation of 8.6. After *Mathematize*, mean scores rose to 69.9 with a standard deviation of 9.8. Overall, standardized confidence scores increased by 6.4 points on average. Teaching confidence increased by an average of 11.8 points while math confidence increased by an average of 3.6 points. While most teachers experienced increases in scores, four teachers had decreasing overall confidence scores, eight had decreasing scores in math confidence and two had decreasing scores in teaching confidence.

The PMPCK measures participants' knowledge of math content necessary for effective teaching at the preschool/4K level. The survey includes two play scenarios featuring potential math learning. For each scenario, respondents are scored based on their ability to provide examples of math, identify what type of math the example illustrates, and explain how it demonstrates math. Higher scores on the PMPCK indicate a greater breadth of knowledge across early math domains. We standardized PMPCK scores on a 100-point scale. Mean pedagogical content knowledge scores

increased by 2.33 points, from 26.7 in the Fall to 29.0 in the Spring (with standard deviations of 9.9 and 10.2, respectively). The median score increase was 4.38. Of the 22 teachers who completed pre- and post- PMPCCK surveys, twelve participants' scores increased while eight decreased. Notably, mentor teachers' scores decreased overall, while non-mentor participants' scores increased.

Many teachers identified changes in their own understanding of and comfort levels with the early math concepts that are critical to their instruction.

"...overall it is helping me feel more comfortable in talking about in depth math concepts with the children."

"I feel a lot more comfortable teaching math to four-year-olds because like before I wasn't quite sure where I should stop or how far I should push them or what it should look like, and I feel like now I have a good sense of that."

Teachers described increases in their awareness of early math. Intentional opportunities for reflection, observations in their own classroom and various activities in *Mathematize* seemed to facilitate this increased awareness. Some teachers reported noticing the math that is already happening in their classroom and in their teaching. Others deepened their awareness of how different children approach math in different ways and the range of skills that children are capable of when it comes to early math.

"After this class I have reflected how to incorporate math into every aspect of the classroom. I feel it has made me more aware and allowed me to more naturally talk about math with children."

"[The course] has really made me sit back and observe students and look for math happening in play. And let go of needing to be in control of the learning moments. That they're happening all around me all the time. And realizing the value in just observing, listening, and then asking questions to clarify their thinking. And the importance of that and how much math is already embedded when you set up a really rich learning environment."

"When we did that [Describe and Build activity], I thought there was no way we could do it in the classroom with four year olds. I was like, "No I can't see it." And then people like started sharing ideas and I was like, "OK, maybe it could happen."

"...the opportunity to journal and look for things happening in the classroom specific to measurement. And I really thought, oh, this is going to be a very sparse activity for me. I don't think I'm going to find anything. We're not doing measurement right now, and -- not that we weren't doing measurement, but we weren't planning, like, what I used to think were measurement lessons, or measurement activities necessarily...I was blown away. In one day, there were, like, five different things I was trying to type and take pictures of, and within that span of the week and a half that I had done that, I was just flabbergasted at how much

measurement was happening. And knowing those big ideas, and defining measurement more broadly, that kids are comparing sizes. Kids are seeing if things are longer, or shorter, or wider, or, you know, bigger than, less than types of things...Like, they're doing so much on their own, and we were just asking those questions again. Well, tell me more about that. How did you know that -- you know, and just those few questions, everything exploded. So I think that was just completely eye-opening for me. You know, I had underestimated kids. I really had."

As teachers shared their thoughts and take-aways from each Saturday session and described their goals upon completing *Mathematize*, they frequently expressed new understandings about instructional supports and a desire to implement new strategies. Course content on open-ended questions and quality feedback loops attracted teachers' attention as they considered changes they wanted to make in their practice.

"Creating. I want to do more activities/provide more opportunities for my children to brainstorm, plan and produce materials. I'd like to start by trying to incorporate more think-pair-share opportunities during large group and see how my students interact and brainstorm together. I would also like to have my students try drawing out their ideas in the block area before building, so they can practice planning out their creations. "

"I would like to integrate more Concept Development and Quality of Feedback into my teaching practice. I would like to focus more on having children solve , predict and compare and evaluate their thinking by scaffolding and expanding on their thinking. "

"I want to focus more on analysis and reasoning with my students to really get them thinking about the work that they are doing. I plan to ask more open-ended questions and encourage the students to work with each other and ask questions to their peers. "

Teachers reported changes in their teaching practice. Some teachers shared small modifications that they have made, such as using more early math language at mealtimes or making transitions about early math, using ideas and materials shared in *Mathematize* sessions. One teacher reported questioning her entire use of calendar in her morning meeting time so that she could refocus it and embed early math. Several teachers shared that this year, the district allotted a budget for materials in their classroom. They described their choices in purchasing early math materials to integrate across the various centers in their classrooms. Several teachers also described changing their use of space after completing observations in the classrooms of their peers. For example, one teacher replicated the practice of having a designated early math table so that she could work individually with children in a dedicated space versus spreading across the floor where other children played and learned. Teachers gave examples of how they had used materials and applied what they learned in *Mathematize* to previous lessons that they had used in their classroom, reporting success in their implementation.

"The little cards for subitizing were really helpful this year for my kids. I noticed a very big difference in my kids this year than last year. I was kind of putting a little focus on that towards

the beginning of the year, like in October and November. And giving them little transitional activities using those. And it would, it really made a difference. ” ”

Many teachers, in describing how they modified existing lesson plans or implemented new early math activities from the activity matrix, demonstrated their instructional support strategies which spanned instructional learning formats, concept development, quality of feedback and language modeling. For example, this teacher’s scaffolding and use of music as an additional modality supported her students in identifying and producing shapes. These are important factors of Instructional Learning Formats and Quality of Feedback.

”And I had one child who, he just all - he'd get the paper, and he would just scribble, scribble, scribble. Every time, that's all he would do. And I said, "Okay, we're going to try and draw some shapes today." And scribble, scribble, scribble, scribble. But then once I broke it down a little bit more, and we were doing this triangle dance song - I don't know if you know that, but it's like, my kids' favorite. So we're introducing shapes with the class, and then once they figured out, 'Oh, yeah' so then all of a sudden, he started drawing triangles on his paper. And then we introduced another one, and I did a song about circles; and then he started drawing circles. And then I showed him an object, and all of a sudden, he just drew it, which was crazy to me, because he wasn't doing any of that prior to this.”

In a lesson on perspective-taking, this teacher fostered creating, integration and connections to the real world, all components of Concept Development.

”So, this week, we're learning about maps. And students read the online book, "Me and My Map". And then, we asked them to make maps of their bedrooms and show them on Zoom. And sort of orient us with the shapes of what was in their bedroom and those special and unique features that made it their own. And so, I was thrilled that every student was really excited about sharing the map that they created and really having an aerial view sense of their map... They, they were excited about owning this map, making the map, and doing it. And so, I could tell that they had paid attention. I mean, we had learned about birds the couple of weeks previously. So, I felt like the aerial view connection to the making of the map, like made sense to them. And then, they also wanted to talk about maps that they are familiar with and what they have actually used a map for.

Lastly, this teacher’s lesson on measurement featured aspects of analysis and reasoning and advanced language, which are key to Concept Development and Language Modeling respectively.

”Measurement was something I didn't do a ton of before. I had so much fun with that, and I'll continue to do a lot with measurement. In fact, I just ordered some materials like a 100-foot measuring tape. And they love measuring things. And I have the materials in the classroom, but I've never really taught measurement. The way that I should have been... just like reading and learning about, like, the standard and non-standardized measurements. And we did a lot with these owls and measuring. We've read about owls and wingspan. And we did, like, stuff

about, like, measuring. Well, what does that mean if they had, you know, a wingspan like this, which who had the larger wingspan. And we got out stuff, like, actual measuring tape for that. So, you know, we just did a lot of, like, digging a little bit deeper into that. And then I have, like, little stuffed owls in different sizes, so we used those. And we did, like, standard and non-standard measurement.”

VI. Reflections from Teachers

Overall, teachers were very satisfied with the professional development. Feedback and reflections from participants, the design team, leadership and MEP staff, indicate the following strengths of this work:

- The collaborative approach in designing the professional development allowed for a richer experience for the design team and leadership and a focus on specific needs of the Madison 4K community.
- Teachers reflected positively on the content and format of the PD, as well as valued the resources and tools provided.
- Teachers also valued PLCs and opportunities for peer learning.

We also identified several challenges with the professional development:

- Leaders and MEP staff indicated the large time investment in creating and running the PD and the need to balance efficiency and collaboration.
- Teachers and leadership also acknowledged that covering too much content can come at a cost of in-depth learning and analysis.

Feedback from participants

Over the course of the series, we collected and applied feedback gathered from teachers. We elicited written feedback from teachers each Saturday session. In the synchronous portion of the final Saturday, we structured a ‘syllabus walk’ in which each mentor used a set of slides we produced in advance of the session to facilitate reflection on each component of the series. Lastly, after the final session, we interviewed nine teachers who volunteered, including four teacher mentors. These feedback channels revealed the most liked and disliked parts of the series, conflicting feelings about some components, and remaining unmet needs.

In general, teachers shared many positive sentiments about the overall focus, structure and tone of *Mathematize*. Teachers expressed gratitude for having PD focused exclusively on the learning and development of four-year-olds:

“...just being able to participate in quality PD, because I feel like a lot of the PD we get is hit-or-miss for 4K teachers, and we're kind of either lumped in with kids that are younger, or kids that are older. And 4K is a very specific age group, and I think people who truly understand it understand how it's different, and that it's not the same as kindergarten, and it's not the same as being a two or three-year-old.”

“I thought it was great when you gave us resources or when you, you know, allowed us to be the four-year-old who's working with whatever materials and question that you gave to us. And

sort of thinking how do children feel and handle this when they're working in a group with their peers, you know. So, I liked that you flipped that perspective on us. And I felt like that was valuable experience that I took with me back into the classroom."

With the conclusion of the first session, teachers from a variety of site types shared with us their appreciation that *Mathematize* catered to the unique needs of the different 4K site types so that teachers across settings could participate. They reiterated this message throughout:

"I feel like, in 4K, there's a division between who's in public school, who's in centers? Like, the opportunity to go to different centers. For them to come to us was, I thought, really invaluable. And it's really like looking at one another as professionals, you know."

"...the networking that was taking place between all of the participants and being able to form more relationships between early childhood centers and the teachers in the district. So, that was a big takeaway for me."

Teachers highlighted the importance of peer learning and the range of experience and expertise brought to the PD by their peers. This set the stage for a rich PD experience and relationship building across 4K sites.

"I noticed a lot of people who were eager to share their own ideas and practices. It is great to see how different approaches can arrive at the same outcome."

"...listening to the different stories and activities people are doing, it -- I just sat back and thought, wow, you know, there is so much wisdom in this room, and we never get a chance to do this..."

Some teachers also appreciated the additional compensation they received for participating in *Mathematize* (\$200 per session). However, those who mentioned compensation did not describe it as a primary motivator to participate. The value was more symbolic than material.

"And of course, like the idea of being treated like a professional and like getting paid was amazing. Never had that ever."

"Also that, you know, we were getting paid to do something to help us professionally was enticing. I thought, wow. That just feels good."

Teachers liked the general format of the series and the format of the individual Saturday sessions. They positively described the sustained nature of the series across the school year, the spacing of sessions and approach across sessions. In addition, teachers found balance in the learning formats embedded in the sessions.

"It was a balanced session that included small and large group discussions, videos, examples and individual work and reflection."

"I think for me [Session 1] just set up the quality of the things that we were going to be doing in this class, and it was just so content rich and really opened the door for the type of work we were going to be doing and really diving deeply into math content and also CLASS."

Teachers welcomed early mathematics as the featured content for the series. They found the presentation style for the math content to be effective and took significant insights away from many of the structured PD activities.

"And I was interested when I saw the information on it, because I was like, 'Oh, I really would like to up my math in 4K.' You know, I feel like everything was like, literacy, literacy, literacy."

"...aligning the CLASS domains with math was brilliant. Because we don't ever get math PD. We get a ton of literacy and socioemotional types of professional development, so -- and I think that shows why we're stronger in those areas than math, and, you know, the quality of feedback, and all of that stuff."

"Like the first class at the Goodman Center, Beth was talking and like, yeah, we all know it's important to get students to do operational thinking and counting. But it's just like her way of presenting and some of the videos that she included. It was just like reminding us how astonishing it is to count in the first place. And to have one-to-one correspondence and to make sense of amounts and operational thinking. And how much we ask of children that is so naturally part of what they do, anyway. So, I think that sense of expounding on our opportunities in the ways that we teach was part of like just that first feeling at Goodman... You know it just made it so much more natural and organic. And I think because of your university connection, it was almost like you gave us the license to be freer in our teaching."

"The big ideas clicked right away...And it -- I don't want to say it's never been laid out like that before. I'm sure it has, but for some reason, in the format that it happened, the timing that it happened, it was like, oh, okay, that makes sense."

Teachers also responded positively to the carefully selected resources used in *Mathematize*. The main text, *The Big Ideas of Early Mathematics*, received consistent praise, as did the CLASS dimension rubrics. Teachers used the take-away materials from each session, with the 10 frames and quantity cards becoming classroom staples.

"...these things from the book, you know, this part at the back, you know, with the big ideas, like, I want these. I'm going to make copies of these and, like, just keep them. Like, I'm going to, like, laminate them, like, make it nice and keep them in my planner, you know, and, like, use that to remember all of these big ideas."

"Like if there's something that seems just a slightly bit boring to me, I'll give up on it, but with this book whenever we had a chapter to read, I was always very into reading. I was always taking notes, highlighting everything. So, I think the book itself is a great math tool to have."

"I loved that rubric that you gave us, because I refer to it now all the time."

The PLCs played a pivotal role in bringing content to life and solidifying concepts and strategies for instruction. Teachers built trusting relationships with their peers and learned through the many interactions among members of PLCs.

"...like having those opportunities to learn from other people and see their ideas is like really powerful, you know?"

"It was so valuable to hear other people's ideas, things that I think 4K teachers don't get to do enough, because so many of us are isolated. We don't have PD a lot of places. Even when I worked for the district, it was very spotty. I was alone in my building. I didn't -- I had to kind of create networks to try to talk to people. So having that was very helpful, and it makes me realize you need to have that."

"...on a math level, I think just having those conversations with colleagues and -- seeing different peoples' places on where they are at and being comfortable to like have our PLCs and have these relationships develop, so that way there's this level of safety that people can really kind of share and express, like where they're at, things that they've tried, things that they know that they should work on, and kind of have those honest conversations."

Teachers gained insights, ideas and inspiration from the classroom observations they conducted with their peers. Peer learning extended beyond early math content to designing environments and maximizing learning among the daily routines.

"I enjoyed the opportunity to be able to, to go out and look at other learning environments, not only how they were set up, but the materials that were available, how teachers implemented ideas, how they talked about math concepts, language and literacy concepts, and just kind of interwove everything...So I appreciated that, that opportunity. I know it's made me reflect upon when I'm putting new things in the classroom or I'm switching things out or adapting things, I tend to look at things now in a new light."

"And I also think that the meanings around the classroom visits, like the premeeting and the after, like that whole component, is a really good piece to have. I feel like some of those takeaways could have really flopped if we didn't have time to reflect and discuss with another person and share those things, which maybe we kind of felt that because some visits popped up and we didn't all get our final observations in or discussions in."

"But like going and being in Savannah's classroom was really exciting just to see the way that her management was and all the little acts of math and literacy that she just tucked in that you didn't, you know, that I was really cognizant of and writing those down. And then the nice thing was that Savannah said when she came to my room, she was like, 'Well, Louisa, you were doing, you know, so many of these things.' She's like, 'I don't think you realize all the stuff that

was going on in the room.' And I don't think that when you're in the moment, you know, you really do know what's actually going on. So having someone come in and say, 'Hey, these are the great things that I saw. This is something you might want to try.' I love that because I don't think that, you know, it's just nice."

Teachers highlighted the relevance that *Mathematize* had for their teaching and the fact that the PD gave teachers content and resources they could immediately use in their classroom.

"I felt like every time we left the [PD sessions], I was inspired or had a cool new idea or focus. And it was always rewarding to go and play that out in the classroom."

"There was never a time where I left and I felt like we couldn't use any of the stuff, it was all things that we could take back with us and use right away, no matter where we were or what we were doing...[W]e packed so many things that are relevant into this PD that it was always astonishing when you'd look up and see that it was time to go, like there were so many more things we could do!"

"And I liked that there was always a take-away. [Y]ou could go in Monday morning and set it up and they'd come in on Tuesday and go right at it. And so that was nice because I think we all kind of look for those different, different things, different ways to reach different children."

A few components of *Mathematize* received mixed reviews from teachers. In general, teachers agreed that the videos embedded in the pre-session work and the Saturday sessions were effective tools for learning. However, opinions varied in the way to best use the videos and which videos had the biggest impact. Teachers preferred videos of teaching practice, as opposed to child assessment videos. Some also expressed their preference for videos of MMSD teachers. Conflicting opinions had to do with the timing and structure of viewing and discussing videos and whether teachers watched videos multiple times.

"I think using videos of teachers in our district was really good. Just that way we can relate to somebody that's in the same district as us. I don't think that there was a video that I didn't -- wasn't drawn into watching or was bored during or anything, so I think the videos were good."

"...was frustrated that we watched the same video during the session that was assigned to see before. Perhaps another video that shows a similar concept."

"I love watching the videos of other teachers in the classroom. I find it so beneficial to see different teaching styles and get ideas for ways to improve my own teaching."

Teachers had varying thoughts about the online learning tools and electronic resources available to them through *Mathematize*. Teachers seemed to warm to Canvas between Sessions 2 and 4. However, several teachers said that the online replacements could not match the experiences of being in-person. The value that teachers placed on the early math matrix seemed dependent on how much time they spent familiarizing themselves with the tool.

"I think after the super snowy one where we didn't have many people there, where we just kind of sat down and we looked at [the matrix]. I mean I only had myself and one other PLC person, but as a whole group we just kind of sat down and just looked at it. I feel like I didn't really understand it before that, but then when we sat down and just kind of looked through it and then we looked for a specific activity or a specific standard, then it just kind of clicked and now I have no problem."

We identified three elements viewed more negatively by teachers in *Mathematize*. First, teachers recommended that the full extent of expectations for the professional development series be laid out in advance. This appeared to be mostly in reference to the expectations related to PLC meetings, as well as the final reflection project. Teachers cited reasons for this as the opportunity to better plan for their classroom and use of content, as well as to ensure more congruence in commitment levels of participants.

"I think you need to be super clear in the beginning what the expectations of the course are. Sometimes I felt like we had, like, suddenly, like, new things that we had to do or integrate that we didn't know about before. So, and I think it would have been helpful to have a sense of the project, right away, on day one. So, that it could sort of focus our thinking and our framework for the year."

"I feel like some people in the class were extremely committed to it, and other people were whiny. And I had no patience for that, and I think that's kind of what frustrated me about my particular PLC when I first started. I just -- I was kind of floored at the attitude that was happening. You know, because, again, this was completely voluntary, and it was a paid opportunity [laughter]. That never happens. I just was floored that, like, people couldn't make time, when I thought it was very clear that it was going to be a big time commitment. I mean, most teachers spend a lot of time on their craft."

In terms of *Mathematize* content, teachers' only complaint was about the division of CLASS instructional supports and early math content into distinct morning and afternoon sessions during our second Saturday meeting. Teachers felt overwhelmed and confused as they attempted the lesson planning activity for Exploring Geometry with The Secret Birthday Message. The CLASS concepts remained too abstract when we separated them from the math content. This feedback came to light right away and we were able to adjust the approach used in the third Saturday session.

"I remember feeling, like, overwhelmed with not knowing even where to start because there was just so many concepts that you could really dive into. And not even touch the book yet. So, it seemed like a really simple task, but it ended up being a little overwhelming"

"I know in session we did with the book on big chart paper, which I think it was just hard because we were all coming from different contexts, so I think that was a hard activity, at least in session."

"... separating the concept development out from the math I thought was a little bit trickier. But when you combined the two together, it made more sense... And you could see, okay, these are some really good type of questioning skills. And this is some really good feedback that you could say to a child when you are engaged in an activity, a learning activity with them."

"When we were bringing those in CLASS and we kind of switched and kind of molded the instructional strategy practice and the math topic together -- I think it really unified -- yeah, really unified what was going on."

The final critique that teachers offered focused on the need for more, whether it was more classroom observations, more time to connect with PLCs, more time to cover content, especially the CLASS dimensions, or more CLASS resources. Many teachers requested more tangible resources for CLASS, specifically the *CLASS Dimensions Overview*, a laminated trifold that summarizes the indicators within each dimension by level of quality. The mentors received this resource in their design team materials. One teacher also perceived that teachers at school sites knew more about CLASS and use it more regularly in their teaching.

"So maybe the mentor teachers' classroom could have been like a third one in each round or something because we never did get to our mentor teacher's room. We did. We had our last PLC meeting there in her room because we wanted to see it. But, you know, like, I kind of would have loved to have seen her in action so -- but, anyways, I just think that that experience was great."

"More PLC work. Not sure what that would be, but I was craving more interaction and more sharing from the PLC. At the same time, as a mentor, wasn't sure how much to initiate that outside of the time that was originally suggested when the plan for PLCs was created at the start."

"What I think would be -- would have been great is, if at the very beginning, we would have all gotten the little CLASS booklet, like, as part of the PD, like just this is what it is because for some reason I didn't really get that initially... I would have loved it if we had gotten that, like, right off the bat because it seemed like this is basically about teaching math with that lens, like a CLASS kind of thing. That would maybe be, like, something for an improvement."

"Michelle had something called CLASS that sort of like was the organizational framework for this course. And it felt like we should have all had that, too. It was a really nice sort of way to guide our thinking and our language around math. And I remember, like, wondering why we didn't get that. That would have been super helpful."

"I keep this with me now everywhere... and I'm like oh. I can just pull it out and be like oh the feedback that I just gave there was not so good. I feel a lot more comfortable with this now but being given one of these was amazing because I can just simply open it and be like, okay,

climate, need to change this. This is what it should look like. So, I think that that was -- in breaking it down for each topic that we talked about was super helpful too." (From a Mentor who received the trifold)

Feedback from the Design Team

Members of the design team had several opportunities to provide feedback on their dual roles through mentor surveys at the conclusion of each Saturday session and a final design team debrief meeting. Design team members described feeling heard and that they had a say in how to meet the professional development needs of 4K teachers.

"I think this process has been an extremely valuable learning experience. The ability to plan, do, and review allowed us to improve upon each session. I think we learned ways to hold learners accountable, the importance of diving deeply into what good teaching encompasses (CLASS), and the value in observing each other. I think we have learned along the way and each session was better than the previous one."

"...like what Deborah was sharing, the feeling of being in a PD and your needs not being met, and having visions of, 'This is what I need.' And then, you know, sharing that with your colleagues, and sometimes having the opportunities to share it with administrators or directors, but most of the time not being able to. Or, feeling like you're not being heard, because there's another plan in place. And so, it was nice to be able to be a part of that, and I think that it came at a time where I, personally, was feeling a lot of frustration with professional development. And so, yeah, I was excited to be asked to join and be able to provide feedback and insights."

The design team members who also fulfilled the role of mentor expressed the importance of having supports for mentorship, including direction that allowed for flexibility to customize the work of their PLCs. Despite feeling heard in the design of *Mathematize*, having some supports for mentorship, and enjoying the overall opportunity, design team members also shared that they felt frustrated at points when roles, assignments and process lacked clarity.

"Initially, I didn't really know what my role was, or what I was supposed to do, I just kind of entered into it a little later, so I wasn't sure. But, when I was in the role, I felt that we kind of had the ability, more so at the end than the beginning, to say what we kind of thought was working and what we could do differently. We could really give our input and really be listened to, and then changes were made based on what we felt would be beneficial to everybody. So, that felt kind of gratifying, that we could have something that was meaningful for all of us."

"So, we divvied out the math concepts, and it was like, "Okay, dig into this, dig into this," and so then, I did. And I researched all this, and then I felt like we didn't really go back to it. I mean, you guys were like, 'Here is what we found,' and I was like, 'Oh!' Which was great, and it would've taken a ton of time to do that in person, but that was a frustrating feeling."

"...when looking at how this was all designed, I think, like last summer, those sessions where we started, I think it was truly like, 'Here's a group of people we've brought together. We have this idea and this concept, but we really aren't sure, other than, here's our main objective and here's an objective, something about mathematics and CLASS, we aren't quite sure how this is all going to form.' So, I feel like it was really team effort, taking in information, and hearing from field staff and teachers. And then, some started forming, and I think that was, too, trying to maintain that teacher voice, and that's where we got into that piece about teachers digging into these concepts, like Hannah Marie and I first did, and we all signed up for some. But then as things started going and the school year starts, realization set in, and it seemed like then the MEP staff took more of the wheel, and then it was meant for the teacher part of it, and the design team, to kind of review. Like, then when we met, I saw it more as, 'Here is an outline, skeleton plan, and what do you all think? Or what are some inputs and insights here?' And I feel like it wasn't just like, 'Here's what we're going to do'; it really was taking our feedback a little bit, because changes were made and things like that. "

VII. Reflections from Instructional Leaders (Written by Graue & Witthuhn)

When we (Beth and Culleen) were approached with the opportunity to help develop and lead this PD, we both felt that it was too unique of an opportunity to turn down. We recognized Mathematize as a chance to collaborate with educators, administrators, and others who support Madison 4K but who are outside of our usual bubbles, and to impact practitioners and children in a deep and lasting way. For Beth, the opportunity to engage directly with MMSD's 4K program and teachers was appealing, particularly because work that bridges the University and the community is, in her opinion, too rare and too often undervalued. Similarly, Culleen was drawn to the opportunity to collaborate with the University as well as the chance to connect simultaneously with teachers from all three 4K site types.

Several things made Mathematize truly unique in our eyes. First, unlike many PD offerings, which focus on curriculum, assessment, or other structures or tools related to teaching, we knew that Mathematize would be designed with teaching and centering what teachers said they wanted and needed for their professional growth. Not only did we hold this as a core goal, we knew that the practitioners on our Design Team would keep us tethered to that focus. In that way, we had all the necessary pieces to design a truly responsive learning experience that was tailored to 4K practitioners. Mathematize was also special because of the incredible resources we had at our disposal. We knew from our participation in designing MEP's prior research that the PD could be focused on the particular needs of Madison's 4K community. MEP also provided financial and administrative resources to ensure that we could treat Mathematize participants like the accomplished professionals we know they are.

One of our goals for Mathematize was to build a community of practitioners that could learn together over time. In Madison, several conditions serve to limit work with peers. Many sites have only one 4K classroom, leaving these educators without regular opportunities to collaborate. The community approach to 4K implementation resulted in few opportunities for teachers across program types to interact and they never received professional development together. We wanted to support 4K teachers to develop networks of colleagues that they could draw on during the PD

and beyond. We also knew from prior experience that the feedback and support that educators offer one another can be just as powerful, if not more so, than anything we do as facilitators. Fostering this community in the rather limited time we had together was a challenge, but we knew that setting aside time each session to build rapport and allow educators to connect with each other would be a worthwhile investment.

We were also committed to offering teachers the kinds of meaningful, reflective, and relevant learning experiences that we knew they craved. For instance, we knew from the outset that peer classroom observations would be an essential component of Mathematize. We wanted teachers to observe each other in pairs so that they would be able to see how other professionals carried ideas from the PD into their unique contexts, and then have a built-in reflective partner with whom they could process what they observed. It was also important for us to make sure that teachers left each session with tangible tools and materials that they could bring directly into their classrooms. We both expected to learn a lot through our involvement in Mathematize and this certainly bore out. We learned a number of lessons as the year went on and adapted our approach whenever we could. For instance, with hindsight, we recognize that four CLASS dimensions plus four math domains may have added up to too much content for teachers to engage in meaningfully, and the scope of the Mathematize curriculum could have cost us opportunities for in-depth and integrative thinking. Design Team teachers also helped us see that weaving math content and CLASS instructional supports together, rather than exploring them separately, would allow teachers to integrate these ideas into their practice in a more authentic and meaningful way.

Another lesson from Mathematize was that some of the things that made this such a compelling and effective opportunity also created challenges in the moment. For example, good co-teaching rarely means dividing work; instead, taking full advantage of a partner teaching relationship means multiplying the time spent planning, coordinating, and debriefing. But that time was well worth it. Co-facilitating offered us the rare opportunity to observe and learn from each other, and to see in real-time how teachers were engaging with the experiences we had developed. Knowing how best to take advantage of the expert resources offered by teachers on the Design Team and members of the broader project team was another challenge, as it required us to stay several steps ahead of the group. This was no easy task given we were building and adapting this program as we went! Yet, Mathematize would not have been the same experience without the feedback, insights, and support from the Design Team members and, in particular, the mentor teachers.

We are very pleased with how much teachers seem to have taken away from their participation in Mathematize, and we're proud of the experience we were able to provide. We also recognize that Mathematize benefited from financial and human resources that are not typically available for PD. Rather than discourage us from trying to replicate or sustain this kind of collaborative, high-quality, research-based professional learning, we think that it pushes us toward new ways of thinking about research and community collaboration. We see the resources provided by MEP and IES, as well as CRECE's investment in this project, as seed funding that makes this kind of program easier to sustain moving forward. As we look to the future, we hope that Mathematize can serve as a foundation or launching pad, and that other individuals, groups, and resources can step in to continue the relationships we developed here.

VIII. Reflections from MEP- from the RPP angle (Written by Grodsky & Vaade)

MEP has made substantial investments in work in 4K. In fact, the first few projects we took on were around 4K participation (Pyne et al. 2017) and the association between 4K participation and literacy skills at the beginning of 5K (Grodsky et al. 2017). Our commitment to work in early childhood education is rooted in our commitment to educational equity. MMSD and MEP share an understanding, supported by an expansive literature in education, that the best way to address inequities in student learning is to ensure that students begin elementary school with comparable levels of knowledge and skills. It's a lot harder to catch up than it is to start off on equal footing.

When we initially outlined this grant, MEP had both substantive and structural objectives in mind. Our co-directors at that time did not have expertise in early childhood education research and implementation; for that, we relied on the expertise of others at the university (Beth Graue and Katherine Magnuson, in particular) and at MMSD (Culleen Witthuhn). Substantively, we saw an opportunity to take our relationship with the district's 4K program to the next level. We had worked closely with the administrative data on 4K, producing reports on [program participation](#) and the [association between participation and kindergarten readiness](#). We had also studied the 4K-5K transition, including a [review of school practices](#) and a [pilot home visiting program](#) with a handful of 5K teachers (with the support of the Spencer Foundation). The project we proposed to IES would be the first to put us inside 4K classrooms and would involve collaboration with a larger group of teachers across the district. For MEP, we ultimately wanted to conduct research that improved instructional quality in MMSD and beyond.

Structurally, the project presented an opportunity for the head of early learning in the district (Culleen) and the director of the Center for Research on Early Childhood Education (Beth) to collaborate to improve the quality of instruction in 4K. Each brought particular strengths to this work. Beth had extensive experience designing and implementing PD for 4K teachers as well as a deep understanding of research on early childhood. While relatively new to Madison and MMSD, Culleen had previously developed a strong 4K program in another district, had created and delivered PD there and had the organizational power to make change in MMSD. By positioning them as co-designers of the PD and co-leads in the implementation of this work, we hoped to seed future research-practice collaborations and jumpstart a professional relationship between two key players in Madison early childhood. The project also funded several graduate students, capitalizing on their academic and professional expertise and bringing them into dialogue with practitioners and researchers. This sort of training is vital for the maintenance of RPPs now and into the future, as students gain an appreciation of the unique opportunities they can secure through collaborating with practitioners in research. For MEP, we ultimately wanted to develop stronger relationships between district leaders and university researchers interested in early childhood in Madison.

Throughout the course of the project, we encountered several tensions common in RPP work. First, in developing the PD, we confronted a tension between efficiency and collaboration. For example, we originally hoped that teachers on the design team would collaborate with university researchers

on all phases of the design process. Due to scheduling constraints that didn't always work out and we, at times, had to sacrifice full collaboration to move the development forward. Second, university researchers and district staff struggled at times with conflicting norms. For example, university researchers tended to be more direct in addressing points of disagreement, while district staff tended to voice those concerns in more abstract ways. When scheduling meetings, district staff needed blocked times weeks in advance, while researchers preferred to schedule them a few days prior to avoid having unnecessary times blocked on calendars. In these instances, norms that serve to optimize work in one setting tended to inhibit work in the other, making collaboration across research and practice more challenging. Finally, we struggled at times to be nimble and provide structure. We were building the PD as we went and, while the product was successful, the process sometimes lacked the clarity we might have wanted it to have. It was a learning process for everyone.

MEP set out to accomplish two goals with this project: 1) improve instructional quality in MMSD 4K and 2) strengthen relationships between district staff and university researchers interested in Madison early learning. While we met challenges along the way, we believe this project achieved these goals. We used the early stages of this work to define strengths and growth opportunities in 4K instruction, then mobilized that information to make change via improving teacher practices. Teachers got a lot out of their work with *Mathematize*. It gave them a space to collaborate around mathematics, bridged the varied instructional settings of 4K work in the district and provided opportunities for teachers to observe and engage with one another's instructional practice. The experience of attending professional development sessions, experimenting with new approaches to play-based instruction, observing one another's classes and reflecting on those observations contributed helped build a sense of community with and across the PLCs. At the time of writing, we are working with mentor teachers to continue *Mathematize* virtually through the 2020-2021 school year.

In addition to giving teachers the tools and training to enhance the quality of instruction, we also fostered more collaborative relationships between district staff and university researchers. It allowed us to strengthen our ties with and between leaders of both CRECE (Graue) and MMSD's early learning program (Witthuhn), building trust and sowing the seeds for future collaborations. *Mathematize* has provided doctoral students and researchers working in MEP with exceptionally rich opportunities to understand the challenges and benefits of PLCs as a means to support pedagogical development around mathematics in 4K. *Mathematize* also created opportunities for experienced teachers to take on a leadership role on designing and supporting PD, recognizing their professional expertise and having them work collaboratively with university researchers to spread their knowledge.

IX. Recommendations for Future Professional Development

By all accounts, *Mathematize* was a successful program of professional development. While we were unable to evaluate how the PD influences student learning, we were able to collect reflections from teachers and other artifacts that speak to the development of their understanding

of and confidence in teaching mathematical concepts foundational to higher order mathematical thinking. We believe that further research would show that *Mathematize* changes teachers' approaches to play-based instruction and, through their instruction, enhances the mathematical skills of children in 4K.

Mathematize was expensive. The cost per participant was about \$3,150, including PD instructor time, incentives, substitute teacher time, resources, printing costs, and meals. It took a fair bit of staff time to schedule the instructional rounds and significant funds to pay for substitute teachers and to compensate teachers for their off-contract time. At the same time, given that the program was delivered as a whole rather than in separable components, we are optimistic but less certain about the benefits of the parts than we are of the benefits of the whole. *Mathematize* is an example of synergy-- where combining elements gives more than their sum. Thus our first recommendation is to **repeat Mathematize with fidelity, incorporating the readings, videos, presentations, instructional rounds and PLCs as we have outlined in this report.**

Second, we recommend that MMSD **continue to support the PLCs that took root in *Mathematize*.** Simply giving teachers time to collaborate around pedagogical challenges and to engage in discussions around one another's practice enhanced professional community and led to improvements in instruction. *Mathematize* created some momentum for this group of educators; we hope to see that momentum preserved.

Third, if the District is unable or unwilling to replicate *Mathematize* in its entirety, we recommend that the District **leverage individual components of *Mathematize* to support professional development of teachers in 4K.** Given our focus on the program as a whole in this project, the district should evaluate the impact of any efforts to implement a partial *Mathematize* design. The PLC structure holds tremendous promise as a vehicle for continued professional development and instructional improvement. PLCs should not, however, simply be unstructured groups. They should have instructional objectives, outlined in collaboration with Witthuhn and her staff or independently, and should incorporate time for instructional planning, implementation, observations and individual and group reflection.

Between March and November of 2020, we gained a much greater appreciation for the potential technology holds for addressing some of the logistical and financial hurdles we encountered in fielding *Mathematize*. We believe it would be possible to:

- Offer modules of Mathematize through a virtual platform, incorporating breakout sessions for group work and discussion;
- Video record classrooms and share those recordings on a secure platform to support PLC observations of one another's practice;
- Capitalize on existing video resources, including the library of instructional practice curated by Beth Graue and others in the Wisconsin Readiness Equity Network, of which MMSD is a member (represented by Culleen Witthuhn);
- Use existing professional development time to support these efforts.

In the extension of *Mathematize* we are deploying starting in December of 2020, we plan to experiment with some of these innovations with a subset of PLCs that participated in the original *Mathematize* project.

Fourth, we recommend that the District **build future PD around the structural elements of Mathematize** which we believe contributes to the program's benefits. The key elements of *Mathematize* were:

- *Integrating learning content with pedagogy.* Mathematize was designed around core substantive domains of mathematics content and scaffolded by the learning supports dimension of CLASS. It's not an either/or; we believe successful instructional improvement requires both.
- *Employing CLASS as a professional development tool* and providing teachers with tangible resources to help them develop new strategies of instructional support and strengthen existing competencies.
- *Designing 4K PD that draws upon and builds professional community across the 4K program.* MMSD has adopted a community approach to 4K and should do the same for PD for 4K. Teachers and students at ECE and Head Start sites should enjoy the same opportunities for growth as those attending school sites. We believe this is an issue of equity.

Finally, we hope the Mathematize experience will lead MMSD to **reconsider the professional pathways it makes available to 4K teachers.** As noted above, the mentor teachers that participate in *Mathematize* exhibited instructional skill and qualities of leadership. They clearly enjoyed their leadership roles in the PLCs and the PD more generally and seemed to develop as a result of those opportunities. We encourage MMSD to explore ways to take advantage of the expertise of these mentor teachers, including creating opportunities for mentor teachers to provide coaching to other 4K teachers and supporting mentor teachers through other opportunities to strengthen their leadership skills.

Works Cited

- Darling-Hammond, L., Hyler, M.E. & Gardner, M. (2017). Effective Teacher Professional Development. Palo Alto, CA: Learning Policy Institute, pp 1-76.
- Grodsky, E., Pyne, J., Vaade, E., Camburn, E., Bradley, D. (2017) Preparing the Littlest Learners: Four-Year-Old Kindergarten Readiness in MMSD. Madison, WI: Madison Education Partnership. pp.1-22.
- Pyne, J., Grodsky, E., Vaade, E., Camburn, E., Bradley, D. (2017) Madison Metropolitan School District Four-Year-Old Kindergarten Program: Patterns of Enrollment. Madison, WI: Madison Education Partnership. pp.1-13.
- Young, K., Ramberg, E., Awkward-Rich, L., Boonstra, K., Hoiting, J., Snyder, J., Graue, E., Grodsky., Jeppson, A., & Vaade, E. (2019) Understanding the Quality of Instruction in Madison 4-Year-Old Kindergarten. Madison, WI: Madison Education Partnership, pp. 1-29.

Appendix A: Project Timeline

July 30, 2019	Design Team Launch
August 12, 2019	Design Team Meeting
September 5, 2019	<i>Mathematize</i> Application Release
September 22, 2019	<i>Mathematize</i> Applications Due
September 24, 2019	Design Team Meeting
October 5, 2019	<i>Mathematize</i> Session 1: Number & Counting
October 5, 2019	Design Team Session 1 Debrief
October 7, 2019	Canvas Setup for Participants Begins
October 29, 2019	Round 1 Classroom Observations Begin
November 14, 2019	Round 1 Classroom Observations End
December 12, 2019	Design Team Meeting with Amy Parks Consultation
January 11, 2020	<i>Mathematize</i> Session 2: Spatial Relationships & Shape (Postponed due to snowstorm)
January 18, 2020	<i>Mathematize</i> Session 2: Spatial Relationships & Shape
January 18, 2020	Design Team Session 2 Debrief
February 11, 2020	<i>Expanding the Notions of Play with Angela Pyle</i>
February 18, 2020	Design Team Meeting
March 3, 2020	Round 2 Classroom Observations Begin
March 7, 2020	<i>Mathematize</i> Session 3: Measurement & Data Analysis
March 7, 2020	Design Team Session 3 Debrief
March 25, 2020	Wisconsin Safer-at-Home Order Begins
April 14, 2020	Design Team Meeting (Zoom)

April 25, 2020	<i>Mathematize</i> Session 4: Operations & Relations (Zoom)
May 9, 2020	Post Surveys Due from Participants
May 19, 2020	Design Team <i>Mathematize</i> Series Debrief (Zoom)
May 20, 2020	Round 2 Classroom Observations End
June 10, 2020:	Final Projects Due

Appendix B. Classroom Observation Tools Created and Used by PLCs

Example 1: Purple PLC

Small Group math lesson: Measure the Woolly Worm

Math Noticings:	
<p><u>Instructional Learning Formats:</u> <i>How is the teacher engaging children, maximizing learning opportunities?</i> (Ex: effective questioning, hands-on opportunities, students actively participating)</p>	<p><u>Concept Development:</u> <i>How is the teacher promoting higher-order thinking skills?</i> (Ex: Why and/or How questions, creating/producing, connecting concepts, using prior knowledge)</p>
<p><u>Quality of Feedback:</u> <i>How does the teacher extend learning through their responses to students' ideas, comments, and work?</i> (Ex: scaffolding, follow-up questions, students explaining thinking, student persistence, encouragement)</p>	<p><u>Language Modeling:</u> <i>How does the teacher facilitate and encourage children's language use?</i> (Ex: back and forth exchanges, peer conversations, open-ended questions, repeats and extends/elaborates, connected to familiar words)</p>

--	--

**Don't forget to jot down questions you may have as well. Ask if taking photos of things (NOT children) is ok in order to reference later.*

Math about the room (materials, activities, kids doing math)	General observations / Other (noticings you want to remember: classroom environment, transitions, organization, student work, etc)

Example 2: Red PLC

Red PLC Observation Form

Math	Behavior
Transitions	Management

Appendix C: Blank Template for Early Math Activities

[Activity Name]

(source:)

Math Concept:	
Mathematics Developmental Progression:	<ul style="list-style-type: none"> • <i>Preceding Developmental Milestone(s):</i> • <i>Focus Skill(s):</i> • <i>Subsequent Developmental Milestone(s):</i>
Wisconsin Model Early Learning Standards:	
Teaching Strategies Gold Objectives:	
Assessment Protocol	
Materials Needed:	
Activity Description:	<p>Format:</p> <p>Preparation:</p> <p>Instructional Introduction:</p> <p>Activity:</p>
Instructional Supports:	<p><i>Things to Look for:</i></p> <p><i>Questions to Ask:</i></p> <ul style="list-style-type: none"> • <i>Concept Development:</i> • <i>Quality of Feedback:</i> • <i>Language Modeling:</i> • <i>Instructional Learning Formats:</i>
Interest Area Extensions:	

Appendix D. Snapshot of the Early Math Matrix

WI Model Early Learning Standards

- B.EL.1 Arranges sets of objects in one-to-one corresponde...
- B.EL.1 Can rote count and counts concrete objects to 5 an...
- B.EL.1 Counts with 1 to 1 correspondence up to 20 objects...
- B.EL.1 Explores numbers and imitates counting
- B.EL.1 Names and can write number symbols 1 through 20 ...
- B.EL.1 Names and writes some numerals
- B.EL.1 Recognizes some numerals and associates number ...
- B.EL.2 Compares concrete quantities to determine which h...

Teaching Strategies GOLD Learning Objectives

- 20.a.2 Verbally counts (not always in correct order)
- 20.a.4 Verbally counts to 10; Counts up to five objects acc...
- 20.a.6 Verbally counts to 20; Counts 10-20 objects accurat...
- 20.b.2 Demonstrates understanding of the concepts of one...
- 20.b.4 Recognizes and names the number of items in a sma...
- 20.b.6 Makes sets of 6-10 objects and then describes the p...
- 20.c.2 Recognizes and names a few numerals
- 20.c.4 Identifies numerals to 5 by name and connects each ...
- 20.c.6 Identifies numerals to 10 by name and connects eac...



Madison
Education
Partnership

The development of this tool was supported by a grant from the Institute of Education Sciences (R305H180053). Opinions expressed do not represent the views of the U.S. Department of Education.

Instructions for Using the Standards and Activities Matrix

1. Click on a WI Model Early Learning Standard from the developmental domain of Cognition and General Knowledge or a Teaching Strategies GOLD Objective that you will be focusing on in your teaching. You can choose multiple WMELS standards or multiple GOLD objectives but not a combination of standards and objectives. All of the activities that address your selection will appear.
2. To filter the activities more, you can also specify a math domain and or activity type. You can select multiple options within these categories by pressing the "list" button in the right-hand corner.
3. Access the full description of activities using the accompanying *Mathematize Your CLASS Math Activities* file.
3. To reset the filter, press the clear filter button in the right hand corner. Be sure to do this for every category.

Note: If you access the matrix and all activities don't seem to be appearing, make sure that the filter has been cleared for each category. Then try selecting your preferred options again.

Math Domain	Math Concept	Activity	Activity Type	Source
Number & Counting	Counting, Cardinality	The Math in Dots	Small Group	Website: Erikson Institute
Number & Counting	Counting, Cardinality	The Math in Dots	Small Group	Website: Erikson Institute
Number & Counting	Counting, Cardinality	The Math in Dots	Small Group	Website: Erikson Institute
Number & Counting	Counting, Cardinality	The Math in Dots	Small Group	Website: Erikson Institute
Number & Counting	Counting, Cardinality	The Math in Dots	Small Group	Website: Erikson Institute
Number & Counting	Counting, Cardinality	The Math in Dots	Small Group	Website: Erikson Institute

Appendix E. Interview Questions for Instructional Support Videos

Concept Development

1. Thinking back to some of the CLASS information on Concept Development, how would you describe this instructional support strategy to another teacher?
2. Why do you think this is such an important strategy in teaching? What effect does it have on children's learning and development?
3. Tell me about how you promote analysis and reasoning with your students.
4. What is one of your favorite ways to get your students creating in your classroom? (If you'd rather talk about one of the other CLASS indicators, feel free!)
5. What are some of the ways you approach integrating concepts?
6. How do you make sure that the content and concepts that you are teaching have real world connections for your students?
7. What do you look for to see if you've been successful supporting an individual child's concept development?
8. Now thinking about your class, how do you know how successful you've been in advancing the group's learning in concept development?
9. What advice would you give a teacher who was working to provide more effective concept development in their class?
10. If you had to choose one thing that you think makes the most difference when it comes to concept development, what would it be?

Narrated tour of classroom, with discussion on:

- How you plan your environment and your lessons to promote concept development.
- Reflections on your own growth and goals related to concept development.
- Anything else you think would benefit teachers!

Language Modeling

1. Thinking back to some of the CLASS information on Language Modeling, how would you describe this instructional support strategy to another teacher?
2. Why do you think this is such an important strategy in teaching? What effect does it have on children's learning and development?
3. Tell me about your strategies for promoting frequent conversation in your conversation, including, and any examples more specific to back-and-forth exchanges, contingent responding and/or peer conversations.
4. How have you developed your own habits in offering open-ended questions to students?
5. What innovative ways have you embedded the ideas of repetition and extension or elaboration into your teaching?
6. How do you use self- and parallel talk as a language modeling tool?
7. What is one (or more) of your favorite ways to encourage advanced language in your classroom?
8. What do you look for to see if you've been successful supporting an individual child's language development?

9. Now thinking about your class, how do you know how successful you've been in advancing the group's learning through language modeling?
10. What advice would you give a teacher who was working to provide more effective language modeling in their class?
11. How do you customize your practice for your students who are English language learners?
12. If you had to choose one thing that you think makes the most difference when it comes to language modeling, what would it be?

Narrated tour of classroom, with discussion on:

- How you plan your environment and your lessons to integrate language modeling.
- Reflections on your own growth and goals related to language modeling.
- Any connections you make in your teaching between language modeling and early mathematics.
- Anything else you think would benefit teachers!

Appendix F. Resources Used to Develop *Mathematize*

Brownell, J. O., Chen, J.-Q., & Ginet, L. (2014). *Big ideas of early mathematics: What teachers of young children need to know* (First edition). Pearson.

Clements, D. H., & Sarama, J. (2014). *Learning and teaching early math: The learning trajectories approach* (Second edition). Routledge, Taylor & Francis Group.

Copley, J. V., Jones, C., & Dighe, J. (2016). The Creative Curriculum® for preschool.

DREMEITE. <http://prek-math-te.stanford.edu/>

Erikson Institute Early Math Collaborative. <http://earlymath.erikson.edu>

Heroman, C., Burts, D., Berke, K., & Bickart, T. (2010). Teaching Strategies GOLD™ objectives for development and learning. Washington, DC: Teaching Strategies.

Hynes-Berry, M., & Grandau, L. (2019). *Where's the math? Books, games, & routines to spark children's thinking*. National Association for the Education of Young Children.

Moss, J., Bruce, C. D., Caswell, B., Flynn, T., & Hawes, Z. (2016). *Taking shape: Activities to develop geometric and spatial thinking. Grades K-2*. Pearson Canada Incorporated.

Strasser, J., & Bresson, L. M. (2017). *Big Questions for Young Minds: Extending Children's Thinking*. National Association for the Education of Young Children.

Van de Walle, J. A., Lovin, L. H., Karp, K. S., & Bay-Williams, J. M. (2018). *Teaching student-centered mathematics. Developmentally appropriate instruction for grades pre-K–2* (Third edition). Pearson.

Wisconsin Model Early Learning Standards Steering Committee. (2008). Wisconsin Model Early Learning Standards. *Madison, WI: Wisconsin Department of Workforce Development, Wisconsin Department of Public Instruction, and Wisconsin Department of Health and Family Services.*

The Wisconsin Readiness Equity Network (WREN)

Appendix G. Final Project Guidance

Overview

Storytelling can serve many purposes. It can be used to share information with others. It can also support the process of reflection. We aim to promote both of these aspects in this culminating activity. Each one of you joined *Mathematize* with your own goals, perspectives, and prior experiences, so each of your journeys has been unique. For your final project, you will tell the story of one aspect of your learning during this course.

While the current situation makes it impossible to be in your classroom right now, we hope that you will have on your devices—or in your heads—some artifacts of your practice (photos, plans, memories of interactions, etc.). We would like you to use these artifacts to tell a story of one way in which your early math teaching practice is evolving since you began *Mathematize*. Like any story, yours should have characters, a central focus, and multiple scenes, but this one does not need to have a neat resolution. In other words, we expect that your story will include aspirations or intentions for your future practice.

Once you've identified your focus, you should trace how that aspect of your early math teaching practice has evolved, including what sparked the change, how it has manifested in your planning, teaching, and in child learning. You should also forecast how you intend to grow this aspect of your practice moving forward, including questions, goals, or action steps for the future.

Format: What could your final product look like?

- A learning story
- A storyboard
- An illustrated journal

Examples of possible artifacts:

- photo of a child's finished or in-progress work;
- photo of a child engaged in activity with an explanation of what they were learning and how you supported that;
- video of you teaching;
- transcript or recounting of a conversation with a child, colleague, or parent;
- photo of part of a learning environment, including explanation of how you selected materials, how they were used, and what learning you observed;
- lesson plan or other representation of planning
- *If you don't have photos or videos, it's ok! You can always describe it instead!*

The details:

- Upload your final project to the Canvas discussion board no later than **June 10th**.
- You should use as much space as you need, but if it helps to have some guidelines, we estimate that you'll use 4 – 8 artifacts to tell your story.

Appendix H: Project Roles

Our research team consisted of MEP leadership and staff, MMSD's Director of Early Learning and a UW Professor of Early Childhood Education, as well as a post-doc researcher, two graduate assistants and an undergraduate student. Each member of the project team had unique responsibilities and roles as summarized here:

- Eric Grodsky: Madison Education Partnership Co-PI, Professor of Sociology and Education Policy Studies
 - brokered relationships; provided guidance on research design; facilitated meetings; secured resources
- Beth Vaade: Madison Education Partnership Co-PI, MMSD RPEO staff
 - facilitated collaboration between MMSD and MEP, including supporting recruitment, and communicating with administrators/leaders
- Culleen Witthuhn: MMSD Director of Early Learning, PD co-facilitator
 - served as co-facilitator; selected PD content; developed and facilitated parts of PD sessions
- Beth Graue: Sorensen Professor of Curriculum and Instruction, PD co-facilitator
 - served as co-facilitator; selected PD content; developed and facilitated PD sessions; provided guidance on research design.
- Kathryn Boonstra: Post-doc researcher
 - designed PD study with input from research team; conducted fieldwork and analysis; supported PD design and implementation as needed
- Amanda Kruger: Project manager
 - provided project management support; served as the main point of contact for participants and site partners; coordinated classroom observations and secured substitutes during classroom observations.
- Julianne Snyder: Research assistant
 - retrieved, curated, and packaged/presented high-quality mathematics lessons and activities, drawing from Erikson, DREME, and other resources; facilitated some PD components, such as warm-ups and take-aways; curated resources for facilitators
- Jill Hoiting: Research assistant
 - developed the course website; supported other technology components such as video creation; developed resources, including the early math activity matrix
- Amanda Venske: Lead Transcriber and Undergraduate Office Support Staffer
 - provided general support for the implementation of the professional development and the research study