Designing Relationally: How Teacher-Designed Professional Learning Expands Practice

Dawn Williams

A dissertation

submitted in partial fulfillment of the

requirements for the degree of

Doctor of Philosophy

University of Washington

2023

Reading Committee:

Ann Ishimaru, Chair

Gail Joseph

Soojin Park

Heather Hill

Program Authorized to Offer Degree:

College of Education

University of Washington

Abstract

Designing Relationally: How Teacher-Designed Professional Learning Expands Practice

Dawn Williams

Chair of the Supervisory Committee:

Ann Ishimaru

College of Education

This study presents an opportunity to see how ECE teachers can create early learning math professional learning. Utilizing participatory design research methodologies and expansive learning theory as a frame, it offers valuable insight into what teachers' value and want out of professional learning experiences as evidenced by the emerging design principles. Furthermore, it suggests that teachers themselves may be crucial players in developing the profession. The findings demonstrate how powerful relational and collaborative learning opportunities can be for teachers professional learning and in this case, teachers defined their own collective professional identity. I also include lessons about the importance of goal-driven intentional facilitation moves that support processes of partnering. Further, this study provides a new potentiality for how state ECE agencies can develop, partner, listen, learn, and fund professional learning differently. More equitable professional learning is possible when teachers are positioned as expert knowledge holders and design professional learning.

Acknowledgements

I am privileged to have an extensive list of supporters along this journey. Thank you is inadequate because countless examples of support could fill up a gratitude book that would be full of selfless and beautiful examples of being there for someone.

First, to Juanya, you are deeply appreciated for all the ways big and small you helped to make this possible. You have been there for me, listened, and never gave up on me. Thank you Cydalise and Gabriela for your encouragement and hugs along the way! Thank you, mom, Mike, Jeff, and Pam, for your ongoing support and faith in me.

To my committee, thank you for your commitment and patience along this journey. This dissertation reflects your time and investment in my work, and I am thankful and appreciative for every moment of your time given to it.

Thank you to my Framily Sarah, Joselyn, Caroline, Angie, Lewissa, Adrienne, Melissa, Karen, Kate, your spouses, and children. You all gave my kids the good life and filled their lives with fun while I pushed through to meet another deadline, helped to assuage my guilt and freed me up to concentrate because I knew you all were providing the best thing for them at the time.

To my graduate school community of scholars, Aditi you are forever in my heart. Christine, Carlyn, Kat, Jess, Katherine, Adam, Ishmael, Karen, Mary, Fannie, Dalya, Cricket, Asha, and Asiya, all of you shared your time and brilliance with me reading my work and providing encouragement. You always believed in me and would show me what I could not see myself. Let us write together!

To my study participants, thank you for your participation, openness and giving your time to this study. I carry you all with me and I am thankful for all I learned from you.

Dedication

For Cydalise and Gabriela, may you also have the courage, support, and dedication to stay committed, driven, and passionate to pursue what is important to you.

Table of Contents

Chapter 1: Introduction and Framing Literature

Introduction

As the Early Care and Education (ECE) field works to professionalize the teacher workforce, substantial evidence suggests that professional learning is critical to improving child outcomes (Institute of Medicine [IOM] and National Research Council [NRC], 2015; Power to the Profession, 2020; Ullrich, Hamm, & Herzfeldt-Kamoath, 2016; Palmer, 2018). Yet teachers express dissatisfaction with aspects of professional learning such as relevancy to everyday practice or availability of trainings, (Power to the Profession, 2020; Whitebook, 2014) and wide variations in teacher qualifications present a challenge to designing effective learning experiences (IOM & NRC, 2015). Although the field of ECE acknowledges and advocates for policymakers to listen to and act on recommendations from teachers themselves, teachers are rarely positioned as the creators or designers of their own professional learning. Furthermore, ECE policy can be rooted in deficit perspectives intended to "fix" what is lacking in teachers (Brown, 2019).

Teachers' educational backgrounds, lived experiences, and proximity to teaching practice position them with opportunity to practice, implement, and innovate while engaged with children every day (Carr & Skinner, 2009). Practicing teachers, especially those who may be marginalized by the unaffordability of formal education and traditional professional learning offerings, have expertise that often is not a part of professional learning development or higher education course design. Professional learning developed by state systems occasionally includes teachers as consultants about professional learning through stakeholder engagement processes such as focus groups, listening sessions, or surveys seeking their feedback (Power to

the Profession, 2020). In other cases, Head Start programs require that teachers be a part of committees when selecting new curricula (Head Start Performance Standards, 2016). The Unifying Framework for the Early Childhood Education (Power to the Profession, 2020) calls for government bodies to be "…heavily influenced by the recommendations from the profession" (p. 26). Thus, positioning ECE teachers as codesigners of their own professional learning can bring them to the decision-making and design table fostering a more equitable professional learning system.

This research investigates how a team of teachers codesigned their own learning within an existing statewide professional learning intervention. Drawing on expansive learning theories to understand how systems might tap the expertise of teachers, this participatory design research study examines how the engagement of early childhood teachers in a codesign process impacts their agency as designers of professional learning, and as a result, their potential as contributors to transforming the workforce.

Research Questions

1. How can ECE teachers codesign professional learning about math, what are the factors that lead to its creation, and foster transformative agency?
2. How does positioning teachers as designers of professional learning in a codesign process shape their professional learning, knowledge, and identities?
3. How did the facilitation seek to foster design team interactions and shape processes of partnering?

Next, to frame this research I will discuss the literature on professional learning as it relates to early childhood education. Then, I take up expansive learning theory (Engeström, 1987) to understand the learning that occurs in the design space and pull that together to explain the Participatory Design Research (Bang & Vossoughi, 2016) methods I use to investigate this phenomenon.

Literature Review: Professional Learning Landscape and Creation

Professional learning is important to ECE, and at the state level, policymakers influence who creates and develops it. I argue that teachers should be positioned as creators of professional learning, but to do that we must understand the early childhood professional learning context and the role policymakers play in it. To that end, this literature review examines the professional learning landscape to understand current conditions in the field. Positioning teachers as designers of professional learning is a shift from typical development. I examine literature that suggests the importance of this shift for policymaking. First, I define professional learning situated in the research about what constitutes effective professional learning and how teachers engage with it. I also focus briefly on professional learning as it relates to math learning in the early years. Professional development (PD) and professional learning are distinct, but the literature reviewed uses both. I will use PD when a piece referred to it as PD and not professional learning. In general, professional development is short term or one-time training opportunities, while professional learning encompasses ongoing learning experiences such as year-long in-service trainings or professional learning communities (O'Brien & Jones, 2014). Cabusao, Fleischer, & Polson (2019) define professional learning as a "collaborative venture in which teachers are recognized as learners, leaders, and knowledgeable professionals" (p.1). Thus, this study is situated in professional learning, which seeks to move beyond traditional PD.

Why Professional Learning is Important

The literature demonstrates a need for well-qualified and trained ECE teachers. The *Transforming the Workforce for Children Birth-8* report (IOM and NRC, 2015) emphasizes the need for a well-qualified workforce to create high-quality early learning environments, which produce the best outcomes for children. As a result, policies were developed to stress teacher preparation and professional learning, with teachers being central to creating high-quality early learning experiences (IOM & NRC, 2015; Ullrich, Hamm, & Herzfeldt-Kamoath, 2016; Palmer, 2018). Additionally, neuroscience research has informed the field of the strong connection between children's early years and future development, thus indicating a need for well trained and qualified ECE teachers. As a result, emphasis is placed on having children ready for kindergarten which has led to increased funding for early childhood education (IOM & NRC, 2015). Well-trained and qualified teachers are essential to early investments to decrease opportunity gaps, especially for low-income children of color (IOM & NRC, 2015).

Professional Learning Policy Approaches

The *Transforming the Workforce for Children Birth-8* report (IOM and NRC, 2015) found that, "Although children are ready and eager to learn, many early childhood educators are not prepared to engage children in rich subject-matter experiences that lay the groundwork for success later in school and in the workplace" (Brenneman et al, 2009b; Clements and Sarama, 2009; NRC, 2001b, 2007; Sarama and Clements, 2009, as cited in IOM and NRC, 2015, p. 241). Policy and instructional improvement challenges exist due to teachers' lack of knowledge and preparation, highlighting a need for access to high quality professional learning that focuses on increasing teacher knowledge, aligning with learning trajectories, and supporting overall instructional practices (IOM and NRC, 2015). Other challenges include access and affordability

in professional learning. Buyesse, Winton, & Rous (2009) argue that professional learning is the most effective approach to preparing practitioners and improving their instructional and intervention practices after they enter and continue in the workforce. Yet, this training comes at a financial cost to ECE teachers who are typically underpaid in comparison to K-12 teachers (Barnett, 2003; McLean, Whitebook & Roh, 2019; IOM and NRC, 2015). High-quality professional learning is essential, and its equity and affordability should be as well.

Early care and childhood education policy is rooted in a history of creating and implementing professional learning from deficit perspectives. Christopher P. Brown (2019) argues that our field tends to base much of its own policy on addressing the seeming deficits in specific populations, primarily low-income children, and families of color, as opposed to the unjust systems that perpetuate inequalities. For instance, policies often build from the notion that investing in early childhood targeted at low-income children of color is a financial benefit to society because it prevents future costs of incarceration and public assistance (Reynolds, Temple, Ou, Arteaga, & White, 2011). While that policy approach has been effective in increasing funding and attention to the field, it is driven by a deficit perspective, depicting Black and Brown children as future adults who will be incarcerated or in need of public assistance. Although well-intended and resulting in funding for early childhood, the focus on remediating deficits has increased negative beliefs of marginalized communities in this country. These deficit-based policy decisions extend to teachers as well. Brown (2019) argues, "Moreover, those involved in children's lives, be it their families or the early educators who work with them on a daily basis are often framed as lacking" (p.1). Policy targets on qualifications position teachers as lacking the required knowledge and training needed to reach policy goals. Further,

assurances for teacher well-being, such as pay parity for having the same degree as K-12 teachers, did not infuse policy goals. For example, a plan for increasing teacher pay did not accompany the Head Start requirement to have 50% of teachers have a BA degree. Birkland's (2001) point, that policymaking is heavily value-laden, begs the question as to whose values are being served in the realm of professional learning.

Positioning teachers as designers of professional learning requires a shift in perspective about teachers. This research seeks to counter these deficit perspectives through the philosophy of abundance (Dudley-Marling, 2019) which, "…presumes an optimistic explanation for human thinking, learning, and ability. This abundance perspective assumes each person regardless of age, gender, economic circumstance, or geographic location, is constantly in the process of constructing meanings based on her or his own life experiences" (Miller, 1993 as cited in Dudley-Marling, 2019, p. 59). A philosophy of abundance in policymaking would require shifting policy goals from remediating problems to acknowledging and building on strengths. In the case of teacher qualifications, credentialing programs could shift to accepting CEU's teachers have obtained over the years from trainings and conferences, as credits towards their degrees. In terms of professional learning, a philosophy of abundance would position teachers as experienced knowledge holders, acknowledging and valuing their learned experiences and resourceful tool bags. Overall, it would mean pointing at policy as the problem, not people. Ibram X. Kendi reminds us that "This is the consistent function of racist ideas-and of any kind of bigotry more broadly: To manipulate us into seeing people as the problem, instead of the policies that ensnare them" (Kendi, 2019, p. 8).

As efforts to professionalize the field are gaining attention, I argue that ECE teachers need an active role in curriculum development amongst the many efforts in higher education, state Quality Rating and Improvement Systems (QRIS), and organizations such as the National Association for the Education of Young Children (NAEYC). Policymakers face a difficult challenge in developing professional learning policy to meet the needs of the ECE workforce because there is wide variation in how ECE teachers become qualified to teach and the impact that low compensation has on the field (IOM and NRC, 2015). In addition, the ECE field's complexities differ from K-12 in respect to settings, education levels, professional experiences, race, ethnicity, and language (Buyesse, et al., 2009; Ryan & Ackerman, 2004; IOM and NRC, 2015; Whitebook, McLean, Austin, & Edwards, 2018, Whitebook, 2014). The experience of teachers in the ECE workforce shaped, in part, by policy context and political influence. Professional learning efforts are more successful when the characteristics and organizational contexts of both providers and learners are considered (Buyesse, et al., 2009). Many pieces make up the puzzle of what is required to transform the workforce; for the purposes of this study, I will highlight the variation in types of programs, qualifications, and compensation.

Variation in Types of Programs and Settings

The variety in settings and programs in which the workforce serves creates the need for an array of teaching strategies since requirements for and approaches to working with infants, toddlers and preschoolers are all specific to age. Also, the professional development needs of family childcare (FCC) providers can differ from a center-based teacher. FCC providers who are small business owners are, typically working alone without an assistant teacher, and can serve up to twelve children ranging from infants to elementary aged children. In contrast, licensed

preschool centers typically have twenty children enrolled with a lead and assistant teacher for a 1:10 teacher to child ratio, may be independent privately owned, in a community-based organization, or in a school district. For those who develop professional learning opportunities, it is important to understand child development and to tailor opportunities to meet the needs of recipients (IOM and NRC, 2015; Whitebook et al., 2018).

One aspect of the variation is the setting or types of programs the workforce serves in. Variety in settings and program types creates the need for variation in teaching strategies because those employed for infants can differ from those used with toddlers and differ from those needed for preschoolers. Also, the professional development needs of family childcare (FCC) providers can differ from a center-based teacher. FCC owners can serve up to twelve children ranging from infants to elementary aged children. FCC providers are small business owners who are typically by themselves without an assistant teacher. In contrast, licensed preschool centers typically have twenty children enrolled with a lead and assistant teacher for a 1:10 teacher to child ratio, may be independent privately owned, in a community-based organization, or in a school district. For those who develop professional learning opportunities it is important to understand child development and emphasize how important it is to tailor opportunities to the context the recipients are from (IOM and NRC, 2015; Whitebook et al., 2018).

Professional Development Needs Vary because of the Variation in Qualifications & Compensation

Professional development cannot presume a similar starting point for ECE teachers who reflect a broad range of qualifications (IOM and NRC, 2015; Whitebook et al., 2018). To illustrate, the minimum qualifications to be an ECE teacher range from 18 years old with high

school diploma/GED to owning a family childcare home, from having a BA degree to being a lead teacher. For the state-funded preschool workforce, 28 states require a BA degree, 25 states require a BA plus certification, and four states require a BA and have parity in pay with public school teachers (Friedman-Krauss, Barnett, Garver, Hodges, Weisenfeld, & DiCrecchio, 2018). Alternatively, Head Start requires that all lead teachers have BA degrees (Head Start Act, Section 648A(a)(3)(B), 2007). These variations in qualifications make professional learning critical to appropriately training the workforce. A report from the National Conference of State Legislators (2018) emphasized: "Preparation and training for ECE workers comes in many forms and often those participating are already working in the field. Policymakers looking to build a well-qualified ECE workforce must therefore support the training and educational advancement of both current and future workers" (Palmer, 2018, p. 5). This reminds us that professional learning opportunities are critical for practicing teachers that might advance their degrees and participate in continuous improvement.

The early childhood training system is complex and confusing to navigate for several reasons. One, teachers can enter the field at a variety of starting points which has created a landscape with many different professional learning providers (Power to the Profession, 2020). This wide variety of providers is another reason the system is complex, with professional learning opportunities available in higher education, of course, but also from independent consultants, national, state, and university-based organizations that develop and deliver professional learning, for-profit companies, or built into systems such Head Start or Child Care Training & Technical Assistance (Power to the Profession, 2020; Whitebook, 2014). Further, other early childhood approaches, such as Montessori, offer a different credentialing pathway

such as training through the American Montessori Society. Across the nation, policy making bodies are responding to this need by developing standards including QRIS that define standards for qualifications (Zaslow & Tout, 2014) and NAEYC which recently revised their professional preparation standards (NAEYC, 2020). Also, professional learning options vary from ongoing offerings such as coaching or communities of practice to one-time trainings or conferences (Power to the Profession, 2020). Teachers need clear pathways to navigate such a varied, complex system. To that end, some states have set up workforce registries, where state systems impose annual requirements, mandating trainings for teachers to work through various pathways while states can monitor, track, and collect data (Power to the Profession, 2020; Whitebook, 2014).

The establishment of required professional learning opportunities illuminates the racial wage gap and low pay overall for ECE workers, as trainings - neither accessible nor affordable - create further inequality. Learning opportunities such as conferences and trainings typically come as a cost to a field that is underpaid when professional learning pathways should be affordable (Hamre, Partee, & Mulcahy, 2017; Schachter, Gerde, & Hatton-Bowers, 2019). According to Bureau of Labor Statistics (2019) the median pay for preschool teachers in 2019 was $30,520 compared to $59,420 for kindergarten and elementary school teachers. Additionally, approximately 50% of ECE teachers rely on some form of public assistance (McLean, et al., 2019). Further, racism is embedded in pay discrepancies, with African American teachers earning less than their colleagues. The Center for American Progress found that on average, African American female teachers working full time make 84 cents for every $1 earned by their white counterparts which leads to a 16% wage gap (Ullrich & Herzfeldt-Kamprath,

2016). Additionally, lead teachers are most often the recipients of training (Snyder, Hemmeter, Meeker, Kinder, Pasia, & McLaughlin, 2012) leaving assistant teachers without access to professional learning opportunities or receiving it secondhand from their fellow staff member. This approach to professional learning can not only leave assistant teachers (who are often teachers of color) behind, but stifle opportunities to grow into generally higher-paid lead teacher roles (Head Start Program Information Report, 2016).

The ECE workforce is predominately female and is more racially and linguistically diverse than the K-12 teaching population. In K-12, 20% of the workforce are people of color, while in ECE it is 40% of and 27% speak a language other than English (Whitebook et al., 2018). With most trainings delivered in English, a sizable portion of the workforce gets left behind, offered content that is inaccessible (Mayfield & Cho, 2019). State QRIS systems have prioritized translating English materials into other languages such as Spanish. Another approach to making professional learning multicultural would be to deliver content at conferences or trainings in different languages, or led by trainers who speak languages other than English. The implication is the need for more linguistically diverse designers of professional learning.

Although the intent of these policies was not racialized to create inequities, disparities in pay, position, access, and affordability of professional learning opportunities have undoubtedly led to racialized outcomes (Kendi, 2019). With such discrepancy between teacher training and preparation, it is difficult for ECE teachers to navigate the current terrain. Professional learning developers must respond to a wide range of racial and linguistic diversity, education, and experience levels to offer adequate opportunities that are affordable, accessible, high-quality, and scaffolded to meet a variety of needs.

Early Math and Professional Learning

In addition to professional learning being important to child outcomes, math is especially important because there is opportunity to develop children's math abilities early on and children need positive early learning math experiences (Johnston & Bull, 2021 & Clements & Sarama, 2018). For example, math learning in the early years is a critical period for fostering mathematical thinking and approaches to problem solving (Clements & Sarama, 2018). Chen, Hynes-Berry, Abel, Sims, & Ginet (2017) in their study about mathematical thinking from birth found that infants have innate math abilities and if untapped could be lost. Yet, as Aguirre, Herbal-Eisenmann, Celedon-Pattichis, Wilkerson, Stephan, Page, & Clements (2017) stated it, "There is a long standing, thoroughly documented, and seemingly intractable problem in mathematics education: inequity (p. 125). In the early childhood space, Ribner, Ahmed, Miller-Cotto, and Ellis (2023) explain the rank-order stability in children's math skills that indicates children who enter kindergarten with lower math scores than their peers are unlikely to catch up to peers with higher skills because those disparities persist. Access to high-quality early math experiences can lessen the opportunity gap for BIPIC children and provide more access to careers in technology (Lavigne, Lewis-Presser, & Rosenfeld 2019; Aguirre et al., 2017) Several pieces of literature speak to professional learning as an effective approach for enhancing educator's competence and confidence in their own math abilities and their instruction to young children (Hunting, Mousley, & Perry, 2012; Franzen, 2014; Perry & MacDonald, 2015). Johnston and Bull (2021) explored educators' perspectives on early learning math through a survey and found that although educators found math relevant at this age it did not manifest in educators' descriptions of their teaching practice and suggest practitioner led research projects as an effective form of professional learning to support educators' comfort and confidence.

Professional Learning Creation & Development

The professional learning literature base in early childhood is well-established covering lessons learned from interventions in a variety of content areas and contexts about teacher learning. For instance, in their ECE PD literature review, Snyder et al. (2012) reviewed 256 studies to learn about PD in ECE. To narrow my search, and since the purpose of this study is to examine how teachers can design professional learning, I have homed in on professional learning literature that can inform design processes. To that end, this section will review literature on the characteristics of effective professional learning, who creates said professional learning, and the role of the teachers in it.

What is Effective Professional Learning?

To engage in designing new learning opportunities, it is prudent to understand the characteristics the literature considers to be effective professional learning. Given variations in the ECE workforce, it is important to offer a comprehensive definition of professional learning. In 2009, Buyesse, Winton, & Rous authored an article seeking consensus on a definition of PD in early childhood. They argued that a common vision and definition could provide guidance and clarity on professional learning, and increase the quality of the workforce. A definition could also aid in policy development, such as when state QRIS systems establish professional development plans. The following definition was the result: “Professional development is facilitated teaching and learning experiences that are transactional and designed to support the acquisition of professional knowledge, skills, and dispositions as well as the application of this knowledge in practice” (Buyesse, et al. 2009, p. 239). The definition also includes the components of the conceptual framework the who, what, and how. The “who” includes the characteristics of those receiving professional learning. “What” is the composition of the

knowledge and competencies in professional learning and the "how" is the way the PD is delivered. These components can be used to develop, implement, and evaluate professional learning (Buyesse, et al. 2009). The definition and conceptual framework are included for the sake of discussing and digging into what "quality" PD means from the literature, and to shape and inform outcomes impacted by this study.

Substantial literature exists to address the effectiveness of professional learning. I am including primarily early childhood literature on effective PD and some seminal pieces from K-12 literature. Ongoing professional learning that is sustained over time is more effective than one-time training days (Darling-Hammond, Hyler, Gardner & Espinoza, 2017; Yoon, Duncan, Lee, Scarloss, & Shapley, 2007; Buyesse et al citing Hill, 2007; Winton & McCollum, 2008). The development of professional learning should incorporate "evidence-based" practices (NAEYC & NACCRA Training and Technical Assistance Glossary, 2011), and is aligned with existing standards and curricula practitioners already in use (Buyesse et al citing Hill, 2007; Winton & McCollum, 2008; Sun et al, 2013, citing D. Cohen, Raudenbush, & Ball, 2003; Correnti, 2007). The content developed addresses the continuum of children's abilities and needs (NAEYC & NACCRA Training and Technical Assistance Glossary, 2011; Borko, 2004), and is most beneficial when it is focused on specific content such as math or literacy (Darling-Hammond et al., 2017; Buyesse et al citing Hill, 2007; Winton & McCollum, 2008). Explicit links between research, theory, and practice lead to more grounded and relevant professional learning (NAEYC & NACCRA, 2011). This finding suggests that it will be important for professional learning developers to incorporate the connections between research, theory, and practice in their products. Delivery of professional learning is effective when using approaches from adult

learning theory and engaging learners actively through relevant and meaningful activities such as using models and examples of practices. (Darling-Hammond et al., 2017; NAEYC & NACCRA, 2011; Sun et al, 2013 citing Desimone, Porter, Garet, Yoon, & Birman, 2002). Best practices also include follow-up to continue the learning and make it sustainable in the form of coaching, consultation, communities of practice, collaboration in job-embedded contexts, peer support and relationships (Snyder et al, 2012, Darling-Hammond et al., 2017; Buyesse et al citing Hill, 2007; Whitehurst, 2002; Winton & McCollum, 2008; Whitebook, 2014). Further, I argue that there is more investment and engagement in professional learning when the topics are of interest to the teachers being trained. Snyder et al., (2012) argue that from research we need to know more about the active ingredients, which aspects of professional learning make information meaningful and successful in terms of supporting teacher learning.

Findings on what constitutes effective professional learning can inform future professional development by providing guidance on how and what to develop. To that end, how teachers learn from professional learning is also important to consider. Like the ECE workforce, learning comes in a variety of forms, and multiple forms can exist at once (National Academies of Sciences, Engineering, and Medicine, 2018). Sociocultural learning theory acknowledges the social nature of learning and situates learning in social interactions (Vygotsky, 1978). Since evidence shows teachers value and prioritize peer learning and collaboration, as well as the job-embedded activities of planning and reflecting on instruction in groups, sociocultural learning theory can be applied. For use in this study, I created emerging design principles from this literature to guide the design. The list of literature-based emerging design principles is available in the appendix.

Who Creates Professional Learning?

This section covers the creators of PD and reviews the limited instances in the literature where teachers have a role in PD creation. In the "who" part of the definition mentioned above, it includes those that receive professional learning and a minor mention about those who provide it. The definition encourages developers to consider and remember that individuals vary regarding their qualifications, experiences, race, culture, and ethnicity. Also, professional learning efforts should consider the characteristics and organizational contexts of both providers and learners (Buyesse, et al., 2009). As described in the earlier section, the ECE workforce serves in a variety of contexts, each with its own nuances. Thus, sociocultural aspects of providers and learners are pertinent and should be a part of the development of professional learning. In literature, however, what we learn about developers relates to their level of degree and professional experiences (Buyesse, et al., 2009). Further, in the Early Childhood Education Professional Development: Training and Technical Assistance Glossary (NAEYC & NACCRRA, 2011) their definition of who provides early childhood professional learning is,

> **"**The job titles of the individuals who provide PD are many and varied—higher education faculty, trainers, program administrators in their training and TA roles, individual consultants, child care resource and referral training and TA staff, and others. These professionals provide education, training, and/or TA to individuals working or preparing to work with young children and their families and those working or preparing to work on behalf of children in training, licensing, resource, and other administrative roles related to early childhood education" (NAEYC & NACCRA 2011, p. 4).

Notably, teachers themselves are not a part of this definition, the most obvious reason being that they are the recipients. According to Buyesse, et al., (2009) PD providers, "…organize and facilitate learning experiences that respond directly to problems of practice, primarily by promoting practices that are evidence based and recommended by the early childhood field"

(p.238). Further, Power to the Profession (2020) also calls for government bodies to be "heavily influenced by the recommendations from the profession" (p. 26). In other words, the field acknowledges and even pushes for policy decision-makers to listen and act on recommendations from the profession. Practicing teachers, up close providers of service delivery and holders of knowledge, would certainly have problems of practice to address. Further, according to the applied definition of professional learning, we understand that experiences and organizational context of providers, or sociocultural aspects of learning, offer important grounding. The glossary does have a definition of peer-to-peer TA which holds that, "…a significant expert knowledge base exists in the field and that peers who have solved challenges on the ground have developed tools and strategies that can be shared with their colleagues" (NAEYC & NACCRA, 2011. p. 14). This definition acknowledges the knowledge base and expertise of teachers and values the learning that can occur when peers support each other.

States also play a significant role in professional learning in early childhood by establishing policies, required training, and priorities and workforce registries (Mayfield & Cho, 2019; Hamre, Partee, & Mulcahy, 2017). In some cases, states contract with organizations to develop professional learning. For example, Washington State contracts with five different organizations to develop and deliver professional learning. In addition, providers in various capacities offer trainings to meet annual requirements, including independent consultants, for-profit national providers, and publishers of curricula such as Creative Curriculum training (Whitebook, 2014; Power to the Profession 2020). Data from K-12 found that most of the spending to develop PD were internal investments by school districts and that there is

approximately $18 billion spent annually on professional learning (Whitebook, 2014). Since few empirical studies investigate the creators of PD, most of this information was gathered from professional organizations. In general, PD is created and delivered by publishers, PD organizations, higher education faculty, program/district administrators, or other qualified trainers. Next, I will explore teachers' role in creating professional learning. To clarify, I am investigating the literature on teacher-designed professional learning for other teachers in the form of, for example teacher trainings delivered on in-service days or professional learning conferences. This review does not include the plethora of design-based research studies of teachers and researchers designing learning solutions such as curriculum design or instructional solutions for students.

Teachers' Role in Creating Professional Learning Opportunities

In their article about collaborative professional development, Helterbran, and Fennimore (2004) emphasize that "…professional development opportunities can only be successful if they are perceived as a venue to be crafted *for* and *with* teachers, rather than something to be done *to* them" (p. 267). Limited research examples exist of ECE teachers creating professional learning; instead, the learning is created *for* teachers to grow, increase knowledge, and advance in their careers, all in the name of continuous quality improvement. However, the research presented here explores roles teachers have in PD creation that are beyond the role of reviewer and feedback provider. Although Baker's (2018) qualitative study to understand two Kindergarten teachers' experiences with a PD intervention centered the teachers, they weren't the ones creating PD. Baker (2018) argues that the focus on fidelity of PD implementation undervalues teachers' experiences and sought to center learning from

teachers' experiences in their ability to implement PD with fidelity. The Instructional Leadership Corps, a statewide effort in California where expert K-12 teachers are trained to lead ongoing PD within their own districts (Lotan, Burns, & Darling-Hammond, 2019), supports teachers to deliver PD that supports national standards. Teacher experts deliver workshops, in which lesson plans are developed, student work is reviewed, and reflections on teaching practice take place. In this instance, teachers are positioned as experts to implement PD and engage in a small degree in developing it.

A few approaches to professional learning engage teachers as designers. In networked improvement communities (NIC) (Bryk, Gomez, Grunow, & LeMahieu, 2015) teachers are taking an active role in their professional learning by collectively investigating problems of practice. NIC's engage teachers in iterative Plan-Do-Study-Act cycles to prepare, test, and learn from the problems of practice they address together. Teacher learning and improving practice are centered as teachers engage quick learning to improve cycles (Bryk, 2015). The authors posit that improvement can be addressed more effectively if an infrastructure and intentional ongoing support for teachers to connect and learn together exists (Russell, Bryk, Dolle, Gomez, LeMahieu, & Grunow, 2017). In this example, teachers have a dual role as designer and decision maker about professional learning. Van den Akker and Nieveen (2021) discuss the role of teachers in curriculum design and call for the use of Teacher Design Teams, groups of teachers within the same school who collaborate through an iterative design process to make improvements to their existing curriculum. For example, in the collaborative design study conducted by Voogt, Laferrière, Breuleux, Itow, Hickey, & Mckenney (2014), three different examples illustrate the active involvement of teachers in the creation and implementation of

curriculum. This, in turn, facilitated their own professional learning, as teachers took a cyclical approach to design and experienced collaborative agency.

Equity Opportunities in ECE Codesign

When considering research approaches to studying professional learning, Fishman, Konstantopoulos, Kubitskey, Vath, Park, Johnson, & Edelson (2014) argue that "the future of professional development will be designed, not discovered" (p. 261). They argue that there is value in both qualitative and quantitative approaches to research on professional learning, and design approaches better position teachers to have an active role in professional development research through design, not simply as participants providing feedback or review. Although the codesign studies on professional learning in ECE are limited there are codesign studies that provide insight on how to address equity issues in ECE. For example, Gutiérrez, Higgs, Lizárraga, & Rivero (2019) conducted a social design-based study that focused on imaginative play of a group of young Latinx fifth graders. Although fifth grade is not considered early childhood, imaginative play is a concept that is particularly important in ECE. One of Gutiérrez et al., (2019). findings were that by approaching codesign through accessing and documenting children's imaginative play, the children's roles were remediated as constructors of complex imaginary situations and problem solvers. This finding speaks to equity not only because it centers a nondominant population but also because it reveals potential for creative problem solving when children are positioned as designers. Harper, Caudle, Flowers, Rainwater, & Quinn's (2023) study increased equity of voice when they conducted a design study on computational thinking in ECE and their approach centered on surfacing the culturally relevant computational thinking practices of families and teachers. The families and teachers influenced culturally responsive theories about computational learning. Finally, as Gutiérrez & Vossoughi

(2010) argue, it is important to design for equity through the methods and processes utilized in design-based research and attending to issues of power, agency, identity, and institutional barriers.

This literature review provides an explanation of the role that professional learning has in workforce development, why professional learning is important in general in early learning math, who creates professional learning and the opportunities for teachers to be considered in that process. From these studies, teachers are either in the role of experts who deliver PD or are recipients of PD where researchers observe and learn from their experiences. All but one (Baker, 2017) of the studies that discuss teachers' roles in PD focuses on K-12 teachers, which amplifies the need for ECE research and opportunities in early childhood to explore how teachers can design professional learning. Using PDR, this study explores the efforts of a design team of early childhood educators to create early childhood math professional learning within an existing intervention. Next, I will explore the theories informing my conceptual framework.

Chapter 2: Framework and Methods

Conceptual Framework

Design-based research studies necessitate the use of conceptual lenses that examine and seek to understand the learning and design processes that occur in design spaces. Design studies widely use cultural historical activity theories (CHAT) for these examinations because they acknowledge the sociocultural aspects of learning within a defined space referred to as activity systems (Engeström, 2001). Within activity systems there are principles and processes by which we can understand the activities occurring in the design space. Next, I will identify and explain the CHAT theory, principles, and processes I utilize in this study – expansive learning theory (Engeström, 1987; 2001) and participatory design research (Bang & Vossoughi, 2016).

The Role of the Activity System

In any given activity system, the components - division of labor, community, rules, subject, and mediating artifacts leading to the development of the object are inherently present (Engeström, 2011). In my study, the object is an expanded form of early childhood math professional learning designed to meet the outcome, as indicated by the literature, of professional learning for teachers which in turn, supports children's learning and development. In addition, the study specific outcomes were 1) cultivated transformative agency as designers. 2) collective professional identity, and 3) object evolved into codesigning professional learning with peers virtually (the triangle depicted below in figure one.

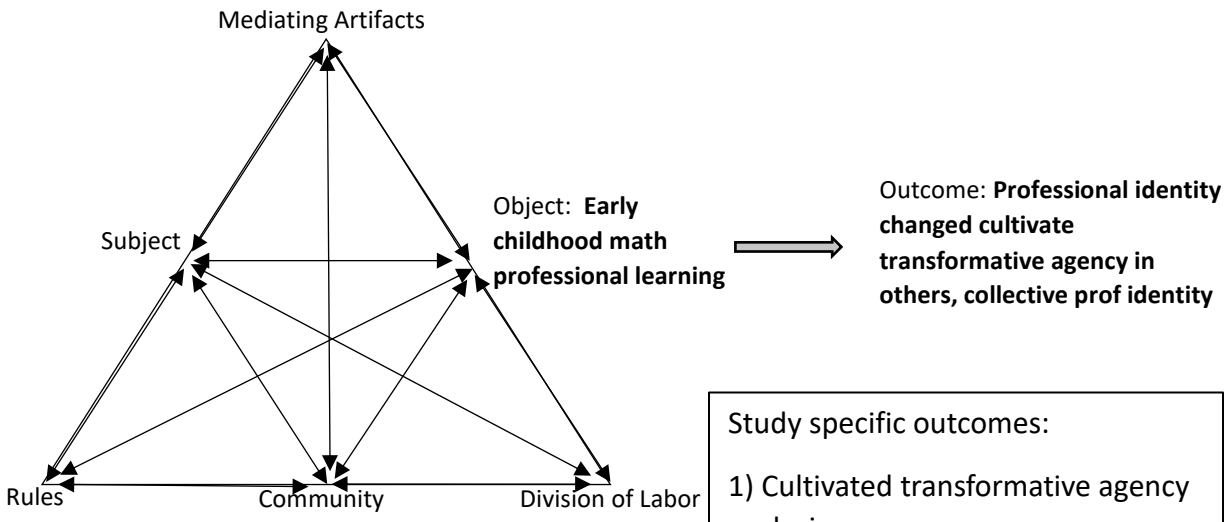


Figure 1 Activity system adapted from Engeström, 2011.

In my study, community, division of labor, and mediating artifacts played a heavier role in the design space because of the activities we engaged in. For example, the Google docs were mediating artifacts that we worked on together. Team members took on various tasks during the development creating a division of labor. The design team itself became a community as we worked towards the object. These components are mentioned in my findings and discussion because they have a role in the activity system. However, the components are not included in my conceptual framing because I am not using them to analyze my findings. The object is negotiated through an iterative cycle that occurs within the activity system. I am utilizing expansive learning theory actions as the iterative cycle and PDR principles to address my research questions.

Expansive Learning Theory

This study draws on expansive learning theory (Engeström, 1987; 2001) which is the notion that new knowledge can generate and expand through an activity system of individuals working together in a collective space to create new knowledge or develop different notions of an object (Engeström, 2001). Within this activity system participants engage in a series of learning actions that comprise an expansive learning cycle (Engeström & Sannino, 2010). The learning actions of the expansive learning cycle are conceptual framing as well. Engeström & Sannino (2010) explain the conceptual framing as a "…heuristic conceptual device derived from the logic of ascending from the abstract to the concrete. Every time one examines or facilitates a potentially expansive learning process with the help of the model, one tests, criticizes, and hopefully enriches the theoretical ideas of the model" (p. 7). The expansive learning cycle organizes learning process with a cycle of six actions questioning, analyzing, modeling, examining the model, implementing, reflecting, and consolidation. This is the process the design team used to design the object (Engeström & Sannino, 2010). Pictured below is the iterative process of learning actions in expansive learning theory.

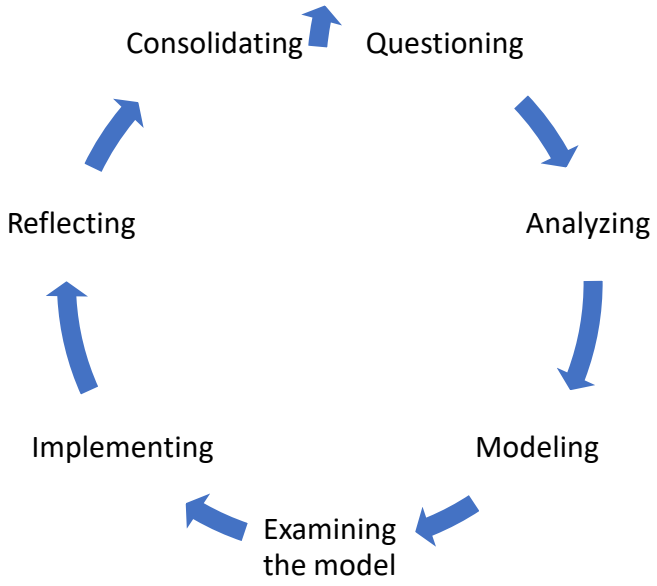


Figure 2 Expansive Learning Cycle adapted from Engeström & Sannino, 2010

Questioning involves inquiring, discussing, and raising questions about existing accepted practices and wisdom. Analyzing includes gathering information, resources, and data about the issues raised and analyzing artifacts, history, data, or other empirical knowledge to understand it further. Modeling is developing a model in an applicable form that addresses the problem under investigation. Examining the model is testing and refining it prior to implementation. Implementation is putting the model to use and includes observing to see how the model is used. Reflecting includes analysis of the observations and discusses lessons learned from implementation. Consolidation brings the process together, makes revisions, and finalizes the tool or product (Engeström & Sannino, 2010).

Participatory Design Research Principles

In addition to the learning actions in expansive learning theory, activity systems are sociocultural learning spaces that are full of activities and interactions that inform the space. Participatory Design Research (PDR) as described by Bang & Vossoughi (2016) has several

principles that can be used to examine the sociocultural aspects of learning. For this study I focused on multivoicedness, critical historicity, agency, role remediation, relationality, multivoicedness, and epistemic heterogeneity. Bang & Vossough (2016) explain, "PDR attends to the ways in which critical historicity, power, and relational dynamics shape processes of partnering and the possible forms of learning that emerge in and through them (p. 174). Using these principles helped me understand the factors that influenced the subject-object relations. Bang & Vossoughi (2016) prioritize critical historicity as a lens to attend to representation and prioritize the experiences and histories design team members bring to this process. In this study, historicity allowed me to acknowledge that each teacher entered the activity system with their accumulated knowledge and experiences that influence their professional identities and perspectives about their own teaching and professional learning. Regarding relationality and agency Bang & Vossoughi (2016) suggest, "…PDR may be a productive methodological and theoretical tool in this endeavor because it can afford the deliberate cultivation and focus on the co-constitution of transformative agency and expansive forms of relational agency as an explicit object of analysis" (p. 184).

Relationality played a prime role in this study to provide a lens to examine subject-subject relations between design team members and my role facilitating those dynamics. Relationality is facilitated in and through the ways we engaged in processes of partnering and the activities done during design team meetings. I also focused on agency as an aspect of power because participants in an activity system held different positions with varying degrees of power, options, authority, and positionality. In this study agency and role remediation helped me examine the degree to which teachers felt empowered to add professional learning

designers to their roles and identities and to discover the potential for transformative agency. Role remediation allowed me to attend to moments when there were shifts in subject-subject relations and how those shifts were influenced by collaborative processes. Multivoicedness acknowledges that there are multiple actors and voices interacting and contributing to the system (Engeström, 2001; Bang & Vossoughi, 2016). In my study multivoicedness referred to the contributions teachers on the design team made and I drew on this concept to track their contributions and how their ideas develop. Finally, Bang & Vossoughi (2016) argue for a design space of epistemic heterogeneity where the diversity of knowledge and character is privileged. I drew on the notion of epistemic heterogeneity because there was a variety of representation and ideas within the group that contributed to creating new knowledge.

In this study, I ask research questions about how the expansive learning cycle impacts teachers' agency as professional learning designers. My conceptual framework accounts for both the learning and power dynamics present in the activity system. This aided in understanding the transformation of the object, agency, power, how roles shifted, and positionality. The combination of these learning actions and the principles of multiviocedness, epistemic heterogeneity, agency, role remediation, relationality, and historicity, form my conceptual framework. This combination will allow me to address my specific research questions as illustrated in the table below.

Research Questions	**Theoretical Framing**	
	Expansive Learning Theory	**PDR Principles**
How can ECE teachers codesign professional learning about math, what are the factors that lead to its creation, and foster transformative agency?	Questioning, analyzing, modeling, examining the model, implementing, reflecting, and consolidating.	Historicity Multivoicedness Epistemic heterogeneity Agency

		Relationality
How does positioning teachers as designers of professional learning in a codesign process shape their professional learning, knowledge, and identities?	Questioning, analyzing, modeling, & examining the model, implementing, reflecting	Historicity Multivoicedness Epistemic heterogeneity Agency Role remediation Relationality
How did the facilitation seek to foster design team interactions and shape processes of partnering?	Questioning, analyzing, modeling, examining the model, implementing, reflecting, and consolidating.	Agency Relationality

Table 1 Research Questions aligned to Theory

Methods: Participatory Design Research

Participatory Design Research (Bang & Vossoughi, 2016) is an appropriate method to understand the factors that shape the object. Like design-based research (DBR) studies, PDR methodologies address problems of practice and interventions are designed by researchers and practitioners together as a design team working within an activity system (Collins, Joseph, & Bielaczyc, 2004; Reinking, 2021). The effort to address this problem of practice is an iterative and collaborative codesign process with the design team and produces recommendations for practice (Reinking, 2021). Consequentially, the development of learning theory on both the individual and organizational levels is a focus (Bang & Vossoughi, 2016; Reinking, 2021). PDR adds a focus on including the expertise of families and communities particularly from nondominant groups (Ishimaru, Lott, Torres & O'Reilly-Diaz, 2019). Also, in addition to the principles I employed from my conceptual framing, PDR attends to racial and cultural power dynamics and seeks to shift those through social transformation (Bang & Vossoughi, 2016). As you will see, my study did not center on nondominant communities. However, I did apply PDR principles to understand the role facilitation played in fostering agency and impacted power

dynamics. Furthermore, I sought to understand the experiences of the design team as they developed the objects. Specifically, what did they see as the problem, and how did they make sense of it? What solutions did they develop and why? How does what they learned as a part of the process expand what we know about teacher-designed professional learning? How are the teachers on the design team empowered as creators and designers of professional learning for their peers? How were the tools implemented? What learning happened for the design team members? To set the stage, I will begin by explaining the study context and who participated. Then, I will explain the methodological approaches to the study.

Study Context and Participants

My study is a part of the STEAM Trunk Math Pilot Study which was an online professional learning intervention in early childhood math. The STEAM Trunk Math Study engaged teachers in a free professional development intervention that required participants to watch content about early childhood math which was delivered through a professional development talk show called Circle Time Magazine (Joseph, 2016) and use math materials from a free box of materials we provided called STEAM Trunks. Participants filmed themselves using the materials with children and uploaded the video to Coaching Companion, a secure video coaching platform. It is through this platform that coaches viewed videos and provided feedback to participants.

The results from this study, raised questions about professional development, math content, and instructional quality which prompted further investigation into the active ingredients that make professional learning meaningful and successful as described by Snyder et al., (2012). For example, what types of content or professional development would result in

higher instructional quality or an increase in math learning opportunities? What content speaks to teachers, and how is that content knowledge taken up? In an effort to take a more grounded approach to the math content, the current study engages teachers who took part in the pilot study in a design process to develop tools to support math instructional quality.

Design Team Participants

All participants were invited to an open call at the end of the pilot study inquiring whether they were interested in helping to design professional learning based on the study results. The recruitment email described the design work, the estimated time commitment, and informed them of the $300 stipend available for participating. All those willing to participate were invited to the design team meetings. No further selection criteria were used to recruit participants. Of the ten responses, the six participants listed below signed the consent forms and participated in meetings and interviews. The recruitment email is available in the appendix. Participants included teachers with under three years of experience to those who have been in the field for more than 20 years. A variety of early childhood programs were represented, including family childcare (FCC) programs, state & federally funded PreK, centers such as Montessori, and a religion-based program. Design team members served infants, toddlers, and primarily preschoolers. Most of the design team identified as white and cis-female. Participants totaled six: one Latinx, and one African American, two were FCC providers, one is a coach, and three are center-based teachers. Although I employ PDR methodology in this study, I do not foreground racial identities and nondominant experiences or communities which is one of the approaches in PDR. As noted, my study participants except for one are not from nondominant backgrounds.

Name	Type of Care	Ages of children served	City
Joyce	Coach	Birth to 5	Kent
Rose	FCC	Toddlers and preschool	University Place
Sara	Center	preschool	Olympia
Mary	Center	preschool	Bellingham
Diana	FCC	preschool	Olympia
Dara	Center	Birth to 5	Pomeroy

Table 2 Participant Demographics

Procedures

Principles from PDR were used to investigate the activity system of a design team of early childhood teachers who went through an expansive learning cycle (Engeström & Sannino, 2010) with the objective to design early childhood math professional learning. The expansive learning cycle was the iterative process used to examine the problem of practice. The learning actions of question, analyze, develop, and examine the model; then to implement, reflect, and consolidate what was learned was the iterative cycle, (Engeström & Sannnino, 2010) but within these actions I want explicate and name how those processes manifested when applied to this study. The procedures are grouped into two sections because the activities in those learning actions were similar.

Questioning, Analyzing, Modeling, and Examining the Model Procedures

The procedures for this group of learning actions involved activities to achieve the following aims.

1. Open the space for expansion through reflective and relational activities.
2. Review data to focus on the problem of practice.
3. Brainstorm ideas then, categorize and sort those ideas.
4. Select an idea to design, design it, and test it.

To open the space for expansion to create new early childhood math professional learning and, given their previous experiences in the study, the design team engaged in reflection activities to process and imagine expanded forms of professional development and meaningful learning experiences. Reflective activities were important for several reasons. One, to create something new, the design team had to conceptualize, expand, or refine their thinking around the current problem of practice. Secondly, reflecting on primary characteristics of their most effective learning experiences helped to avoid recreating the same training. Third, reflecting together in the design space offered a shared activity system as a container for the design team's shared experiences and learning. This reflective process began to create the environment where the principles of multivoicedness and epistemic heterogeneity were present. Also, as mentioned in the literature review section, Snyder, et al. (2012) argue for the active ingredients that lead to meaningful and successful outcomes. This process can help to bring those active ingredients to the forefront.

The questioning action of the expansive learning cycle involves multiple participants identifying problems of practice. To that end, we also engaged in conversation to raise questions about the results of the pilot study by reviewing data from it. Examining the pilot data from the pilot study helps to identify problems - and potentially raise contradictions - of practice particular to this context. Further, one strength of having participants from the previous study is that they provided context-specific reflections. This is also in alignment with how Buyesse et al. (2009) describes the role of PD developers as "organizers and facilitators of learning experiences that respond directly to problems of practice" (Buyesse, et al., p.238).

During the questioning and analyzing actions, the team brainstormed ideas for tools and made sense of the ideas through sorting them into categories. Below is a graphic of the iterative process we went through that allowed us to expand and decide on tools to model. The reflection activities in these actions allowed us to break from typical professional learning experiences and led to fruitful brainstorming. The sense-making process of deciding the categories and sorting the ideas allowed the team to decide and articulate the tool they collectively agreed upon. Then for the next learning actions, they modeled the tool and refined it to examine the model. The modeling process also followed this iterative process because the team brainstormed ideas for initial posts then, articulated and modeled a vision statement and refined it through an editing process. In this way the iterative process became the procedure.

Questioning, Analyzing, and Modeling Iterative Process

Figure 3 Iterative Cycle one

Implementing, Reflecting, and Consolidating Procedures

The procedures for the implementing, reflecting, and consolidating learning actions focused on the following:

1. Reviewing the model
2. Reflecting on the models and design process
3. Consolidating the professional learning

The implementing learning action focused on reviewing and reflecting on the model and took on a slightly different iterative process which is depicted in the graphic below. During those meetings we reviewed and reflected on the model by discussing the posts on the Facebook

page. These reflections yielded more brainstorming and articulation to create the next planned posts on the page. The procedures used for the reflecting and consolidating actions were discussions during team meetings about the design process and reflections from individual interviews.

Implementing Iterative Process

Figure 4 Iterative Cycle 2

Mediating Artifacts and Communication

The mediating artifacts we used are another aspect of the subject-design space relations. In the first meeting explicit attention was paid to Zoom and Google documents functionality establishing them as a component in the design space. In the first meeting, I reviewed Zoom features and gave directions and reminders in the moment of how we could interact including chat and raising your hand. The transparency in using the artifacts drove how we used the tools in later meetings. The transparency meaning, they were available to all of us, and we used them, so it became a part of how we functioned during the meetings, thus becoming a principal component of the design space. The Google documents became mediating artifacts that were jointly negotiated and became central to the subject-design space relations. I also provided an overview of using Google docs and what the experience would be like when we were all contributing to the page. The structure of meeting communications built consistency, which I argue increased the teams comfort and willingness to continue participating. Prior to the meetings, I sent reminders and working agendas. During the

meetings, I shared PowerPoints with agenda items, goals for the meeting, and activities we were doing. After meetings, I sent follow-up emails that had PDFs of the PPT's, our next steps and action items.

Data Collection

Data was collected through video recordings of the design meetings, interviews, and documents. The documents include joint Google documents, PowerPoints used during the meetings, agendas, and follow-up emails and exchanges summarized in the table below.

Type of Data	Number	Notes
Design team meeting videos & audio files	12	20 hours because some meeting went longer than 90 minutes
Zoom meeting chat	8	Meetings 8-12 did not have any chat activity
Interviews	6	Ranged from 45-60 minutes long
Google documents	4	
PowerPoints	7	PPT's were not used during meetings we designed objects
Emails	29	

Table 3 Data Collection Summary Table

Design Team Meeting Videos

Data for the design team meetings was collected through video recorded on Zoom. Each of the 12 meetings lasted approximately 90 minutes. Zoom served as a mediating artifact in this study as participants utilized the features to interact during meetings. Zoom provided video, audio, and chat transcripts of meetings. The following is a description of a design team meeting that serves as an example of data collection during design meetings. The design team reflected on a time when they discovered or learned something new. Next, they described the feelings they had in that moment, where they were, and what that means now. These types of reflections were recorded via the chat feature and on joint Google documents. Once work began on the joint Google documents, I shared my screen thus capturing the action on the

Google document on video. I have a video record of any edits made on the Google document, by whom and when it occurred during the meeting.

Interviews

To better capture participants' experiences and specifically address the research questions that attend to historicity, role remediation, and agency, interviews were conducted with each design team member (n=6) to further understand the contextual histories and unique contributions they brought to the design space. Interviews were conducted and recorded via Zoom and lasted approximately 60 minutes. I created a semi-structured interview protocol (Merriam, 2009) that asks three sets of questions related to the participants backgrounds, design process, and tool creation. The background questions helped to understand their professional training and experiences and provided insight into how those experiences informed the design space. The design process questions shed light on how they personally experienced the design space, allowed for reflection on their own agency and personal growth as professional learning designers. Lastly, the object creation questions helped to understand their sense-making about the tools. See appendix for the protocol. The interview protocol was reviewed by an advisory group in which I participate. The feedback helped me to revise several questions in the background and design process sections that better allowed the participants to narrate their experiences more fully. The review also helped me to clarify the connections between the interview protocol and research questions to ensure there were clear connections and that they were adequately addressed.

Documents

I collected several types of documents as data specifically: joint Google documents, PowerPoints and agendas used during the meetings, chat transcripts, and follow-up emails and

exchanges. Merriam (2009) describes these as researcher-generated documents that serve to learn more about the phenomenon. I argue that in this study the documents are also participant-generated because the design team members informed and contributed directly to the documents. The PowerPoints for each meeting provided structure and served as a record of the activities in which we engaged. After each meeting, I created an agenda for the subsequent one to serve as initial guidance, not prescriptive outcomes. Since it is crucial to the design process that meetings be teacher-led, I anticipated creating the next agenda only after careful reflection and analysis of each meeting. After each meeting, I sent out thorough follow-up, including next steps, resources, and reminders for the next meeting. The follow-up emails and exchanges are a record of needs and interactions throughout the design process. Google documents served as the space where the objects were created, reflections and brainstormed ideas were created. The participants contributed to the documents in real time making the joint Google documents a mediating artifact (Engeström, 2001) because they act as a space of joint interaction and contradiction in the activity system. The joint Google documents act as a rich source of data collection, with video recordings of the activity on the documents illustrating our creation process. The documents helped address the research question about the factors that led to the creation of professional learning and a record of implementation.

Analysis

This analysis section is divided into two parts. The first is a description of how I analyzed videos of the design team meetings. The second part explains analysis of the interviews and documents. Included throughout is a description of how the design team was part of analysis. Below is a data analysis table to provide clarity and expand upon the table presented earlier to

include all the connections between the research questions, conceptual framing, data collection, and analysis.

Data Analysis Table

Research Questions	**Theoretical Framing** Expansive Learning Theory & Principles	**Data Collection**	**Analysis**
How can ECE teachers codesign professional learning about math, what are the factors that lead to its creation, and foster transformative agency?	Questioning, analyzing, modeling, examining the model, implementing, reflecting, and consolidating. Historicity, Multivoicedness Epistemic heterogeneity, agency, relationality	-Videos of design meetings -Interviews -Google docs	Qualitative codebook Video analysis
How does positioning teachers as designers of professional learning in a codesign process shape their professional learning, knowledge, and identities?	Questioning, analyzing, modeling, examining the model, implementing, reflecting, and consolidating. Historicity, agency, role remediation, contradictions, relationality	-Videos of design meetings -Interviews -Google docs	Qualitative codebook Video analysis
How did the facilitation seek to foster design team interactions and shape processes of partnering?	Questioning, analyzing, modeling, examining the model, implementing, reflecting, and consolidating. Multivoicedness Epistemic heterogeneity, relationality	-Videos of design meetings -Interviews -Google docs	Qualitative codebook Video analysis

Table 4 Data Analysis Table

Video Analysis

I examined the video data with video analysis (Derry, Pea, Barron, Engle, Erickson, Goldman, Hall, Koschmann, Lemke, Sherin, & Sherin, 2006; Erickson, 2006) and the constant comparative method of qualitative analysis (Merriam, 2009). The constant comparative method is both inductive and comparative and involves analysis during data collection, coding data,

organizing into categories, and comparing to identify themes (Merriam, 2009). For the video analysis I adhered to the following process as articulated by Derry et al. (2006):

1. Watch videos
2. Content log/memo
3. Identify participants
4. Identify moments to transcribe
5. Make transcripts & memos
6. Memo about research questions
7. Revise research questions
8. Create emergent coding categories
9. Return to conceptual framework
10. Time ordered matrices
11. Revise codes/categories
12. Add subcategories
13. Collapse codes
14. Memo always

Memos

Analytic memos were written after each design team meeting. The memos included analytic, personal, and methodological notes. The memos also served as reflection opportunities for me to plan for the next design meetings because I used some of the analysis to plan agenda items for upcoming meetings. When coding and analyzing the findings, I referenced the memos for in-the-moment analysis to include in the findings (Merriam, 2009).

Content Logs

Content logging was part of the analysis. At the top of each content log, I tracked the length of the meetings, attendance, and major activities. For the content logs I included a table where I tracked the time, content, codes, made claims, and potential findings. When writing my findings, I pulled the major activities from across the meetings into a table which enabled me to generate a roadmap of how the objects developed over time. I reviewed the logs, especially the potential findings section to generate claims. I also wrote claims and evidence while content

logging. When reviewing the content logs, I updated the major activities section. In the potential findings section, I noted areas I wanted to transcribe.

Coding

Once the videos were content logged, I identified moments to transcribe that were evidence of the actions in the expansive learning cycle such as, the process of idea generation and tracked idea outcomes to understand group responses, interactions, and ultimately, the impact on idea expansion. This process aided in the development of a qualitative codebook and aligned well with my conceptual framework specially to understand how epistemic heterogeneity and multivoicedness manifested (Merriam, 2009; Miles, Huberman & Saldana, 2014). I did not transcribe every meeting. I had an initial codebook developed from the literature which included terms, definitions, and examples derived from my conceptual framework, including the learning actions in the expansive learning cycle (questioning, analyzing, modeling, examining the model, implementing, reflecting, and consolidation) and the principles, multivoicedness, agency, role remediation, epistemic heterogeneity, and critical historicity. In addition, the analytic memos and content logs helped me to develop further codes. For example, sharing arose as a powerful theme. Sharing, connection, inclusion were related terms the team used which I coded together. A focus on infant/toddlers arose as well across design meetings which became evident when reviewing the content logs and the major activities section. Infants/toddlers and what they know, how to assess them, and how to teach them came up frequently but was heavily present at the earlier and later meetings.

The learning actions in the expansive learning cycle helped me to better understand the learning taking place by tracking and attending to how the contradictions are negotiated in the

activity system (Jordan & Henderson, 1995). Codes of these actions were evidence of the learning that occurred in the activity system. Each piece of data went through a round of coding where I looked for evidence of the actions in expansive learning cycle. Using qualitative software, I coded and pulled those segments into documents for each action. Next, I returned to analytic memos and wrote some for each of the actions for initial synthesis across data sources. Then, used those memos to write findings organized by the learning actions. I also coded for evidence of the PDR principles by identifying instances of those concepts. For example, to discover historicity I looked for instances of teachers' experiences, backgrounds, lessons learned from previous learning experiences. As the data was reviewed, I went through an open-coding process (Merriam, 2009) and added additional terms to the codebook that enabled me to identify what happened related to my research questions. For example, a code of "practices" allowed me to identify any time a practice is mentioned and whether that practice was currently in use, being refined, being examined, or is new or a refinement of a practice. A code of "agency/positioning" allowed me to identify instances of teacher power or initiative. A description of my codebook is available in the appendix.

Analysis During Data Collection

In addition, analysis occurred while collecting data because the design team reviewed mirror material (Engeström, 2011) and because I wrote analytic memos after each design meeting to capture reflections while fresh (Merriam, 2009). The mirror material the team reviewed included reflections and brainstorming lists from previous meetings which in turn were used to make decisions about object development. I selected initial segments that aligned with actions of the expansive learning cycle for transcription. Also, the examining the model and reflecting stages of the expansive learning cycle were analysis processes that occurred

during codesign where we examined the model and its implementation. During those actions, the Facebook page was examined and analyzed by the design team to determine what their next posts would be and how to encourage engagement.

Interview and Document Analysis

Using the codebook, I qualitatively analyzed the joint Google documents and the transcribed interviews. As mentioned in the data collection section, the Screen Share feature employed during Zoom meetings allowed me to capture a recording of the actions taking place on the Google document. This enabled me to analyze the development of Google documents, follow the path of idea generation, observe trends in contributions and airtime, and examine what facilitated or hindered their use of Google documents. Like the video analysis explained above, I content logged the Google document portions of the videos, specifically looking for moments of agency and idea generation. The lenses of my conceptual framework were applied to create analytic memos looking for themes, such as agency, multivoicedness, epistemic heterogeneity, contradictions, and historicity to attend to agency in and across the Google docs and interviews. Documents (agendas, chat transcripts, PowerPoints, and emails) were used primarily to triangulate evidence from design meetings. The combination of these data sources provided an opportunity for triangulation (Merriam, 2009) of the data, with different sources analyzed to address the research questions. I kept emails in a folder in Outlook called “Design Team” so I could track all the messages and exchanges about the project. I organized emails by subject, created PDFs of the messages which included all the exchanges.

Researcher Positionality

I am both a researcher and serve as a facilitator of the design team process. I also played a role in the pilot study on the research team and as a writer & producer of the online

professional development Circle Time Magazine. I am also an experienced content developer of early childhood professional development and currently am the Director of Professional Learning and Coaching supporting state-level professional learning development and training. This gives me insight into how state professional learning systems work. These experiences can serve as a resource to the design team but there is a limitation of bias towards the content and its role in the state system. For this study I am an insider (Banks, 1998) because of my professional roles and experiences but also an outsider because I am not in the role of teacher any longer.

Study Limitations

PDR centers racial and cultural dynamics of individuals and communities from nondominant communities. Despite my positionality as an African American woman who shares those research interests, nondominant communities are not centered in my study because my study participants are predominately white. However, race and culture are social identities of every person and through a historicity lens were present and encouraged in this study.

Chapter 3: Facilitating for Relationality

Findings & Analysis

The next three chapters present the findings and analysis from my study. The chapters provide evidence for the processes of partnering that facilitated the team becoming designers and how they capitalized on their experiential expertise to learn collectively. This chapter illustrates how the centrality of relationality shaped the activity system because the subject-subject relations influenced each learning action and facilitated the relationships amongst the team and the motivation behind the tools they developed. To that end, this chapter begins with an overview of the design process and provides a roadmap for how the object developed. Next, I will explain how I established the design space including processes of partnering and beginning relationship building. Then I share evidence from the questioning and analyzing actions that lay the foundation for design principles and refine the problem of practice. I also highlight the facilitation moves that begin to foster relationality.

Overview of the Design Process

The findings are written in the order of the expansive learning cycle and follow the development of the object through the cycle. Integrated throughout the findings are evidence of the facilitation moves that influenced the activity system. Over the course of 12 design meetings, the team developed two tools, defined design principles, and formulated a collective professional identity for themselves. The first tool was a Facebook group called *Let's Get Mathematized* and the second was a teaching tool called *Math Moves* which was a reference card to help teachers understand math concepts about counting, measurement, geometry, and patterns. The graphic below provides a roadmap of tool development across design meetings.

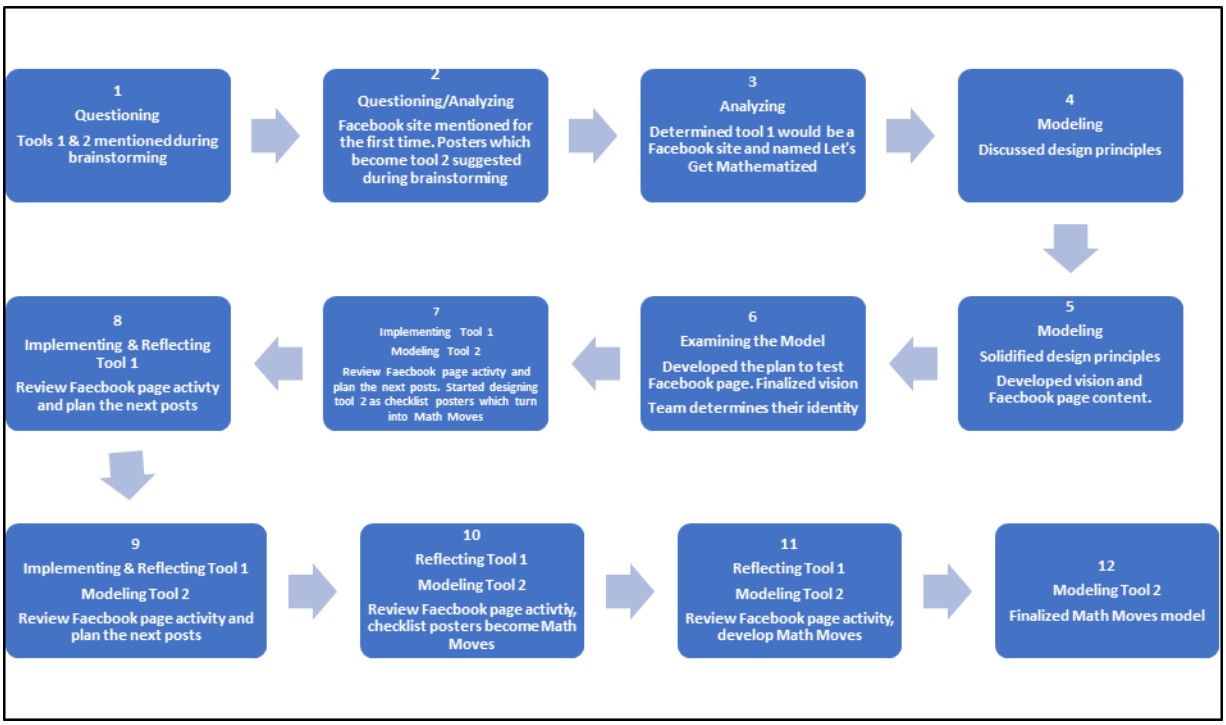


Figure 5 Graphical representation of how the objects developed across design meetings.

I want to provide a snapshot of how the objects developed across design meetings to provide clarity but also context prior to delving further into the findings. The design team met over the course of eleven months. Meetings 1-4 were weekly and after that we met monthly. Meetings 11 & 12 were spaced further apart because of summer breaks. The initial meetings were full of brainstorming ideas about what professional learning could be developed and even in the first meeting the idea for a vocabulary list of terms and an online site where teachers could connect was generated. Those ideas were the foundations for tools one and two. It was clear this group desired to create a space where teachers could learn from each other. By the third meeting the team determined they would create a Facebook site called Let's Get Mathematized. The design principles were discussed and refined in the modeling process. The Facebook page was modeled and examined by the design team over two months and then shared widely with their various networks. In the sixth meeting, the team discussed their own

identity and established a collective professional identity for themselves. The subsequent meetings involved reviewing the Facebook site and planning posts. Reflections on the Facebook site motivated the team to continue developing checklist posters which teachers could reference about math concepts. This turned into the second tool, the Math Moves reference cards.

By this point, the bonds on the team were so strong that although work on the Facebook page had reached a natural end, the team desired to continue learning from each other so, we continued to meet three more times over the summer and develop the Math Moves resource. It was not the intent to create two tools, but the teams' desire to continue working together and feeling like they could do more with the ideas that were brainstormed spurred us on. The collective professional identity that developed for this design team is one of the primary findings of this study. The subject-subject relations mirror the subject-object relations because the design team who became a "community of practice" for themselves, designed an online community via a Facebook group for their peers. This graphic is provided to give you a snapshot of how the object developed. The remainder of the findings will elaborate on this development organized by the expansive learning cycle actions.

Relational Processes of Partnering

The expansive learning cycle actions do not begin with relationship building, tone, and context setting but they were foundational to the success of this group process. However, the participatory design research principles I am using as a conceptual lens emphasize the importance of relationality and the processes of partnering that shape activity systems (Bang & Vossoughi, 2016). Applying those principles in the analysis process made it evident there were

facilitation moves I made prior to the first design meeting that contributed to the subject-design space relations and the subject-subject relations. The subject-subject relations are about who the participants are, the backgrounds they bring into the experiences, and how they interact with each other. The subject-design space relations are all the influences affecting our meetings such as the mediating artifacts we used including the Google docs we co-created, using zoom features, and how the team interacted with them. It was also the types of activities used for reflection, brainstorming, and planning. These all informed the design space and influenced the foundation for an environment of epistemic heterogeneity. Also, communication outside of meetings through email and follow-up influenced the space and built trust & security. Intentional facilitation is critical to this step. Next, I will explain how we established the design space and fostered the subject-subject relations.

Subject-Design Space Relations: Setting the Context and Object

The activity system was influenced by the context, communications, and expectations shared prior to meetings. Expectation setting is subject-design space relations and is a step in the process of establishing the design space. Although the tools were unknown at this point there was a context we were worked from, and the object was defined as developing ECE math professional learning. Establishing the design space was about setting up the context and planning for intentional facilitation. What participants were told prior to and during the first meeting matters because it influences the mindset, they bring into the design space. It is important to the participants comfort, their time, and willingness to participate when the overall purpose is concrete. Prior to the first meeting participants were told they would be designing professional development about math for the next set of participants in the study.

> At the end of the STEAM Trunk math study last year, you indicated that you'd be willing to help design the next study. We are ready to do that and would love to have you join the design team! You will be designing the professional development about math that the next set of participants in the study will use. It's an exciting opportunity to shape what that content will look like for many early childhood teachers, and I'm thrilled to design something with teachers who do this work every day! Since there are teachers all across the state participating in the design team, we will hold our meetings online using Zoom. There will be 4 meetings that will last for 90 minutes in late October & November. There will be a bit of work in between meetings to try out the designs. We can offer $300 for being on the design team. If you are willing, we will meet most likely in the evening or on the weekend. I'd like to find a time that works for you. What evenings mon-thur or anytime Saturday or Sunday work for you? (Recruitment email, 10/2/2018).

This level of communication that is explicit about the time commitment, what will be created and how we will work together is a facilitation move that sets clear expectations which aids in establishing the tone and foundation for a successful design space.

Communications about the context and structure before, during and after, became part of the subject-design space relations and also helped to define the purpose for the participants. The STEAM Trunk math pilot study was a shared experience that also defined the design space. I explained that all of them participated in the STEAM Trunk math PD and indicated they were interested in participating in designing more PD. I shared "This study is embedded in a PD that already exists and we're engaging in the expansive learning cycle to learn more about how to enhance it, how teachers learn, how teachers want their PD, and guidance that helps teachers facilitate math learning for young children" (Design Team Meeting 1, 10/23/2018). Another important communication to shape the context was about the object. It was important from the very beginning that they knew there were unanswered questions we would address together through design. To illustrate here is how I explained the object, "We're coming together to create & design professional development for teachers about math. What do

teachers really need? What are the challenges? What could be tried out to see how it would work." (MathDesignMeeting1 PPT, 10/23/2018). Here, I was intentional from the very beginning to not only state verbally but also have another learning mode of a visual reminder to reinforce the purpose of why we're coming together. This was important to reinforce and doing so verbally and visually helps to do that. I intentionally included open-ended questions to send the message that although they had just been through the PD intervention there was more to learn, and our time spent together would focus on exploration and creation. I wanted to get them thinking about possible tools and to make it clear that our starting point was going to be something new we would create and to do that we would think about what teachers need. These processes of partnering helped to establish the subject-design space relations.

Subject-Subject Relations: Beginning Relationship Building

Relationship building was critical to the process of partnering to foster subject-subject relations amongst the design team but also my relationship with them. Before we could begin the actions of the expansive learning cycle, we needed to establish relationships within the design team. This is a collective space where we sought to do work together that expands beyond our current understanding. It was important that this space expanded beyond traditional professional learning development spaces, where teachers are passive recipients, to a space that was open to teachers leading with their ideas and perspectives. To address this contradiction, we needed an activity system where that could be possible, a space that was welcoming, emotionally and mentally safe, and where epistemic heterogeneity could flourish. Also, a space where there was multivoicedness so the team knew that their perspectives were valued and sought after. Van den Akker & Nieveen stress that "meaning-making activities need

to be in place to secure the collective learning process" (p. 55-56). Therefore, I planned activities that would set the foundation and get them reflecting which is an act of sense-making. Van den Akker & Nieveen also stress that, "a productive team composition needs to be encouraged" (p. 56). For this study, I began with introduction activities that helped us build familiarity with each other but also, set the foundation and modeled the expectations of what was coming.

Encouraging and Planning for Subject-Subject Relations

As a researcher/facilitator, my goal in the first meeting was to get everyone talking and create a comfortable environment so that epistemic heterogeneity and agency could be possible. I laid the foundation for historicity by asking questions about their past PD experiences, so their histories and professional identities had a pathway into the design space. I laid the foundation for multivoicedness by getting everyone to talk from the beginning to send the message and model that this was space where we would hear everyone's voice. These decisions informed the introductions activity that provided insight into professional identity, meaning how the teachers saw themselves as professionals, what that means, and what roles they play. One of the things this study is trying to understand is how they develop as designers and do they end up seeing that as part of their identity. The first activity asked them to introduce themselves, talk about their professional experience, who they are as a professional and get them to focus on their identity and PD. The prompts for the introduction activity were as follows:

- What's your name?
- Where are you located?
- What type of program do you teach in?
- How long have you been teaching?

- Give us a word or short phrase to describe your best professional development experience.

The introduction included two purposes one to learn about each other but also to focus ourselves on the task at hand. It was intentional that the first activity invited historicity into the design space because I wanted to encourage their lived professional experiences and perspectives. It was important that they knew each other's backgrounds because they serve a variety of ages, in different program types, and locations across the state. In ECE, the differences in context matter, for example teaching in an FCC with mixed-age groups is different from teaching infants in center-based care. Learning from each other's different experiences motivated the team to continue meeting as will be explored later in chapter five. Also, the descriptions of their best PD experiences will be integrated into their emerging design principles and influence the tools created. The table below summarizes the teams' introductions.

Name	**Location**	**Program Type**	**Age groups**	**Teaching experience**	**Word or Phrase for best PD**
Diana	Olympia	FCC	2-10	29	Inspiring
Mary	Bellingham	YMCA	Infants/toddlers	12yrs, 3 years with infants/ toddlers	Encouraging
Rose	University Place	FCC	4-10	40	inspirational, encouraged me to go on and come back motivated to do more for the kids.
Joyce (coach)	King County	CCR		18	Eye opening
Sara	Olympia	Center	Birth-5	6	Fun
Danyle	Pomeroy	1 room in an elementary school	preschool	22	fun

Table 5 Participant Professional Experience (Design Meeting #1, 10/23/2018).

As this section illustrated this study began with utilizing principles from PDR because the design process, and any activity system, necessitates interactions amongst design team members and an understanding of how design spaces are established. In my study, It was necessary to plan for the processes of partnering to foster PDR principles that would aid in the development of the object. Those activities were intentional and began prior to the first design team meeting. Next, I will share the findings from the questioning learning action in the expansive learning cycle.

Questioning

Engeström & Sannino (2010) say questioning is "criticizing or rejecting some aspects of the accepted practice and existing wisdom" (p. 7). In this study, I enacted this through activities that centered on what the design team believed and had experienced about meaningful learning experiences for teachers. I began there because I wanted the starting point to begin questioning existing practices and understandings as Engeström (2011) argues, the starting point is a crucial point that is missing from design experiments. To design math professional learning within an existing PD intervention, the design team needed to distance themselves a bit from what happened before to avoid recreating the same PD. These findings will explain how that occurred in this design space and serve as an illustration of questioning using the expansive learning cycle.

Meaningful Learning Experiences Inform Design Principles

The starting point for tools one and two began from a space of epistemic heterogeneity through reflection activities which invited their historicity and illustrated some of what the team valued about professional learning. To distance them from the existing PD, I engaged them in activities that prompted them to think broadly about their meaningful and effective

professional learning experiences. It was intentional that it was not about math because I was seeking what they valued about professional learning in general as their purpose is to design professional learning. My goal with this facilitation move was to begin the questioning phase thinking broadly but more importantly I sought to understand what was valuable and meaningful about PD from their professional experience. To do that, during introductions each person was asked to describe their best PD experience with one word or short phrase. The next activity had everyone reflect on what makes for a meaningful learning experience and one that was culturally affirming. These two questions served several purposes. One, the activities focused the team on reflection and centering their PD experiences right from the start. Two, the goal was for the individual subjects to contribute and define meaningful learning and PD within the activity system we are all a part of for this study. Three, this also gets the design team focused on the question action of the expansive learning cycle through reflection. These reflection questions were designed to push the team to reflect on why the learning experience was meaningful to get at the lasting impact it had on them. I also wanted to open them to considering informal learning experiences and not bind themselves to formal schooling experiences. My instructions for the activity were as follows:

> Let's take a moment and reflect back on a meaningful learning experience. An experience that made the learning stick so much so that you remember it now. Maybe it was when you were a young child, or an adolescent, maybe you were outside or at home with family. I'm going to set a timer for 3 minutes. Think about the following things:
>
> Meaningful learning experiences
> - Think about a time when you discovered something or learned something new.
> - Where were you?
> - What were the feelings you had in that moment?
> - Was it culturally affirming?
> - What made the learning stick?

Share out
What was your experience and what made it meaningful? This will turn into a guidance document for us as we create the PD. Our guidelines, our goals, our design principles.

As the team shared their meaningful learning experiences, I took notes and shared my screen on Zoom. These notes were also compiled into a list of characteristics of meaningful learning that are available in the appendix.

Diana

- Being interested in the topic.
- The modality of movement while learning makes it stick it's playful, fun, I'm interested when I can move my body I can go deeper.

Mary

- Discovering that I have an opinion and a voice.
- At 21 I took a creative writing class it made figure out how I see the world makes me able to describe it and understand that other people see the world in other ways.
    - Makes me think about how my tiny humans see the world as well.
- Allowing myself to have a perspective.

Rose

- Went back to school 10 years ago to finish her BA went to Evergreen. I hadn't been to school in 35 years, and I didn't think I could do it. The teachers' feedback gave me really good positive feedback and also gave me suggestions for things to try next time. She made me feel that I could do this.
- At Evergreen, they let you pick the topic. It was meaningful because I got to pick the topic.

Dara

- Took an archaeology class and learned about the Nez Perce tribe. We did a dig to search and so it was hands on and then had sessions with the tribe where we learned the history of what actually occurred.
- It all tied in together with the book, hands on, and relating it to real life. With those three options it really stuck.

Joyce

- Anytime I can move or sing it makes it stick for me. I remember as a young child I grew up in Africa it was very rote ways of teaching back there. I couldn't learn my times tables until I went to a foreign teacher's class and she recognized that I

liked music and then I learned my times tables through singing and playing hopscotch.

Sara

- Taking what I'm learning and seeing kids do the same thing I taught them. Child led. I try to run a very child-led classroom (10/23/2018).

As a facilitator, I knew that this activity was the foundation for the design principles. These characteristics of meaningful learning are reflections on what this design team values about how people should learn such as having choices, involving physical movement, hands-on activities, and sharing what is learned. This activity served several purposes. One, with the design team I wanted to begin the process for design principles early on in our time together. Framing the questions around one word that describes your best PD and your meaningful learning experiences is the beginning of the team developing their own design principles. Two, these two questions right away get their minds focused on PD. Third, it connects to historicity and is one of the processes by which individual perspectives enter the design space and contribute to the collective design space experience. The process of the individual becoming the collective was mediated by the tool of taking notes and sharing it. At the end of the activity, I asked for feedback and confirmation if the notes captured what they shared. This was very intentional as this would inform us about the design principles.

Analyzing

During the first meeting we also entered the next action analyzing which involves investigating why and how something has occurred or exists in the way it does (Engeström & Sannino, 2010). A strength of having participants who were in the previous study is that they can reflect on their experiences in that context and use it to inform and shape the design space. That experience is now a part of their history and their learning experience in early childhood

math. To analyze, we focused on defining the problem of practice by reviewing pilot data from the STEAM Trunk math study.

Using Data to Inform the Problem of Practice

Discussing data informed the problem of practice by helping them to understand teachers experiences with ECE math which influenced tool development. As mentioned previously, this study is done within the context of the STEAM Trunk math study pilot. Reviewing the pilot data served a couple of purposes. One, it provided the team with more context for the problem of practice. It also gave them the information and data needed to define the problem of practice for themselves. Here is how I introduced the task, "Now I want to show you the data from the pilot so you can see what happened and where we're at. It will help us figure out what kind of questions and what problems might be good to focus on" (Dawn, Design Team Meeting #1, 10/23/2018). Joint negotiation of the problem of practice from the perspective of multiple stakeholders is a key step in codesign work (Penuel, Fishman, Cheng, & Sabelli, 2011). Reviewing the data allows the team to be informed and identify questions that need to be answered or gaps that could be addressed. This sets up the team to be able to iterate further on the problem of practice. Penuel, Coburn, Gallagher (2013) explain, "Developing a course of action, making a policy, or developing an intervention requires that individuals and groups explicitly or implicitly identify a problem to be solved and link that problem to a solution" (p. 243). For my study purposes, the pilot data is relevant for use in analyzing learning action and define a problem of practice. I am not showing all the pilot data because I want to highlight points in their discussion that influenced tool development and aided them in understanding and defining a problem of practice. All the pilot data is available for reference in the appendix.

The table below is pilot data that measures the frequency of when teachers used math materials. The team pulled from their own experiences to understand why the number of activities done during small group decreased.

Do you use math materials during any of these daily activities? If so, check all that apply.

	Arrival / departure	Transitions	Large group time	Small group time	Meal time	Free choice	Outside
Pre	12	18	22	26	22	24	16
Post	17	24	24	24	24	24	21
Change	5	6	2	-2	2	0	5

Sara explained that small groups were easier to focus on specific activities and was surprised that small group was less. Diana shared that just getting comfortable with the materials helped her be more intentional about math and she became more aware of opportunities to mathematize because it was the materials that helped her integrate it more throughout the day. Rose shared that she uses small group time to accomplish certain goals she has with children individualizing their instruction but because of the study she used math all throughout the day and not just at small group time. Mary shared a similar sentiment when she explained, "I found myself integrating math learning and verbiage into other parts of the day and I started to focus on other things during small group" (Design Team Meeting 1, 10/23/2018). This was interesting because it is Mary's qualitative explanation of what the quantitative data reflected

telling a more complete story. In this codesign space, they are analyzing it for themselves and reflecting on what it means for them from their own experiences. This additional perspective on the data provides deeper understanding of the findings informed by their own lived experience. The team refers to this data when creating the Math Moves reference cards.

The team's discussion about teacher comfort level with math is also relevant because it leads to the team creating tools that increase teachers' familiarity and comfort with math. Rose shared it has to do with how comfortable teachers are with math and it is hard to do if you do not feel comfortable. Sara resonated with feeling uncomfortable about math and shared, "If I don't feel comfortable, I'm nervous about it. The geometry box was the most nervous, but I had success with it (Design Team, Meeting 1, 10/23/2018). Dara also reflected in the comfort data in her post interview and shared, "I remember looking at the data in the first meeting about the comfort you know, and I remember feeling that way about the geometry so I'm so glad we ended up adding to the geometry sheet" (Dara interview, 9/24/2019). Mary shared, "The study changed my perspective on what a math study was. I realized the math language I was using the rest of the day and that's why it makes sense the post scores were higher" (Design Team Meeting 1, 10/23/2018). Again, with this data, the team related it to their own experiences with ECE math which resonated with them and connected them to the experiences of a larger group.

	I feel comfortable planning and demonstrating classroon activities related to counting (e.g. knowing number names and counting sequence)		I feel comfortable doing math activities with the young children in my care.		I feel comfortable planning and doing classroom activities related to math operations (e.g. addition, subtraction)		I feel comfortable planning and doing classroom activities related to measurement and data (e.g. describing and comparing things that are smaller or bigger, more or less, etc.)		I feel comfortable planning and doing classroom activities related to geometry (e.g. exploring and describing spatial relationships and shapes).		I feel comfortable planning and doing classroom activities related to patterns (e.g. creating a pattern of shapes triangle, square triangle, square, etc).	
	PRE_1	POS_1	PRE_4	POS_4	PRE_6	POS_6	PRE_13	POS_13	PRE_19	POS_19	PRE_20	POS_20
Average	5.15	5.67	5.19	5.74	4.93	5.67	4.93	5.63	4.30	5.37	5.00	5.67
Min	4	5	4	4	4	4	3	4	1	2	4	4
Max	6	6	6	6	6	6	6	6	6	6	6	6
SD	0.72	0.48	0.79	0.53	0.83	0.55	0.87	0.56	1.20	1.01	0.73	0.55
Paired TTest	0.001		0.001		0.000		0.000		0.000		0.000	
Change	**+0.52**		**+0.56**		**+0.74**		**+0.70**		**+1.07**		**+0.67**	

In summary, reviewing the pilot data informed their understanding about their problem of practice and provided insight that helps them determine what the tools would be. The review was about analyzing because it allowed them to consider the experiences of others who went through the study as well as question their own experiences. They resonated with the findings about increased comfort and doing more math activities in various parts of the day and not just at small group.

Facilitation Reflections

The review brought to light their comfort level sharing their perspectives in the design space already. My plan was to take 5-8 minutes to share the data and ask the following questions:

- What did you think about that data. Reactions?
- What questions does this data raise for you?
- What do you see as the problem or what to work on?

(Design Team Meeting 1 PowerPoint, 10/23/2018).

However, I never had to ask for their reactions to the data because it started happening organically. This struck me because neither of them knew each other prior to this yet it was so easy for them to share their reactions and personal experiences. That is an indication that even early on there was comfort, ease, and camaraderie already present in the first meeting. The table below summarizes the facilitation moves I made to foster the dynamics needed in the design space. This is also an example of a moment when my plans as facilitator changed. To support agency in codesign, it is important that the team dictate when something happens. It makes the meeting their own. My goal of them reflecting and analyzing the data still happened but, on their timeframe, not my plan or agenda. The lesson learned from this is that as a facilitator you need to be able to recognize in the moment when to cede control over things and allow your agenda to change.

PDR Principle	**Plan and Intended Outcome**
Relationality	The goal was to get familiar with each other and foster subject-subject elations through introductions. I also asked everyone to turn on their cameras.
Epistemic heterogeneity	Asked a prompt that had them share their experiences
Historicity	Asked introduction questions about teaching experiences. Told them they had all been a part of the STEAM Trunk math study, so they had a shared experience. I also wanted to see secondarily see if there was common ground or shared experiences because finding common ground and having shared experiences form bonds and are a part of relationships
Multivoicedness	The goal was to build comfort by providing several things: Asked that everyone respond to the prompts, multiple ways to respond, let people know they were free to eat, get up, do what they needed to do to engage, and began and ended on time. Each meeting had a routine. The expectations were set in several ways: emails sent before and after meetings each time, followed an agenda and set the tasks and agendas at

	the end of each meeting. Routines and expectations provide security

Table 6 Facilitation Moves

Thus far, establishing the design space highlighted intentional processes for partnering. The questioning and analysis actions provided an opportunity to get started on design principles and define the problem of practice. The activities incorporated the design team's perspectives into the design space. At this point, the design space is informed by what the team considers to be meaningful learning and an understanding of teachers' comfort level with math and the frequency of engaging in math activities with young children. With the remaining time in Design Meeting 1, we turned our attention to brainstorming.

Chapter 4: Becoming Professional Learning Designers & Learning Collectively

Through extensive brainstorming, collective planning, and examination the design team harnessed their experiential expertise and began working as designers to create the model. The team was fueled by their drive to connect and learn from each other and peers. Ultimately, the subject-subject relations continued as a source of connection and professional learning for the team and extended into creating a tool that paralleled their experiences working collectively as designers and contributed to increasing their agency. Along the way, I point out the facilitation moves that supported the process. This chapter covers findings from the modeling and examining the model actions in the expansive learning cycle.

Modeling

In the modeling action, the teams' increasing relationality made it easier for epistemic heterogeneity and multivoicedness to be present which contributes to their agency as designers. Their increasing relationality is a strong connection and through sharing of their experiential expertise leads to an activity system rich in professional learning for the team members. Engeström & Sannino (2010) explain that modeling means, "…constructing an explicit, simplified model of the new idea that explains and offers a solution to the problematic situation" (p. 7). For this study we began developing the model through an exhaustive brainstorming process, defining design principles, crafting a vision, and creating the Facebook page. Brainstorming happened during meetings one, two, and three. The model was created collaboratively during design meetings four & five. The model was the vision and initial postings on the Facebook page. Developing the model began with discussing and coming to agreement

on the design principles in meeting four. Also, in meeting four the team discussed assessment and wrote a vision statement. We started meeting five by reviewing the principles, determining that the vision would go into the about section, and that the team should introduce themselves. What follows is an explanation of how the model developed. The design team engaged in joint decision making, negotiation, and division of labor to facilitate the process which were necessary factors in the modeling action. Next, I will share findings for the modeling action beginning with brainstorming.

Brainstorming

The brainstorming was rich in epistemic heterogeneity and multivoicedness which contributed to increasing their agency. The team reflections on their own experiences were sources of learning for each other. Brainstorming began in meeting one and continued into meeting three. It was an iterative process that began with idea generation, moving to categorizing and sorting the ideas, sense-making, articulation, refinement, and prioritization. This section will provide insight into how the tools developed and the processes of partnering that facilitated the discussion. Google documents were used as mediating artifacts to facilitate the process.

Brainstorming Fueled by Experiential Expertise and Multivoicedness

The next section of data highlights how the combination of understanding their purpose as designers and tapping into their experiential expertise, led the team to suggest PD solutions that would be supportive of teacher's practice. Their expertise also contributed to notions of how teachers learn to teach math. Also, mutlivoicedness is evidenced by the interconnectedness of ideas and interactions with each other. Facilitation moves of clarifying the object and reinforcing the design role are highlighted throughout.

Intentional facilitation focused the brainstorming process on the object and was used to ensure the team understood it. Brainstorming by nature is intended to prompt many ideas ranging broadly in scope. However, it is easy in that process to go outside the bounds of the object. I share the exchange below as a facilitation example of how brainstorming was bound to the object. I knew it was important that I set up our task to figure out what we can do to support math instruction based on our best PD experiences, meaningful learning experiences and the pilot data. To begin brainstorming I asked,

> "What do you think could support teachers in improving these types of interactions? Thinking about what we get to do here in this design space, we can think of some ideas, or activities, or something that we think will help teachers with their math instruction in ways that will be meaningful and stick with them. Now I want to take some time to brainstorm some ideas together about what would be really helpful for teachers that we could create (10/23/2018).

Rose asked a clarifying question about the purpose "You mean create as regarding to math or create regarding any learning activity we can do with children?" I say it, "it would be professional development for teachers, something to help teachers with their instruction around math" (Design Meeting 1, 10/23/2018). This exchange established the boundary that the tools needed to be math focused and made our purpose clear. It was important to the process that the team was clear about the object even though at this point the tools were unknown.

From the beginning of brainstorming, the team is reflecting on their professional experiences and knowledge and incorporating them into the design space. The exchange below highlights how experiential expertise can provide reasons why a solution would be helpful. Also, the first brainstorming idea offered by Joyce was the foundation for the math moves resource tool.

Joyce: One thing would be to help teachers be aware of math terms of the different terms of math terms. Sometimes they're using it all through the day but, then you ask them a question like how many times did you use math with the children and then they say no because they didn't have to do any counting you know. So just helping them to be aware of those terms that has to do with the different math subjects or topics terms like, in and out, under, behind, equals, and low. They're using those kind of terms, you know, they are teaching those kids. They mean, more or less.

Diana: yeah

Joyce: Where you know high low, you know those kinds of things that it relates to math.

Dawn: Umhm

Joyce: One of my providers was so excited when I got a book to her to read with the kids and she said they've never done anything around measurements using a number line. After I left, she emails me to ask where I bought that book and then asks for a list of books about math and she was so excited she bought them. So even just books that would help them learn those terms I think would make them comfortable doing other math activities that just doesn't have to do with counting.

Dawn: Yeah, I mean we can think of some materials well like some ways to help facilitate the instruction around materials we've sent out before. But maybe it is a deeper dive around books. Handing her the book is really good but, you know, what helps the teacher know what to say about the book? What are those things because it's busy. If we've got teachers who are not that comfortable, it might be really easy just to have something to look at or refer to when sharing books with kids. That's an idea of something we could create (10/23/2018).

This is evidence that Joyce understood that our purpose was to produce professional learning solutions to support teachers. As this example shows, in her role as a coach, she has some ideas and knows the reasons why they would be helpful. Also, I know as a facilitator of codesign work, sometimes something concrete must be named or modeled in order to make the abstract more concrete. By saying "That's an idea of something we could create" I made a gentle facilitation nudge by articulating an example of a tool we could create.

Dara joins in next and illustrates how she is thinking like a PD designer and utilizing her experiential expertise to target a useful resource for teachers,

Dara: I felt like a poster or whatever, not necessarily that big but like a daily reminder that breaks it down a little bit. It could say use this type of language or have you done this

type of activity or have you pointed out such and such shapes that have different shapes names on it. Like a checklist for the teachers in the room so they can kind of just look up during their time and say, oh you know hey, I did that and make a mental note to themselves like OK yeah, I'm still staying on task. And, you know I have a little bit of downtime, so here's something that I could do you know, pull the shapes out or whatever so having like some sort of like daily checklist type of thing that you post. I mean you could even go broader than that where the kids could actually identify what's this shape and then it gives the teacher a cue to talk about whatever. I mean we all have the shape posters and number posters and all that jazz, but maybe a different way to cue that the kids and the teachers together might help too I don't know (10/23/2018).

This illustrates how useful teacher's experiential expertise is to design because Dara is suggesting a professional learning solution that is grounded in what she knows would be helpful to teachers given her lived experience. This is an example of a supportive solution to aid in teaching math.

The iterative brainstorming process of feeding off each other's ideas is an example of multivoicedness in this activity system and is a factor in how teachers can create PD. This process is central to how this team functioned and repeats frequently. For example, Joyce's and Dara's ideas are interconnected because Joyce's idea about the terms fed into Dara's suggestion about a checklist. This is also an example of transforming into a PD designer because Dara is thinking about what a teacher needs in the moment to do their job. This is evidence that Dara understands what the team is tasked to do, which is design PD.

This line of brainstorming about terms and concepts to support teachers continued and surfaced notions about how teachers learn. While surfacing these notions there is more evidence of them taking on the role of PD designer as they generate potential ideas and solutions.

Diana: Yeah, well just thinking there's a lot of different stages of math development subitizing and so I'm just wondering if a little bit of kind of reminders about the different ways that that we know our math concepts.

Dara: Right

Diana: So, it's not just it's not just counting you know

Dara: yes exactly

Diana: It's being able to look at a set and know how many are in it without counting right?

Dara: Yeah exactly

Diana: I think those are the things that a lot of or some teachers don't just have in their wheelhouse necessarily.

Mary: I think kind of building on that, is maybe something just to show how math concepts are in every center in your classroom.

Diana: right

Mary: Because I think sometimes when you look at a concept like math or science or any big concept you can get very quickly overwhelmed with it until you realize, oh yeah in my dramatic play I have shapes and I have counting and I have those things. In my Science Center I have those things and just kind of showing that you have math in all of your interest areas and how you can better set up your classroom in an engaging way to kind of point towards those math concepts in each sector.

Rose: Yeah, so would that mean likes add in something having the list of ways you can use math in your dramatic play area ways you can use math.

Mary: Yeah, it's kind of like the words that were mentioned earlier that the under, beside that you know those are all in the reading area if you have certain books. I was thinking of that today when I was like setting up my kitchen and I was putting my plates out and the different food and I was seeing all of the different shapes and then making um spots for each of the shapes and a place mat and um having them serve to like the three people at the table so counting. So just kind of finding ways to add it into places and to actually see that it's already there in all honesty.

Diana: yeah, math concepts were already there I just got more language and structure to them right. Like particularly around measuring I would say. Yep, I've always cooked with kids but I didn't always you know have the recipe written out. So, pointing out ingredients how many ingredients are we gonna use what which do you think is a tablespoon and which do you think is a cup you know.

Mary: yeah, same with me exactly the same thing just it was like ah I'm already doing this but it's just a tweaking it the slightest bit so I think people are less intimidated.

Diana: yeah, that's a way to encourage people here you're already doing. Yeah, add this because it is what you're doing you are building in the scaffolding you're building the concepts less more equal even. Even when you're leveling the flour in the cup you know

> that those words are important to math. It slows us down and makes us realize oh this is how we can engage them and then they can feel really those words carry over from area to area. So, you understand you know what level or parallel or perpendicular they could learn those words because they're using them in real ways (10/23/2018).

The notions of teacher learning surfaced how teachers can learn math concepts. They are using their experiential expertise to indicate what teachers may or may not know. Mary talks about how it can feel overwhelming, and Rose suggests the solution of a list for using math in dramatic play. The solution to address teacher learning was to increase comfort and decrease the feeling of overwhelm. This discussion about comfort also connects to the discussion earlier in this meeting about the comfort data from the pilot study, thus they are addressing one of the problems of practice. Their discussion points out that teacher comfort matters and professional learning can be supportive if it can address the feelings a teacher might experience as well. They point out that having the list available could help deter overwhelm because it reinforces that there are math learning opportunities already all around you. Diana describes this teacher learning as building and scaffolding what is around you in the learning environment. Practicing teachers are embedded in their daily work making their contributions to PD relevant. Through reflection, Mary related the discussion to something she had thought about that day and Diana reflected on cooking activities. This continues to be about increasing comfort through recognizing what is already happening but using reflection to be intentional about learning opportunities. Reminding and pointing out what is already happening is another approach to address teacher comfort. Their solutions are targeted to increase comfort and confidence.

I also share this exchange to point out another way multivoicedness manifests in this activity system through self-facilitation. In the exchange above, the team has transitioned,

without prompting, to facilitating themselves evidenced by the back-and-forth exchanges, asking each other questions, and referring to what someone else said. I am purely note-take here and not facilitating at all. This type of back-and-forth exchange continued for the remainder of the brainstorming time and became a primary way the team held discussions.

Brainstorming Creates Engagement and Connections Amongst Team Members

Relationality and agency are factors that motivated and drove the team's commitment to our design work together and was the source for the first tool the Facebook page and the beginnings of the team's own collective professional identity. The next segment builds on Rose's suggestions around teachers sharing with each other. She has a clear idea in mind about the utility of connection to peers from her own experiences and why it is useful.

Rose: you know another thing I was thinking, it would be really great to have a blog site where like for instance one of our favorite books to read is Pete the cat and his four shiny buttons. And I like it because it does math sentences. You know one cat rolled away and so 3 - 1 = 2 left you know and that kind of stuff. We have a little support group and I showed this book to them and they all go wow and they all went out got the book from the library but sometimes it's nice to have a blog that we could just put a picture up of this is the book I read today and this is the concept I taught or here's what the children learned. Or like when you're doing your cooking it's kind of fun for the rest of us to see what you've done and you've encouraged us in our ability to do math or STEAM, science, or anything. But it gives you ideas on how. I've been teaching for a long time sometimes I think my ideas are getting stale I'd need someone to you know to give me a little bit of a step up and then on the other hand I have a lot of good ideas that maybe I'm tired of using but I'm willing to share them with somebody else who might not have thought of that. Sometimes we just need a site where we can go and get some new refreshing ideas and it could focus on math or it could focus on steam or what have you.

Diana: we're setting up um they're called you know provocations you set something up and you maybe have ask a question and the children are left to explore that and there's just pages and pages of wonderful things you can do with washers or acorns you know what I mean? So, there are great books out there. I think figuring out how to sort of get the good morsels that will inspire teachers, right?

Rose: But don't you think it's the best books you've heard about from another teacher because this has worked for her you know. And it excites me when I see somebody that's found something. I've found a tool that whether it be a book or math toy or something when I see that they're having so much fun with it and the children really like it then I want one too or I want to do it with my kids you know. I'm always trying to bring new things into here so it's fun to be able to get that recommendation from another teacher (10/23/2018).

The notions Diana and Rose mention about inspiring other teachers and getting a recommendation from another teacher contribute to the idea for the Facebook page one but are also the beginning of a core component of their own collective professional identity. For Rose, hearing from another teacher is exciting and motivating. One of the things Diana mentioned in one of her interviews is that her interpretation of our task was to create something that teachers would want to do and for her PD should be inspiring. "You know I want PD that is inspiring. PD has to be something you want to do and be a part of that's why I like what we created. I wanted to go the site and see what someone else did and be inspired. Our meetings felt like that too" (Diana, interview 9/18/2019). A sense of motivation and shared agency was developing on the team.

The brainstorming process increased the team's decision-making agency and contributed to their growing connection as a team. When time was up for the first meeting, I attempted to wrap up by sharing my enthusiasm for all we accomplished so far. I verbally named some of the tools that were percolating and tied it back to our earlier activity of describing meaningful learning. This is a facilitation move I want to point out because brainstorming sessions should be expansive, wide, and without limits but within that I also want to push them to think about what those ideas would look like as tools or professional learning

we create. This was a facilitation move to center those nuggets and as a reminder to brainstorm tangible artifacts. The next segment illustrates their engagement in the design space.

Dawn: OK I'm realizing it's 8:01 I got all caught up in the brainstorming. We have accomplished so much today! I've heard several ideas, add things to a blog site, right we could add a bunch of resources, in the moment things, I heard posters and the ways that are accessible that people can use in the moment that we could maybe create to make that a little bit easier for them and meaningful. I think back to our meaningful learning experiences. Next time, we can focus on what could we create that would help people help it be meaningful for them but help them to use it and make it accessible.

Joyce: Just one more thing just quick you talked about the list of the vocabulary. Maybe you could have a chart like a math new vocabulary chart and then it could be you know a chart on the wall where you just put in new words as the children are there.

Diana: Yeah, well there's math concepts and then there's math words like plus minus equals right those are the kid's math words and then there's the teacher words you know what we're teaching about geometry you know subitizing. For some reason I can't think of any other ones, but you know what I'm saying that I think there's a need for both.

Rose: yeah, OK even to teach them concepts like symmetrical how do you teach symmetrical right? You know my favorite is the butterfly and you pull the paint over and it when it comes up it's symmetrical on both sides but that's a perfect example of something so simple that all done but how many of us saw that as an opportunity to teach symmetry boom! It's always really exciting when I see the kids putting something together on their own and then you know and it's even more fun when they teach you than when they're teaching the other children you know peer group.

Dawn: OK the brainstorming does not have to stop here so we will we'll pick up right here where we left off next week. we'll meet again next Tuesday and same time in the same way and if you have more ideas that come to you like throughout the week just e-mail me and I'm gonna add them to our list and put this together for us so we can think about think about them again next week and figure out what we want to focus on how we how we create and build I'm so excited.

Dara: Is there a way that we could get a copy of everything that we went over tonight emailed to us before the next meeting to kind of refresh us and give us some other ideas?

Dawn: Absolutely I will PDF this PowerPoint and send it off to you (10/23/2018).

The team members were committed to the design process, which is evidence of their engagement and interest but also the increasing relationality that was already present in the

first meeting. For instance, Dara's request for the meeting materials so they could review them and be prepared for the meeting is evidence of commitment. Also, Dara was participating in the call while at her part-time job. Furthermore, it is clear they were not done yet when I tried to end the meeting because they continued to contribute. Additionally, Mary sent this email after the meeting in which she expressed her enthusiasm for the work and how it impacted her.

> That was awesome and actually incredibly encouraging. I just wanted to touch base because I will have to miss the meeting on November 13th because I am auditioning for a musical. (A part of Professional development is also self-care which for me is auditioning for a musical :) But once again that was great and I am so happy to be a part of the design team! (Email, Mary, 10/23/2018).

I have included a large amount of data from meeting one, but it is significant that the foundations for both tools and evidence of their increasing relationality occurred in the first meeting. The team was committed and engaged which fuels relationality. During brainstorming my facilitation was less needed because there was an ease in communication making an environment of multivoicedness a reality in the space. Relationality is evidenced by the team's commitment, enthusiasm, and camaraderie and are indications why there were 12 design meetings when my original intent was to meet 5-6 times.

Epistemic Heterogeneity Fuels Plentiful Brainstorming

The idea generation discussions across meetings one and two are evidence of epistemic heterogeneity amongst the team where a wide variety of ideas were expressed, built upon, and confirmed. During meeting two, the team reviewed the list and entered discussion where more ideas were generated. The additional brainstorming added new ideas and was illustrative of their expertise. The ideas ranged from providing math books, supporting infant toddler teachers through language modeling examples, to developing posters for each learning center

for teachers to reference when mathematizing their daily interactions with children. Below is the full list towards the end of meeting two. Added items mentioned in meeting two are italicized. Of the 54 total brainstormed ideas, 37 new ideas were added to the list of 17. Consistent with the first meeting, much of the brainstorming was self-facilitated amongst the team and the ideas were expanded and refined. For example, Joyce's idea about helping teachers be aware of math terms understanding math subjects and topics such as under, high, low, more, less was expanded to more variety of math words for 1's and early 2's that connect to things you do in the classroom. The most consistent theme from the Ideas was about learning relationally, 15 or 27% of the ideas were about connecting, sharing, or inspiring other teachers. Those items are bolded.

Brainstorming list across meetings one and two

- **Helping teachers be aware of math terms.** Understanding math subjects and topics i.e., under, high, low, more, less
- Books for example number line
- Poster checklist of daily reminders to break it down for how to use language, how to do activities. A checklist for teachers in the room to refer to. Easy thing to use during downtime.
- Reminders of different ways we can develop math concepts so it's not just counting it's being able to subitize.
- Show how math concepts are in every center of your classroom. You can better set up your classroom to point to or highlight the math that's already there.
- Ways you can use math in your centers. i.e., in the library books are "next to" each other. Making shapes for place settings at mealtime
- It's less intimidating to hear you're already doing this. Just add this…Understanding the words that are important to math.
- **Blog site where you could put a picture up and share about the concept you taught.**
- **Means/opportunity to share what you taught. Teachers want to learn from other teachers.**
- List of good math books and the concepts they teach.
- **Recommendation from another teacher who is excited about is motivating**
- Mighty Minutes from Creative Curriculum. **Other teachers shared how successful it was.**
- Counting song cards in box 1. Learning by movement & music like the 5 little monkeys.

- New math vocabulary chart that sits on the wall where children could add to it.
- There are kid math words and teacher math words. There is a need for both.
- **How do you teach concepts such as symmetrical. What activities can you do and teachers share with each other.**
- **Child led ideas & teacher led ideas**
- *More variety of math words for 1's and early 2's that connect to things you do in the classroom.*
- *Encourage, tips, and tricks to help infant/toddler teachers*
- *Sign language*
- *Sensory based experiences, hands on, loose parts to explore. Can begin pre-sorting. Have a vocabulary you can translate for them as they explore in play. Pre-symbolic. Early matching games*
- *Foundational*
- ***Ability to create community in helping the teachers that have infants/toddlers***
- ***Fun to see other teachers working with young children****. Repeating, adding just enough information for the infants/toddlers.*
- *CTM episodes aren't well advertised. They were long. Make 10 minute episodes.*
- *Video playlists by skill level, age group, or by concepts for example different ways to teach sorting, symmetry, measure, weights etc.*
- *Want activities to use with materials*
- *Sorting mat where you could sort by color*
- *Posters for infant teachers would be helpful to streamline language. Remind the teachers to use what they already have. The daily routine that they have where they can bring the math out of it. Accessible for teachers to read like a bright poster you can see across the room.*
- *Using the math language infants/toddlers need to hear*
- *Infants learn by exploring. Lots of language modeling. Access to materials helps to facilitate that.*
- *Let teachers know what infants/toddlers are capable of*
- ***Educating the coaches so they know about the resources***
- *Need supporting getting a grasp on how infants/toddlers learn. It's embedded in everyday routines. Its more about that than having lots of materials*
- *Sequencing activities – toothbrushing, hand washing, cooking, coming in the room, leaving at the end of the day, nap time. Even kids who aren't verbal can point to what's next. Kids in a receptive language space can engage in that.*
- *Video examples are powerful to see what it looks like*
- *Shorter videos are easier to show more people at once.*
- *Sometimes hearing from a video reinforces the message*
- *Have different sizes of the episode available*
- *Series of vignettes to teach a concept. For example parts and whole for apples.*
- *Gave math ideas for winter, spring, summer, and fall. Extends math throughout the year.*
- *Something to get us excited again.*
- ***Sharing it with other people***
- *Think about marketing*

- ***We are a resource for each other. There is a Pierce County blog. A Facebook page.***
- ***Connection is especially important for FCC providers. "What's lighting you up right now?"***
    - *preschool teachers' network*
    - *pocket of preschool*
- *Developmental stages section. Sections on art, PBS.*
- ***Teachers could ask for what they want help with and then organized by topics***
- ***Seeing pictures of peers doing it. An exchange of ideas.***
- *Include an assessment in the box for the kids in the beginning and the end to see if there was a change*
- *Include a self-assessment for teachers in the box pre and post to see if there was a change.*
- *Concerns that an assessment for the kids would be testing them in a way that could be harmful.*
- *Questions could be a reflection about the kids. Something simple to help teachers know how kids are receiving the content.*
- *An assessment that points out what teachers can notice about children's work. For example, did they name shapes, they could find the attributes.*

(PowerPoint deck, Design Meeting 2, 10/30/2018).

Relationality manifests in the teams' desire to create community and aid in teachers learning and to facilitate sharing. Towards the end of Meeting 2, In an effort to make sense of this large list of ideas and lean towards priorities I asked the team what was rising to the top as a priority, and it was an ability to create community in helping the teachers learn and share with each other.

Dawn: OK so now I want to ask what what's rising to the top for you, things that feel like a definite yes, we should create this type of thing.

Mary: I think it's like creating community. I think that's really important because it empowers people to do things for themselves based off of what other people do. So, like in the next like month or so, I'm gonna work on getting sequencing all over my classroom because I think that would help my kids a lot and that's just something I took from this meeting today. So, I think creating community in in early learning in Washington would kind of be a really good foundation to do other things.

Diana: And to create other things well in support teaching yeah.

Rose: I like what Mary said about creating community because when you feel like you belong to a group then you pay more attention. You get involved or and that's what you want you.

Diana: You're right and it helps to bridge the isolation that so many family childcare providers feel. Which you know we're losing a lot of them anyway but as a way to you know kind of build each other hold each other up. I like the idea of having some embedded videos because I do think you have that resource which is so great. What's the word I'm looking forward you know basically models teachings of various concepts if we're exposed to those and have and you know an opportunity to engage with that with our peers.

Dawn: OK

Diana: I was gonna say we have a community of practice that I've been in ever since I started early achievers since before my first rating and I've going into my third so that group has really you know they've had a lot of years together and I've often said that's my favorite thing. There are probably people who live rurally or have barriers based on different things that that's maybe less accessible to this and think it's a really accessible tool for lots of people.

Rose: I've belonged to the Family childcare association of Pierce county for 35 years and we are a good resource for each other and the peer group is wonderful but we do give each other wonderful ideas but I think that this is even more powerful because it's actual learning tools that you can use and see it's not just somebody talking in a circle I tried this and we don't often talk about teaching concepts we talk more about the social emotional side of childcare. So, you say I'm doing apples next week what can we do? You can do this and that but you don't see anything visually and it's not talked about in greater length. This would be a better source for them for learning about the actual practicing techniques and teaching so I just think this would be wonderful (10/30/2018).

At the end of meeting #2 it is clear this team believes that connection and providing teachers with the opportunity to share, model, and be inspired by each other is valuable and the direction we should pursue. Their previous experiences in CofP's are influencing this perspective. However, positioning these teachers as designers has shifted what they think could be possible in a CofP when the focus is on learning from each other. For example, Rose says what they are proposing is more powerful because the focus is on learning tools not just sharing in a CofP. Positioning these teachers as designers is key to making this a PD opportunity where the intent is to improve teaching practices in addition to connecting with each other. Also, their motivations and values, such as PD that is inspiring, shared during the list of meaningful learning are present as well.

Brainstorming about Tool One the Facebook Page

The team's discussion that created the Facebook page centers learning relationally in professional learning through connecting with peers who, as this team believes, have ideas that can inspire, inform, and reinforce teaching practices. For this team, the opportunity to connect serves several purposes. One sharing examples of teaching can encourage teachers at any level. Two, seeing examples from other teachers gives you information about your own practice whether it is an affirmation or another idea to try. Three, when the team share ideas with each other they are motivated and excited to try it out. Four, the opportunity to connect virtually is especially beneficial for FCC providers who work in isolation. While discussing connecting with each other Rose says, "We are a resource for each other, you are our leader Dawn, but we are resource for each other. We have this blog that I go to. Is there some way to have a resource where providers can put up their own thoughts and ideas?" (Design Team Meeting 2, 10/30/2023). A message popped up from the chat where Sara said that it could be a Facebook group (chat, Design Team Meeting 2, 10/30/2023). Sara starts sharing verbally which kicked off a 15-minute discussion, and a key transitional moment in the design process, where there was brainstorming around what the Facebook page could be like.

Sara: A lot of these ideas about connecting with other teachers around here and I'm in this group with other people from other countries where there's lots of different ideas that I used and brought inside the classroom. That's what made it really successful too.

Rose: Sara was that a Facebook page?

Sara: Yes, it was a Facebook page I mean we're all on it. I mean I could be sitting here, doing it right now I'm not doing right now. To share those ideas, not just in our state but we could share it with everyone equally you know. So, people that do struggle with math can have an idea of what to do like showing shapes like this or measuring like this let me try this way and get that concept.

Diana: I love that because a lot of family providers we're isolated we don't have no five other teachers to bounce ideas off of you know we're solo and so kind of coming up with a format that that makes it easy to connect the and it's not just a you know a rag session but they're it's actually curriculum based.

Sara: That's the huge partnership of it

Diana: yeah, what's lighting you up right now!

Rose: well Sara just gave me an idea right now for my holiday party so thank you! You need to give us the address for your international Facebook page too. Is it appropriate for providers to be able to go to your Facebook page or your however you set it up? If they if they have something like where I want to learn about this, I'm having a problem with this right now, or I wanna learn how to teach this some new ideas for teaching this. You would almost in a way be like a book where you'd have it in in segments. So, if I wanna do a theme unit on apples you would cross reference that maybe to an art section to a math section or you know so everything that's under apples would be in the different some category or something. I mean like I said I've been doing this for a long time, but I still could use reinforcement

Dawn: I feel like that's one message you're really all really sending me that like hearing from each other and having space share and getting lots of good ideas like this is energizing that's refreshing.

Diana: And for me I love seeing pictures like I said I'm just very visual and that actually seeing pictures of people who you know or your peers versus some anonymous you know Pinterest somewhere right is up like that's almost too much you know you go down that rabbit hole and you just get lost I love the idea of having it be an exchange of ideas.

Rose: or just even, remember that video that you showed of the teacher, and I think the little boy had a truck and some blocks or something and he was scooping up the blocks and I mean that's so simple yet so valid you know. What do you get out of it, oh yeah, I'm doing it right, that's positive affirmation for me you know I am on the right track and I and I think that's important too.

Diana: right sometimes it's not a new idea it's just affirming that that is great look five other people are doing that and their kids are enjoying it well.

Rose: yeah, I think the teacher in the video was doing more or less or something. I thought that's so simple you know just sit there and talk to the children while they're playing and that's what we're supposed to be doing anyway but it's a powerful message because its giving you the tool that yes this is right, I'm doing it right and I need to do more of this.

Dawn: that's super powerful team. It's exciting.

Rose: it is because you know I think that as a seasoned provider I still need ideas. I know that when I first started out, I would have died to have something like this. You've got new

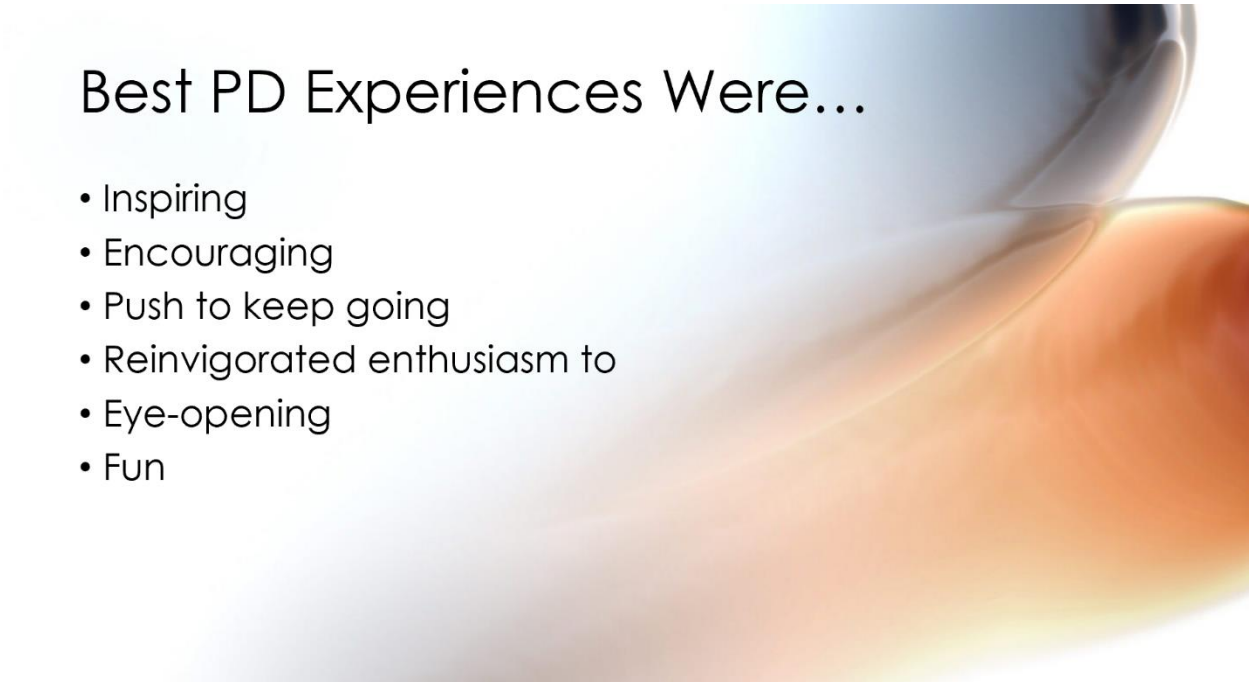
> providers coming into the game and they need to be encouraged and this is a good way to do it and its on their timeframe (10/30/2018).

Although a decision on what tools to create had not been made yet, it was clear the Facebook page was resonating with the team.

The brainstorming process provided evidence for how the Facebook page, the math moves resource, and their own collective professional identity was established. It was entwined in their discussions and brought forward in the activities we engaged in. The comfort and ease of relationships facilitated the epistemic heterogeneity and multivoicedness present in the meetings. The use of the Google doc was another medium to express their perspectives.

Design Principles Reflect Relational Aspects of Teacher Learning

Developing the design principles surfaced the team's experiential expertise and reflected what the team values about teacher learning. At design team meeting four, I started the meeting by focusing on design principles because we were ready to begin modeling. One outcome of design work can be to generate outcomes that are used in other settings (Engeström, 2011; Bevan, Penuel, Bell, & Buffington, 2018). The design principles are an example of an outcome that can do that. Through another process of negotiation within the activity system, the team reviewed and discussed their lists of the best PD experiences and characteristics of meaningful learning, and the list I generated through the literature review about effective PD. The team landed on design principles to develop the model. It was an intentional facilitation move bring back the list of best PD experiences and characteristics of meaningful learning experiences to create design principles. Those lists are below.



(PowerPoint Meeting 3, 11/6/2018).

After reading the list of characteristics of meaningful learning they launched into discussions about sharing, modeling, and assessment.

Sharing for Design Principles – Modeling & Self-Motivating

These examples of sharing point to an individual bringing their historicity in the form of their values and professional identity into the design space but because of the accumulated evidence around sharing throughout the meetings so far it feels appropriate to name sharing as a design principle for this design team. This discussion illustrates their view about teacher learning that sharing knowledge enables more growth, engagement, and learning for both children and teachers. When referring to the lists Diana begins the discussion asking, "That's interesting, seeing that sharing with other teachers and parents. Would we include parents?" Sara responds,

> "Sometimes when you do an activity, and the kid goes home and discusses it. This happens a lot in my room where, I did elephant toothpaste at Halloween and kids went home and discussed it with their parents and they're like 'well what did you do and how did this work?' So, when I wrote out the directions on how to do it, it was sharing that knowledge later on…A lot of the time when I say sharing with parents a lot of those times you have follow-up conversations and they're like 'hey did you know my kid can do the following' (Design Meeting 3, 11/6/2018).

This example is about sharing with parents and how it engaged them in their children's learning. Sara values sharing her knowledge with others, it is part of her professional identity. This next example illustrates the idea that sharing is self-motivating. Joyce kicks off the conversation by talking about modeling.

Joyce: They get excited about math when they see somebody do it. Just having the video on YouTube would motivate them when they see it being done.

Dawn: Sara what's happening on these Facebook groups that makes you want to be there?

Sara: I always like the good ideas. I wonder is it just me or do I need to reapproach? There's a lady that has some of the same challenges as me.

Diana: I love the idea of getting the opportunity to share some of our ideas to be that for someone else. When you get to do that, it feeds you. I have that in the back of my mind

that feeling to discover that. If we could even be a piece of that for the STEAM Trunk, it can really empower teachers.

Dawn: I have a question to check my assumption, is it because we want teachers posting themselves it's an opportunity to showcase to be empowered to do it themselves?

Diana: Yes, I want to do something that I feel like showing. It inherently creates the desire to show off your best, to do your best, and help me problem solve together. We get to be that inspiration for others (11.6.2018).

The team expressed that modeling is one way that teachers learn and furthermore it can be self-motivating as Diana indicated it inspires you to do your best. Sharing has been a consistent value/theme for the whole design team as evidenced by the objects and other suggestions during brainstorming such as getting recommendations from other teachers. Appropriately this topic started because sharing was one of the things on the list of meaningful learning generated in the first meeting "communicating the learning back to the families" (Design Meeting 1, 10/23/2018). This has become a design principle not only because of these discussions but because it is a reoccurring theme at this point.

Assessment for Design Principles – Benefit of Experiential Expertise in Professional Learning Design

In the process of developing design principles, codesigning teachers expanded the notion of assessment beyond compliance to illustrate how assessment can be a natural component of the learning cycle for children. In the team's discussion below, Mary and Diana draw on their experiential expertise to provide examples of how, while delivering instruction, they assess, recognize, and notice what children are learning. Early childhood teachers are especially skilled at noticing and learning what children know in the variety of forms children demonstrate it through play. Teachers do this in intentional and organized ways by observing, noticing, and utilizing the materials and activities present. This is a valuable lesson about teaching because it reinforces the notion that there should be multiple means of assessment

show learners can demonstrate what they know. Thus, the team emphasized ongoing assessment as important to teaching learning and incorporated it as a design principle.

Mary: Effective PD helps teachers be able to assess in the moment, know what to look for, and plan their curriculum by their assessments. It goes full circle if you use the assessment right.

Diana: You're saying effective assessment informs your teaching.

Mary: The STEAM trunks could be a simple assessment like, were they able to use the tape measure and identify anything on the tape measure. Were they able to relate the monkey book to the puppet in any way…you could do a simple assessment for that situation and still get the data that shows the kids are getting it. You know a toddler may not know that this is an 8th mark however they may know this is how far I can pull it out because it's this long I can make it the same as this size. You know.

Diana: Like more or less

Mary: Yeah exactly, you don't have to be precise and say this toddler can get numbers 1-10 but this kid knows how to use a scale and knows how to make the scale even or knows how to make it unbalanced so that would be your assessment.

Dawn: Do you all think this is something that teachers need help in understanding?

Diana: I do because I think a lot of people, I think especially with math it's seen as can they count. Well counting isn't everything there's so much more. It's this mathematizing thing math is happening all the time. If you start with 2 + 1 = 3 they're lost they're gone. That is so boring. But if it comes out naturally it evolves from this story and this activity, I think that's an art, really we're teaching them how to make it meaningful in early childhood that's a dance, they're co-creating it with us. I like to think of it as they don't even know they're learning. Then we're really winning because we have this black or white idea of it's either play or learn. We get them to see it as one ball of wax. To get teachers to see that too. It's not just a checklist. It's deeper than that. So, my hope for this is that a really meaningful professional development it changes the practice, you have to excite the children and the teacher.

Mary notices the idea Diana shared and offers a professional learning solution for teachers.

Mary: If you go back to the assessment idea, if you do an open general assessment, I think it will make the teachers realize that math really is all the way around them. I realized after I started doing the STEAM trunk like wow. This is all around me, there's just different ways I can implement it. So, I think with the assessments it would help teachers to realize all the things that they have, that they're already doing, but not really realizing that they're doing. That to me would come out of the assessment. Like Stone Soup that's a great end of the assessment, how [the activity] evolved. You could put something like how this activity evolved in your classroom on the Facebook page.

> The teacher could get ideas on those different evolvements (Design Meeting 3, 11/6/2018).

The team is acting in the mindset as PD designers thinking through how to support teacher learning and in this example are pulling on their experiential expertise to illustrate that assessment is a natural process. As Mary describes it coming out naturally, behind that is intention on how you're going to interact with a child to do a mini assessment to get evidence of what they know. They demonstrate a deep understanding of how young children learn and specifically are skilled at noticing those opportunities and leveraging it for assessment. As Diana pointed out, this is especially important because so much of math assessment is about kids showing what they know in a specific way, on a multiple-choice test as if there is one way to get a correct answer. However, with young children when you are trying to know what they have learned/or know you must take it in through the ways they show you and all of those ways are valid and true.

Design Principle Development

The design principles the team landed emphasize their perspective of the importance of relational learning. The design principle development was an iterative process of reviewing previous contributions, discussing, responding to prompts, articulating, and modeling. The importance of teacher experiential expertise showed through in the assessment discussion that reflected the knowledge of how to effectively help teachers to understand and learn what children know. The teams' emerging design principles were developed through a reflective discussion while taking the three lists about professional learning into consideration. I posed the following question to reflect on while utilized a Google document as a mediating artifact to record their responses. The reflection asked, what makes for math professional development

that can impact teachers' practices? The team worked in relative silence and added it to the Google document. In meeting five, we reviewed the list and the team decided to move forward with what they composed on the Google doc. Below is the list of emerging design principles.

Emerging Design Principles

- Reinforce the practices by sharing with other teachers and parents.
- Children and teachers share their knowledge with others.
- Modeling is motivating. Show me what it looks like.
- Self-motivating – The act of posting something that you created motives you to be your best.
- Sense of community – it's not just what's happening to me it happens to others.
- Meaningful PD excites the children and the teachers.
- Help teachers to assess in the moment and know what to look for and to plan curriculum by those assessments.
- Effective assessment informs your teaching practice. An assessment tool inspires.
- Effective PD is ongoing – Professional development is effective when conducted in an ongoing manner over time. Ongoing is more effective than one-time PD.
- PD should be relevant and related to what teachers need – PD days are often dreaded requirement days for teachers. PD should be exciting and relevant.
- PD for math should help teachers:
    - To see themselves as capable math teachers
    - Know math content.
    - Notice and understand children's thinking.
    - Use teaching moves that support learning (11/6/2018).

The emerging design principles emphasize relational learning, using assessment to inform practice, and creating relevant PD that engages teachers and builds their confidence.

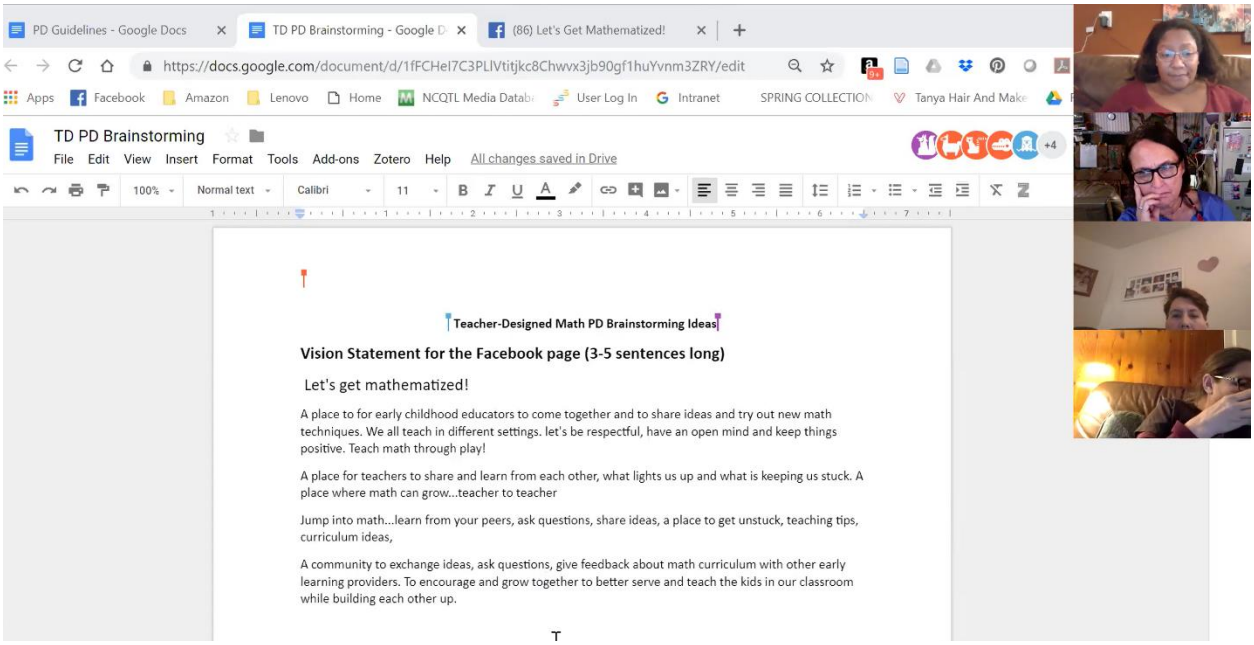
Developing Vision and Initial Facebook Page Content

The process of modeling the vision and content for the Facebook page brought out their agency, experiential expertise, the solidification of the collective professional identity, and yielded valuable lessons about facilitating codesign work. This was collective professional identity shaped through relationality, multivoicedness, epistemic heterogeneity, commitment, and motivation. This section explains how the Facebook page was modeled during design team meetings. As evidenced thus far, the object had been percolating in each meeting and was even

mentioned in the first one. The vision and development of the Facebook page content were very integrated. We developed it on the same Google doc and went back and forth between the two. For the sake of clarity, I separated the modeling of the vision and Facebook posts. The evidence presented in this section narrates how it developed across meetings five and six. The development of the object

Vision: Collective Professional Identity

The processes of partnering to develop the Facebook page content is illustrative of the team's agency and decision-making present in the design space. For example, at the end of meeting four when discussing next steps Diana suggests, "What if we made the Facebook page and we make it private and do some practice posts, play with it, and see what we come up with, see if we like it?" I responded with, "yes love it testing is a step in the cycle Diana! I will send out the page and make us all at the admins" (Design Team Meeting 4, 11/13/2018). The team also had access to the Google doc we used to develop content for the page in between meetings 4 and 5 and the team took advantage of that and started crafting the vision and practice posts. When we returned for meeting five, we used the emerging design principles as guidance and the team negotiated and iterated on the vision statement for their private Facebook page called Let's Get Mathematized. This process was done using a Google doc as a mediating artifact. I am sharing the vision at the beginning and end of the process to illustrate how the team led the editing process and truly defined their collective professional identity for themselves. Vision at the beginning of meeting five:



This segment below is evidence of several things. Multivoicedness was present in the editing of this vision because we were hearing from multiple people but also, they listened to each other and confirmed the direction of the vision. This is also evidence of their shared decision making, the ease with which the team collaborated, and their agency in guiding the process. They negotiated through collective refinement, and this resulted in a more streamlined vision developed through multivoicedness and epistemic heterogeneity. The team asked questions of each other to further clarify what the vision was. I made edits as they discussed it with everyone watching.

Dara: It looks to me like there are four different vision statements.

Sara: All four are amazing but if we could find a way to combine them together that would be great. The ideas are really great, I think if we blend it together it will make it outstanding.

Rose: We don't want it too big, and it needs to focus on a few of the main points.

Dawn: How would you like to go about revising that? We're on the Google doc and we can wordsmith it (Design Meeting 4, 11/13/2018).

This was a facilitation move on my part to ensure the vision was of their making and not me influencing it for them. Then they proceed to tell me what to edit and how it should be changed. This type of negotiation continued while editing the vision statement.

Mary: I think the last one basically is the top part of it and then the next three would be bullets the way that I see it just because the last one basically summarizes the whole situation and the top three are like bullets.
Dawn: Sounds like a beautiful place.
Rose: Take teach math through play and make that a fourth bullet.
Joyce: Dawn I have a comment. Can you just write this in a separate paragraph so we can compare it to what's being said for the vision statement? So, I said we're community for early learning professionals with beginning, moderate, and high math competence to ask questions get feedback encourage each other and using math through everyday activity with young children. Because I remember we had talked about how comfortable teachers were with math from the data you showed so I was thinking if we embedded some things about this is for everybody even if you have confidence as beginning moderate or advanced, you're all welcome here.
Sara, Dawn: yes
Joyce: you can compare it to everything else we've said.
Diana: I think that's what we we're trying to say. Thank you!
Rose: great point.
Diana: I don't think we need both now. Use Joyce's.
Rose: I like that, it's good (Design Meeting 4, 11/13/2018).

Facilitation moves in the section were to ensure the power lied with them to craft the vision by asking how it should be revised. I also affirmed and encouraged the direction they were going in which helps to know if you are on the right track, and served as their scribe so they were free to think and create while I played a role to facilitate their process with more ease. The key facilitation moves were redirecting the decisions to the team, encouraging the process, and providing for the sake of a better word, administrative supports.

The exchange below is an example of how the role remediation as professional learning designers has shifted perspective and is transformative agency into leaders thereby changing how the profession is viewed. The design team had an inclusive vision for the site and saw

themselves as leaders. They viewed the site as a place to find and build community, to bring people together for the benefit of children. As such, they approached the model from a strengths-based approach and not a deficit one.

Joyce: English is my second language but I'm thinking, we are community OF instead of FOR. What do you all think?

Diana: Yes, that's better. It's of and for you know it's both. I think of is very inclusive. For is more 'we're going to do this for you little teachers' Joyce and Sara nod and say yes.

Dawn: Can we talk a little bit more about that inclusive part and why that's important to do?

Diana: I know for me as a family home childcare program, I think they're very isolated so being to me means reaching out to providers all over the state who live in cities, who live in small towns, who are rural. I think inherently family childcare does tend to be small pockets of communities maybe aren't always diverse so you create diversity where it might not otherwise be. I think that's important.

Dawn: Is that a goal or outcome you all want this Facebook page to be for people?

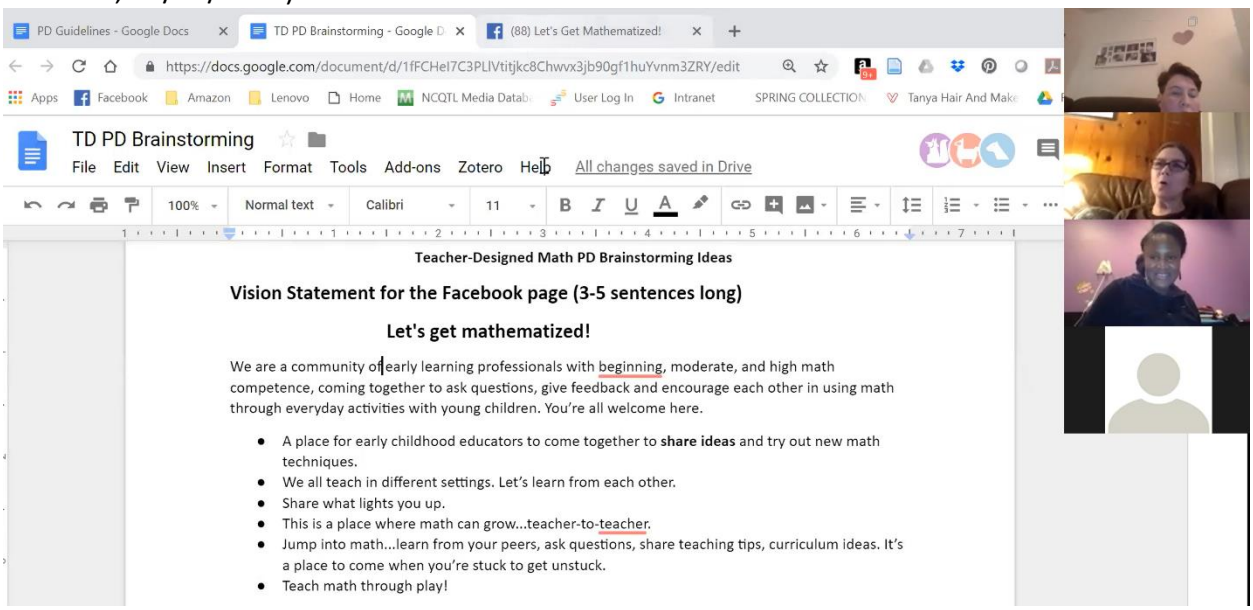
Rose: I also think that we are a profession, and we should portray ourselves as that and just coming back from the national conference has made me really look at that we as teachers are doing for the children of our country. Teachers need tools and I belong to several groups that are nationwide, and I would like to see this one become nationwide because I think it's important… We need to be able to open the doors to all providers because then those are the doors that will be open to children.

Diana: Yeah, the more inclusive we are and the more diverse we are the more children will be effected by it, rewarded and impacted the greater the impact. We don't need to preach to the choir, we need to really lead teachers into understanding that you can do so much with natural materials with play. There's so many ways that mathematizing can be done that's really beneficial (Design Meeting 4, 11/13/2018).

This exchange sheds light on how the group sees themselves but also how they see other teachers. They see themselves as leaders but are doing this along with their peers to support, grow, inspire, and learn with them inclusively. These perspectives are reflected in the final vision:

> "We are a community of early learning professionals with beginning, moderate, and high math competence, coming together to ask questions, give feedback and encourage each other in using math through everyday activities with young children. You're all welcome here. We all teach in different settings. Let's learn from each other. Share what lights you up. This is a place where math can grow...teacher-to-teacher. It's a place

to come when you're stuck to get unstuck. Teach math through play!" (Design Meeting 4, 11/13/2018).



The development of the vision represents the solidification of their collective professional identity. The sentiments put forth in the vision are mirrored in what they have experienced as a design team. This vision is a representative summary of what the design team desires for early childhood math professional learning. The mediating artifacts of Google docs and zoom created an environment that facilitated collaboration, connection, and agency. Next, I will explain how the content on the Facebook page developed.

Initial Facebook Page Content

The last component of modeling was creating initial content for the Facebook page. It is within and through the modeling process that the subject-subject relations amongst the codesigners contributed to tool development which was mirrored in the experience they sought to create on the Facebook page. Their role was remediated into that of professional learning designer when modeling the Facebook page content. This process also surfaced their

experiential expertise to populate the page. During the discussion, Diana brought up a challenge she was having using the dice.

Diana: I need a better idea of what to do with the foam dice.
Sara: The dice for me I couldn't think of the best game or activity for them. I saw this game on Facebook where they did rock, paper, scissors using the dice. It worked. We had 3 or 4 smoky days where we played this higher and lower game.
Mary: We took the dice to prompt saying something nice about a friend. So, they roll and the number it landed on those were the number of nice things you say. We did it during transitions.
Diana: See right now we're doing that thing that could be happening on that page. That is the power of it, quiet brainstorm, shared materials. What if it's a daily post on the page. We do prompts like what did you do with the dice today.
Sara: You could also post a challenge like I'm struggling with the dice what do you do?
Diana: Or ask what's your kids favorite.
Sara: I love that.
Dawn: We're switching gears into planning and it seems like that's where we should go. We can have a plan of prompts do weekly like you suggested and by topic like you suggested.
Rose: Come play with us! (Design Team Meeting 5, 11/26/2018).

Reflection and the act of planning employs their experiential expertise and becomes another form of teacher learning. Diana is using the design space as her own learning opportunity by sharing a challenge and the team naturally begins suggesting ideas. This exchange parallels the activities the team wants to happen on the page as Diana expressed when she said, "we're doing it right now." In addition, there was a shift designer during this discussion because they start generating ideas to populate the page. As a facilitation move, I noted the shift and encouraged the direction the team was taking the process following their lead. The Google document contained a table for planning the posts with three columns listed as content, post, and who for who would do the post. The act of planning the posts provided evidence of their experiential expertise and there was excitement and passion about what they were creating, dreaming big about what is possible.

Joyce: I'm wondering how we can help teachers learn how to incorporate math in different activities every day… I used to do Tools of the mind when I was in the classroom and when graphing weather chart, I figured out I could incorporate more novel words. We graphed the words over the month so we could do comparison graphing. They really got it at the end.

Dawn: That's a fantastic idea because they're seeing it over time.

Diana: I love that because the weather could be their job, a routine. They can make the tallies on the graph themselves. It's like you could tell them the pattern of the weather over time, or they could discover it. That is much better learning like you said Joyce.

Mary: We could have a place on the Facebook page to post files that someone created like the resource you were talking about Joyce. You could add on files so people would get more resources not just a conversation piece.

Diana: I love that. I wish I had this 5 years ago. When I was searching for things. Show me what it looks like (Design Team Meeting 5, 11/26/2018).

This is an example of teacher expertise because it is evidence of their understanding of the concepts and how to teach them. Joyce's example of learning over time and Diana agreeing that learning is better when it is discovered instead of told is an example of understanding how young children learn. That understanding combined with their lived experiences as proof are valuable forms of professional learning especially when combined with reflection.

Facilitation Reflections

The facilitation moves I made during modeling aided the process in multiple ways. Returning to the data from previous meetings is a codesign move but also a facilitation move because it focuses the discussion, keeps everyone on the same page across time, and also helps to clarify the participants perspectives for the researcher. The consistency of sharing information after every meeting and the work that happened in between maintained everyone's voice and perspective in the process. Joyce was not at the meeting where we categorized and sorted but she went back and highlighted her priorities when she was able. Another facilitative move is to provide a variety of means to contribute which aids in continued

participation in an ongoing statewide co-design process. The modeling action required facilitation moves that allowed for epistemic heterogeneity, multivoicedness and agency to be present. As facilitator, I named what we were going to do and what we needed to come to a decision on. I also asked clarifying questions to seek confirmation of my understanding and decision-making, for example seeking agreement on the design principles. Checking my assumptions and seeking clarification helped to solidify ideas. Another move was giving wait time for the team to review, think, and consider this led to meeting five having longer moments of silence. Occasionally, I would break in to remind the team what we are doing in the moment or ask a question to prompt discussion. I would say things like "I wonder what you all think about this? Is this what you want? So then, it would be like this, is that right? Is this what we're looking for? How would you like to go about revising that?" They know I'm going to take notes and write what they say which frees them up to do the heavy lifting of thinking together and not worry about writing it as well. I shared my screen to keep us all focused on the same thing but also provided links to the documents in the chat so they could analyze on their own and go at the same pace. I also made moves to place decision making in their hands by asking things such as, how do you want to go about revising this? These facilitation moves helped move the process along but also ensured the team had ownership over the space.

Summary of Modeling

Examining the Model

Engeström & Sannino (2010) say examining the model is running, operating, and experimenting on it on order to fully grasp its dynamics, potentials, and limitations (p.7.). In this study, we engaged in testing in the model when the team executed their planned posts for seven weeks over the holiday season. In that time, team members each took a day to post

activities they were doing in their learning environments and posing questions to each other about them. To examine the model, in meeting six, we reviewed and reflected on the posts, discussed approving members, pinning posts, and crafted an email to announce the Facebook page. Examining the model yielded further development of the page including adding to the community rules and writing membership questions. This action shed more light on their relationality, division of labor, was full of multivoicedness, At the end of this meeting the team gave permission for the site to be launched publicly. This set us up for the implementation phase.

Chapter Summary

The modeling and examining the modeling actions surfaced expanded notions of teacher learning that are valuable to professional learning including sharing ideas, reflecting, and modeling. Subject-subject relations are shaping the process not only in the activity system but is also paralleled in the desired object. The objects were brainstormed, we created emerging design principles, crafted a vision, and planned posts on the Facebook page. Their collective professional identity starts to take shape when developing the vision which reflects who they are but also a reflection of what they sought to create. When they came together their experiential expertise was leveraged for collective learning. These actions transformed their agency into professional learning designers and remediated their role, so they see themselves as leaders. The relevancy of experiential expertise is evident as their solutions are grounded in everyday teacher practice. At this point, one object has been modeled and the team solidified confirmed their collective professional identity through the vision statement. The next chapter will explore implementing, reflecting, and consolidating the object.

Chapter 5: The Value of Experiential Expertise in Professional Learning

"You know we are our best resources, right?" (Rose, Design meeting 7, 2/11/2019). In this chapter, I illuminate how the design team recognized their own experiences instructing children as a source of professional knowledge and expertise for designing learning for other educators. As the quote above from Rose demonstrates, participants became intentional about planning engagement that prompted collaboration, learning, and even codesign opportunities with other educators. The design team has a fully realized collective professional identity that informs their design process. This chapter covers the remaining actions in the expansive learning cycle implementing, reflecting, and consolidating. The team's drive to be responsive to the activity on the Facebook page produces the second tool, the Math Moves reference card. Additionally, their experiential expertise fuels and expands notions of professional learning that can support teachers.

Implementing: Experiential Expertise Fuels Design and Connection

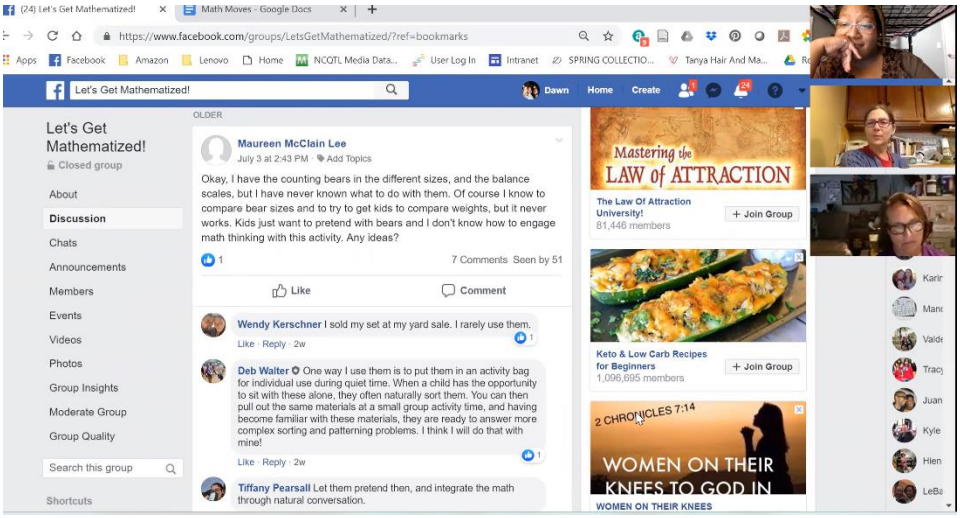
Recognizing the value of their experiential expertise amid ongoing relationships fostered their transformative agency as designers and led them to an implementation process that involved reviewing, planning, and designing to expand learning. This process remediated the roles of the design team and the educators they interacted with. Engeström & Sannino (2010) say that models are implemented "by means of practical applications, enrichments, and conceptual extensions" (p. 7). In this study we did that by making the page available, posting on the Facebook page, reviewing posts by users, and going through an iterative cycle of review, reflect, brainstorm, articulate, and model to respond and plan additional posts based on page

activity. Encouraged by their transformational agency as designers, this action also resulted in the development of a second tool, the Math Moves resource which is reference card to help teachers understand math concepts about counting, measurement, geometry, and patterns. The design process for the Math Moves resource utilized their experiential expertise to expand and refine an existing math resource producing a more grounded and useful resource. In addition, discussions about assessing children and teachers' cultural math practices are explored as examples of transformative agency.

Review and Plan

The design teams' approach to teacher learning was to prompt reflection, engagement, sharing and modeling because the team was positioned as PD designers, and they held the presumption that teachers have expertise. This finding describes how the team approached implementing the Facebook page through collaboration and the learning that resulted.

Reviewing the Facebook posts prompted collaborative reflection on the design team which resulted in learning and deepening of their own practice. For example, a participant posted a question about what to do with counting bears and the team reflected.



Diana: This was a great question out of this about coming to the group to ask what to do with the counting bears. It's great because it really made me think, how am I using those materials. Sometimes other people's questions can trigger your own questions.

Rose: I love how it just kind of naturally had different people with different ideas on what to do.

Diana: I'll read that post and then I'll go back to it and I'm wondering if it's true for other people. I mean what could I do to be more intentional or how could I make that more of a draw to introduce in a different way?

Rose: It's just a chance to reflect yourself. You know and someone else shares, it's not necessarily them saying yes, I know how to do this all the time but sometimes I don't know how to do this. Just like this post here.

Dawn: It sounds like you're saying when you see that post it lets you reflect and it's not like you have to have an answer about it, but it just helps you think about your own practice?

Diana: Right. I want a great use of this toy right? That's I think about. You know there's lots of different types of development and they're wonderful and they all serve really clear purposes like a math course, there's a clear purpose right. But this is giving us a different purpose for people like us that have been doing this for years.

Dawn: I just wonder if something like this more beneficial to your learning now than like going to a training on math?

Rose: I think if you're if you're not familiar with math concepts or you don't feel comfortable with math or you just want to you know get some new ideas, go to a math class and get a boost in it. But you only get to do that you know once a year maybe twice a year but with the with the web page with the Facebook page if you have an issue or a problem or question you just throw it out there and we're here for you.

Diana: I think that's my point too. I find this creates conversation about teaching and that conversation inherently makes you more intentional and because it's reflective practice right, so it becomes essentially a reflective practice group. In some ways I think the questioning is really where you can go deeper. (Design Team Meeting 11, 7/23/2019).

Reviewing the posts gives them an opportunity to reflect on their own practice as Diana pointed out it can trigger your own questions such as how I can be more intentional. Rose points out how this activity differs a bit from going to a training on math because it provides a different professional learning opportunity. In addition to formal training, reflection is a form of professional learning that provides insight that can help improve your own teaching practice.

Furthermore, as Diana points out, reflecting in a group adds another element making it a reflective practice group which for her allows her to deepen her practice. I argue this process of seeing examples of practice and reflecting on your own can aid teachers in practical application in a way that can more immediately benefit teachers and children.

The team utilized their experiential expertise to prompt reflection and learning on the Facebook page to harness the power of reflection as a teacher learning opportunity. The decision to brainstorm, articulate, and model planned posts came out of review and reflective discussions of activity on the page. The team enacted their agency chose responsiveness as an implementation move to foster collaboration and learning with other educators. Rose expressed a desire to see more interaction, "There are some good things and I wish there were a little more. There are a lot of posts, but I want to see more interaction where they're asking questions of each other" (Design Team Meeting 9, 4/30/2019). Rose suggested we post questions to prompt more interaction. The team decided to work on some terms people use infrequently. For example, here are the planned posts about 1:1 correspondence and patterns.

Questions/comments to post to the Facebook group to stimulate conversation.

1. What is your favorite math concept to teach?
2. What kind of patterns do your kids find in nature?
3. One-to-one correspondence is a way to match items 1 to 1. Such as everyone gets 1 spoon at lunch time. How do you know when a child understands this concept? What are they doing? What does it look like?
4. Repeating patterns are patterns that repeat systematically such as AB AB or ABC ABC. The Very Hungry Caterpillar is a good example. The Napping House is an example of a growing pattern which increases or decreases at a constant rate. How do you teach patterns through storytelling? What books do you like to use?
5. How are you beginning to teach patterns?
6. How do you teach patterns through music and movement?
7. Why is it important to introduce patterns to children?
8. How do you know when a child is beginning to understand what a pattern is?

(Design Team Meeting 9, date).

From a practical implementation aspect these planned posts generated activity on the page. However, from a teacher learning perspective the team acting as PD designer is harnessing the power of reflection as teacher learning opportunity. This differs from the assumption that ECE teachers are lacking knowledge. The design team is working under the assumption that teachers have expertise and when it is harnessed and shared, valuable learning occurs. I argue this is happening because the team was positioned as designers and were encouraged to enact their agency to produce professional learning that educators need from their perspective.

The Object Evolved Through Collaboration

The team recognized collaboration as an essential form of teacher learning while reviewing and reflecting on the posts and expanded into codesign with other educators thereby evolving the object. As a reminder, the object was ECE teachers designing math professional learning. This finding reveals how the object evolved into codesign with other educators to recognize their own expertise and reflect to deepen their practice. The following discussion takes place when reviewing a post about counting and is evidence for how much they see themselves as professional learning designers now.

Diana: The standard around numeracy is broad. There are so many parts of counting so we could put something together you know like here's an idea of how we break it down. We could do counting and create a poster about doing it at different points in the day.

Joyce: I liked your definition, Diana. It's important that children understand that the numeral matches and the quantity.

Rose: We need to tell what the goal of the post is. It could say 'the design team is looking for great ideas around how you use counting throughout the day. We are going to be asking you different questions regarding counting over the next few weeks. We'll pull these together in a helpful resource for you.

Diana: Well, I think it's kind of funny because we're taking the idea of collaboration to even the next level. Like guess what we're all going to do make a poster, including you!

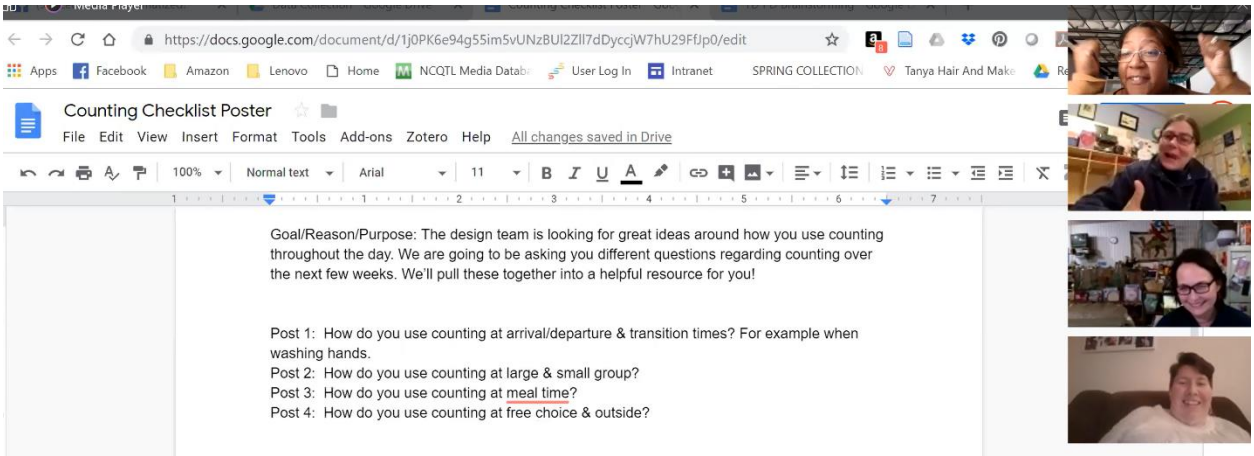
Rose: You could be part of the design team!

Diana: But I do think when you're put in the position of having to think about what is it that I do, you go back, you refer, then we're all teaching each other we're all learning together it's reinforcing versus just having a document to look at. They're actually getting to participate in the creation of that document. It's probably going to be much richer than if just the 4 of us did it you know.

Rose: I think it's almost better to ask them the question because that gives them a reason to respond. You know you can say, "we're looking for some ideas for how to use math during arrival, departure, and transition times do you have any ideas" and leave it at that and let them fill in the blanks because they will. You know I think most of us want to help.

Here are the posts about counting the team crafted:

> The design team is looking for great ideas around how you use counting throughout the day. We are going to be asking you different questions regarding counting over the next few weeks. We'll pull these together into a helpful resource for you!
>
> Post 1: How do you use counting at arrival/departure & transition times?
> Post 2: How do you use counting at large & small group?
> Post 3: How do you use counting at mealtime?
> Post 4: How do you use counting at free choice & outside?



(Design Team Meeting 7, 2/11/2019).

The team desired to create something that useful to teacher learning by incorporating their peers into codesign. Truly the subject-subject relations are mirrored and extended to the tool.

This also speaks to the extent to which their roles have been remediated because they have

fully embraced their role as designer so much so that they are suggesting ways to pass that role on to other educators. Furthermore, this is a form of collaboration that centered empowering their peers. The design team was coming from a philosophy of abundance perspective about teacher expertise through designing interaction on the site that promoted opportunities to show their teaching practices and prompt reflective learning.

I argue that transformative agency emerged in the process as evidenced by the shift in the division of labor in their activity. The team employed an iterative cycle that emerged through executing the implementation action that included review, reflection, brainstorming, articulation, and modeling.

- Review included reviewing the activity on the page including posts, comments, and membership requests.
- Reflect was discussing the posts as a group, sharing what they thought about them.
- Brainstorm was generating ideas for the next posts.
- Articulate and Model were crafting the next posts and posting them.

This iterative process was not something I put in place or designed activities for. The plan was to meet again and review the posts, but brainstorming, articulating, and modeling new posts came from the team. For example, once the page was created, the team delegated tasks to each other, determined what posts to make, and when people were going to do it. Rose gave me the job of posting the planned posts they all agreed on. To illustrate, in this example Diana brings our attention back to the posters and suggests tasks, “So back to the poster. I mean we could, I would be willing to try and take on the counting one. I mean if for instance Sara wanted to take it on, I mean to try it and just throw something back at us.” Rose. “I think collaboration in a project like this is kind of fun and we feed off each other” (Design Meeting 7, 2/11/2019).

The division of labor is evidence of agency because the team is fully empowered to delegate and guide the direction of the site.

The design team's approach to implementation on the Facebook site provides an element of responsiveness and relevance that can be missing in structured and planned PD trainings and curricula. The team's review and reflection of posts on the page prompted them to wonder what they could create that could promote learning and help teachers. This is one of the benefits of having teachers be designers of PD. This was not only an iterative process in the design team meetings but now they are driven to continue designing based on needs they identified from reviewing the posts on the page. They came full circle as PD designers, creating professional learning for teachers by teachers. This highlights the importance of making space for teachers to create professional learning because it can be more relevant to their needs.

Role Remediation into Designers Fosters Transformative Agency

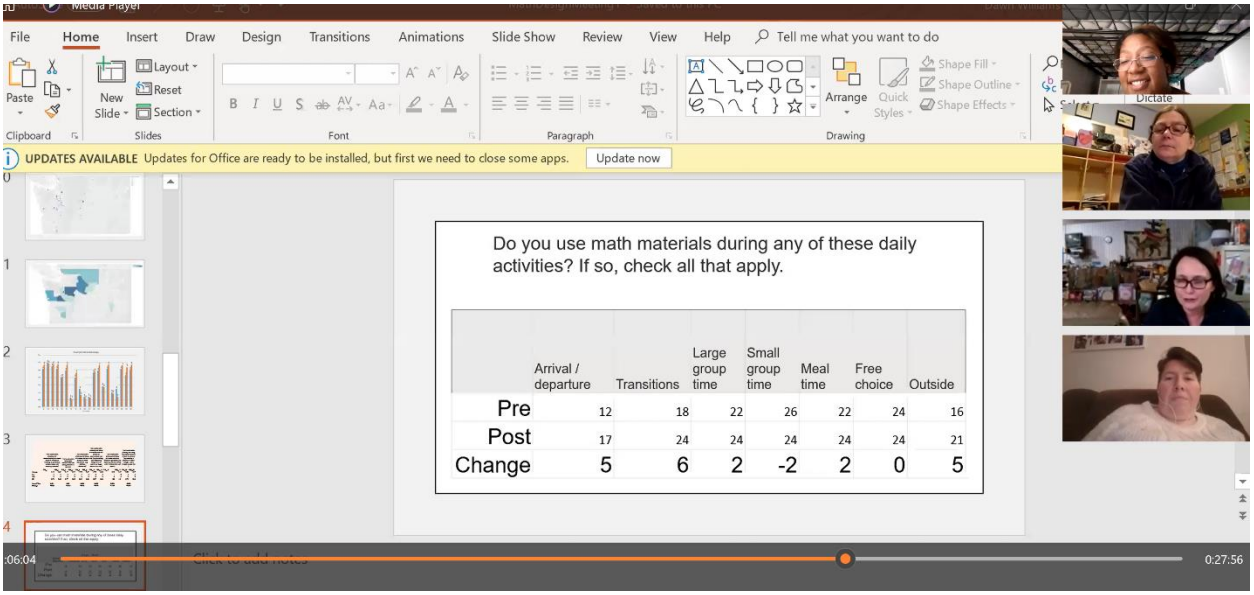
The design team has re-mediated their role and I argue expanded their professional identities to include professional learning designer. When designing, the team pulled on their experiential expertise to create professional learning solutions. They shared insights on how and what teachers should learn through design principles. They also engaged in reflection which supported deeper learning about their own practice. They see themselves as leaders designing for the benefit of and codesigning with their peers. The design team has developed transformative agency as designers. Ishimaru, Lott, Torres, & O'Reilly-Diaz (2019) suggest that identifying turning points in the design process can identify moments of transformative agency. To that end, the next section provides three examples that illuminate the team's role as professional learning designers. The first example describes a new resource they developed

because they were responsive to activity on the Facebook page. Second, they generated an approach to assessment because they reflected on how teachers know what children understand. The last example highlights professional identity through culturally sustaining math activities.

Math Moves: Capitalizing on Experiential Expertise and Codesigning with Other Educators

The team was driven to continue supporting professional learning by codesigning with other educators on the Facebook page. Their original idea was to capitalize on posts from the page and turn those into a poster of helpful tips. This idea evolved into tool two, the Math Moves resource. For the second tool, the team innovated and refined existing PD. Developing the Math Moves resource was driven by the team's desire to be responsive and relevant to the community created on the Facebook page. Their experiential expertise refined the existing resource in ways that added relevant examples and even specific language for clearer communication to children. They expanded on it by adding missing components for time and 3D objects, so it is a more comprehensive resource. This process gave them the opportunity to build, solve, commune, and learn from themselves.

The process began when Diana started facilitating and put out the idea for creating a counting poster about doing it at different points in the day, "How do you count at arrival/departure…how can we use that timeframe to bring a little math in? Sara chimes in, "At free choice they have to count how many kids are in an area" (Design Meeting 7, 2/11/2019). Since they were having this discussion, I pulled in the data I showed during the first meeting about the times of day teachers do math activities to connect it to our conversation and shared my screen.



Rose: You know that would be kind of cool. Do a challenge on the Facebook group and from that challenge you can make your poster.

Diana: Then we create it with everyone

Rose: That would give you some ideas it would get you started. Sara just gave us a good one when she said scooping out the food… I mean we probably are all doing some of this stuff and we don't write it down.

Sara: I don't think about it until I'm talking to you guys.

Rose: You know we're our best resources, right? I think too Dawn if we start out by doing the one for counting and then a couple of weeks down the road we do measurement (Design Meeting 7, 2/11/2019).

This discussion determined our path for developing the second tool which was driven by responsiveness to the activity on the Facebook page. The team feels strongly about the professional learning that comes from teachers as Rose noted when she said "we're our best resources." Not only is this about connecting as a team but it is also about connecting with a larger network through the Facebook page. This is another indication that the object is evolving to collaborative design with other educators not just the design team. Sara pointed out that she doesn't think about it until she is with the group so for her the opportunity to engage in reflection to improve her practice does not happen unless there is a designated space and time

to do so. Sara confirmed this during her interview when she shared “Even though I moved to Iowa and it is much later right now, I pretty much came back to keep connecting with the team” (Sara interview, 9/17/2019). Sara’s point highlights the need for professional learning to include space and time for reflection and given the evidence from this study, time to reflect in collaborative spaces with other teachers is beneficial.

The Math Moves resource is a reference document to help teachers understand math concepts. This modeling process mirrored the first. The findings for multivoicedness, relationality, and epistemic heterogeneity are not significantly different than the modeling process for the Facebook page therefore, I will not detail that process here. A significant difference however is the team enacting their agency to create a second tool and is leading the process. The team developed content for counting, measurement, geometry, and patterns. I will highlight two of the areas and the discussions that speak to their experiential expertise that informed the tool. The full resource is available in the appendix. Building the math moves document provided insight into their experiential expertise and is an example of how teachers as professional learning designers can innovate and improve upon existing resources and make it more relevant to their needs. Joyce’s suggestion from brainstorming about identifying terms from meeting one was brought to the forefront again when developing these resources.

For the measurement section of the math moves document, the team listed measurement attributes and provided some examples of things teachers would say or do to teach about them. In addition, they discussed time and how children understand it. Time was not touched on heavily in the STEAM Trunk research study, so it became a helpful extension. The team shared that of course there is not an expectation that young children are telling time,

but you can teach them about other concepts because they have a sense of routine. The first column are examples they generated that typically refer to time in an early learning environment, a visual schedule, timers, and vocabulary. These are examples children would be more familiar with in an early learning environment, so it is relatable. Another interesting aspect about time is that they started to develop a learning trajectory for it that guides what children can understand at various stages. *Introducing* referred to strategies to introduce concepts. *Emerging* was about building on what was learned and *knowledgeable* was being able to demonstrate that you fully understand a concept. The trajectory helps teachers know what to look for to determine what children understand and what to teach next.

Measurement	
Standard Measurement - tools that use standard measurements such as the metric system (meters, liters, etc.) or the imperial system (inches, quarts, etc.).	
Non-Standard Measurement - using anything to measure such as ribbon or cups.	
Measurement Attribute	**Math Moves - Things teachers would say or do**
Time	When is lunch? When will it be my turn?
Length	How long? How far?
Width	How wide?
Height	How tall?
Weight	How heavy? How light?
Volume	That cup is very full. How much rain did we get? Your cup is half full. Fill a cup ¼ full and say I'm filling your cup ¼ full.

Examples	Introducing	Emerging	Knowledgeable
Time - using a visual daily schedule	Visual sequence cards that show the daily schedule. Could also add words to the visual. The most important part is the teacher talking about the visual schedule.	Adding time or a clock to the visual sequence card. Beginning to understand that parts of the day happen at a certain time. For example "mom will pick you up at the end of snack"	They know the schedule so well they can help another friend
Time - using a timer	Teacher sets the timer, talks about the amount of time that was set, and sticks to the time. The goal is to begin to help kids understand how long 1, 5, 20, etc. minutes are.	Children begin to understand how long something takes.	They would ask to set the timer and know how long to set if for an activity
Time - vocabulary	Introducing time vocabulary and using it such as seconds, minutes, day, week, month, year, seasons	Teacher doing activities including time vocabulary words such as, the Montessori birthday song.	Using the vocabulary accurately

Developing the trajectory was a lengthy conversation. For the sake of time, I will highlight Sara's explanation of how she populated the row about using a visual daily schedule that conveys her understanding of how she knows when a child has mastered a concept.

Sara: Sequence cards, well more visual sequence cards because that way they can understand what's happening during the day. Many children when they enter school, they struggle with that part too…So it would be like visual sequence cards in introducing because your showing them the first time. I want to say the emerging part would be having the words or the clock with the visuals.

Dawn: Adding time or a clock. Kind of like the next developmental stage. Ok adding that.

Sara: The knowledgeable part would be helping a friend. The children are there helping that friend. Like that friend knows the schedule so well they can teach another friend. That peer teaching is important at any age. I have a kid, well he was crying a lot at first because he didn't want to be away from home but now he's the one teaching the visual

sequence cards and I'm like wow now that I think about it he really does know this (Design Meeting 9, 4/30/2019).

Sara was reflecting and building this trajectory using evidence from her own experiential expertise. Developing this with a child in mind aids her in knowing from lived experience how to support a child in understanding time. She is building professional learning with the kids she teaches in mind which illustrates that providing teachers with opportunities to design professional learning can produce content deeply rooted in children's development.

Developing the geometry section was an iterative process that built upon and refined a geometry resource that was already available from the study. The team identified a gap in the existing geometry resource being it did not include enough 3D shapes. After a discussion about symmetry and three-dimensional shapes, the team added 3D shapes and Diana worked on it outside of the meeting by adding pictures. Diana begins this discussion by referencing the existing geometry resource.

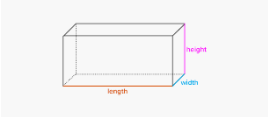
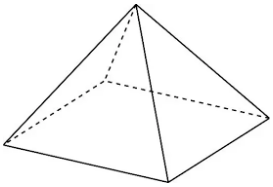
Diana: It was the geometry trunk again. There was this piece of paper here so why didn't I use it or find it useful like what was missing from it? I think we're really getting to it but the process is sort of looking at that and starting to answer it for myself, it sparked me.

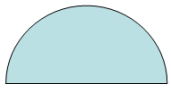
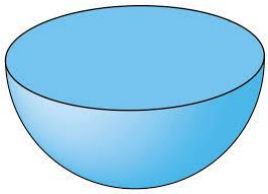
Rose: You know you've just inspired me because I have a lot of shapes here in this room but I don't have the three-dimensional ones. I'm going to go out. I'm sure I can find one in the catalog somewhere instead of three-dimensional shapes because I can have an apple in my hand or tomatoes and say this is a sphere but somehow it doesn't equate as well unless you have the shape next to it.

Diana: I mean you have the different shapes and then they can kind of realize oh yeah I think they think two-dimensional when they see an apple so they would say that's a circle but that's wrong you know. So, I think it's one of those limiting thoughts that we have. I think having those materials in the classroom causes you to name them. To use it to use it and then you have the globe is a sphere what else is a sphere oh the ball so yeah then you suddenly can start contrasting and talking about those shapes. Let's go on a shape walk let's see how but you probably not gonna see pyramids but you know how many spheres can we find?

Rose: Actually, I have a climbing thing in my backyard that's a pyramid so there you go there's one trying to think what else (Design Meeting 9, 4/30/2019).

The existing geometry resource sparked reflection for Diana that forced her to try to address her wonderings for herself. Roberts and Diana are pulling in their experiential expertise to reference what it is like to teach about 3D shapes. More specifically, they noticed children saying things like apples are circles when that is not correct and that having the shapes next to real objects makes it clearer for children. Noticing what children are doing and seeking clearer materials helps them craft a resource that aids them in teaching children. The geometry section is below. It includes the shape name, properties, and example to see it and prompts teachers can use to deliver instruction.

Geometry			
A poster for kids could have the examples and pictures of what to think of and post it in the block areas or others.			
Shape Name	**Properties**	**Example**	**Teaching Moves- Think of...**
Rectangular prism (3-D)	3-D solid shape with 6 rectangular faces, 8 vertices & 12 edges Boxlike shape. Opposite faces are identical		Chest of drawers, trunk, box of crayons, cereal box, books
Rectangular Pyramid (3-D)	3-D solid shape with 4 triangular faces		Tent, architectural pyramids, some roofs

Semi-circle (2-D)	Half of a circle		Activity table, cheese, rainbow, a fan
Hemisphere (3-D)	Half of a sphere		A cereal bowl, half of the earth, half of a watermelon

Different professional learning resulted from the two objects the team developed. The Facebook posts were about sharing experiential expertise and reflecting on it to increase their knowledge. The Math Moves resource harnessed their experiential expertise and child development knowledge to deepen their understanding about math content for young children and their strategies for teaching it. When teachers have the opportunity to build professional learning, they create useful tools but also engage in a process of meaningful learning for themselves.

Designing to Assess Young Children's Knowledge

This example of agency illustrates that the design team's participation in this form of professional learning has reshaped their notion of how to cultivate and notice children's learning through reflecting on assessment practices. Their experiential expertise provides insight into teaching practice and how teachers can understand what children know. In this example, Diana is reflecting on what she is noticing her kids doing around math.

Diana: My brain is a little bit overflowing but we're having so much fun with math. This has been a really great series of four months. I feel like the confidence I'm seeing in them is so, it's marked you know we're doing some of the same things but with a little more focus and emphasis.

Dawn: Tell me more about what you're seeing.

Diana: They are using math language which I think they're seeing themselves as capable. Most of all they're having a lot of fun with it like if I come up with math activities they'll say, 'let's investigate that.' They went to grab their clipboards they wanted to record data. We're studying trees and I think they just have a bigger toolbox. We were drawing pictures of trees and I have a couple of kids who really couldn't figure out how to draw a tree, but we had those templates. One of the kids said it was a rectangle and she used the template to draw her tree trunk. She's resourceful because it's using tools she has. I'm not drawing it for her, I'm not even solving it for her but somebody else had the idea and then she used that idea.

Mary: You could do pre and post assessments for the kids. Like you did for us with the comfort surveys but if the kids feel better, you could find out why. I didn't think about that yet, but my kids are more confident too.

Sara: Mine too

Diana: Yeah, you can do one now and check with them after four months of really focusing and seeing what their thoughts are on it right. I mean I've seen just huge growth and then with that child now I can say, what would you like to learn about, what would you like to do, what do you think you need to have?

Dawn: I have learned so much being with you all. I love this idea. For the next study we could develop some type of child friendly assessment that you can give that may have smiley faces or sad faces or ways that the kids can indicate how they feel, and you could easily get that information from the kids.

Sara: For what they know about math, I noticed that if one child teaches another person I see that they understand the concept better. Then I also know when parents come up to me and they're amazed at what their kids know. Like I was watching this kid explain to her dad how to use a ruler and I'm like, I don't even need to teach you anymore. Those really are the moments with them when I'm like you guys are really getting this.

Rose: It's that they're learning how to learn. I find that if I get involved with them that it really helps them to extend their thinking too and then sometimes it is kind of fun when you hear them reiterate your words or when you hear that when you know that they really are listening later. That's how you can see how much they really know and how much they remember (Design Meeting 10, 5/21/2019.

Rose's statement about children learning how to learn illustrates how important it is for teachers to have space and time for reflective discussions about children's learning. This is a critical form of professional learning because in this example this reflective discussion within

the design space has reshaped their approach to assessing children's learning. A pre and post survey to measure children's comfort with math is another potential innovation on the STEAM Trunk math study. This suggestion develops from a reflection because the team has noticed increased confidence in the kids. They are taking their experiences as part of a PD intervention and envision modifying the comfort survey for teachers as a useful means for understanding if children do feel more comfortable with math. This is another aspect of transformative agency as designers that pulls on yet another experience to develop a professional learning solution. I argue that this would not have occurred had they not been positioned as designers. This conversation took place in meeting 11 of 12. At this stage they are comfortable with each other and used to sharing their experiences. They have expertise in assessing young children but being positioned as designers in this context allows for a new solution to child assessment.

Cultural Professional Identity Expanding Math Instruction

Teachers have holistic academic identities (Ishimaru, Barajas López, & Bang, 2015) that encompass multiple social identities including professional identities as teachers. Using a historicity lens, I take up that perspective and argue that fostering the team's experiential expertise encouraged them to draw from their identities, histories, and their cultural backgrounds to design professional learning. During meeting eight, we reviewed the posts on the Facebook page and started a discussion about measurement posts. Sara brings up that she is going to be making Irish soda bread and can use it as a measurement activity. At the beginning of the discussion, it was not about culture, but by the end of it we ended with a decision to post culture-based math activities. This segment explores expanding conceptions of math instruction with and through cultural practices.

Sara: Cool, I'm going to measure this week too. I wonder if I can get my kids to measure. We're doing Irish soda bread. This is my favorite week. My family's from Ireland originally. So, I bring in all my goodies, all my flags all my stories, everything. The whole nine yards. I have a green box and they get to see it all. They get to see pictures of me as a kid they thought that was hilarious… It's a cool part of my life. So, they are excited for this and talking about it nonstop. Maybe I will videotape myself while we make Irish soda bread.

Dawn: Yes! Plus, that's a representation of who you are and bringing that in. Who you are matters, your culture, your history, your traditions., what you know, what you're passionate about and you get to share that with the kids.
Sara: Yeah, they were amazed by a lot of it like they were like seriously and I'm like yeah seriously.
Dawn: You're going to have way better information than the average person about what these days really mean.
Sara: Yeah, they were amazed I brought in books too about leprechauns because there's all these misconceptions that you're supposed to trap a leprechaun and that's not how I grew up. You know. If you help a leprechaun, then they give you the pot of gold.
Sara: It's a religious holiday but I kind of edit that part for the kids you know.
Dawn: But we've taken that and turned it into something else.
Sara: It's totally different but it is what it is (Design Team Meeting 11, 7/23/2019).

Sara is incorporating a piece of her cultural identity into math instruction. Being Irish is an important part of Sara's identity and is included in her professional identity. She can bring a particular expertise to her teaching because of her lived experiences and cultural heritage. In this example, Sara is comfortable, intentional, and aware that she is bringing herself into the learning environment. I ask Joyce, who worked as a coach with primarily Somali providers, if she has observed cultural math activities done by the teachers she works with.

Dawn: Did you see a lot of culture-based math?
Joyce: You know what no. Actually, I tried to introduce a game we used to play back in my country [Liberia], a cultural math game and when I did that she was so excited that she's like 'we did this too I didn't know we could do this at school with the kids!' You know and she was so excited about it. It's just a game I was teaching the kids and they were all excited they wanted to play it more and more and she's like 'I know this game we used to play it in my country, and I didn't know I could do this and I'm like yeah you can do your culture things here with the children and she's like I didn't know that.
Dawn: Well, she didn't feel like she could do that.
Joyce: It's interesting. Just invite the kids and let's play the game.

Dawn: Yeah, I'm glad you were there to introduce it.
Joyce: She was so excited it brought back memories; you know happy thoughts of her childhood she was so happy that I introduced the game. She said, 'okay well I'll show them some more games.'
Dawn: Well, that was a meaningful learning activity for her growing up. She was playing but she was doing math. Gosh I hope people feel more encouraged to share that, but I wonder if it was really because it is culturally specific. Are people getting the message that this is the way you do math and it's only this way. Do you think people are getting that message?
Joyce: That's true they're probably thinking that way and because it makes them scared because they think I don't know how to teach it or something of that sort, so they don't want to engage in math activities because they feel like they need to do it a certain way and if it's not that way it's not math.
Dawn: hm you know because Sara is over here doing Irish soda bread. It's 100% math, I mean it's lots of other things it's science, but it's representative of who she is and we can add the math to it…I feel like that's something missing and if it's something that can help people feel more comfortable maybe that would be really worthwhile to share examples like that. There's something there about people feeling more comfortable about math.
Sara: I think a lot of misconception about what math is happens too. They're not just sure about it so when you see the activities, they're like oh I never thought of that, or I really like that.
Dawn: Maybe that could be part of our next posts. Some activities or games that are based on your own culture that are math related. Like you were going to film your Irish soda bread?
Sara: yeah, I'm hoping to (Design Team Meeting 11, 7/23/2019).

When bringing their own culture into the learning environment, there is a striking contrast in teachers' comfort level. Sara, of Irish heritage, feels more comfortable and freer to bring her culture in than the African immigrant teacher Joyce shared about who is surprised she could do it all. This discussion resulted in learning outcomes for the team, one of which was acknowledging that a teachers' cultural identity and past experiences are valid and can be turned into curricular and learning opportunities for children. The value of reinforcing and affirming that a teacher is doing the right thing is a strategy the team identified as being beneficial to teacher learning and Joyce is doing that in this example. This also connects to one of the team's design principles, *meaningful PD excites the children and the teachers.* For these

teachers, cultural-based learning was meaningful in their own lives, and they leveraged that to create learning opportunities for the children in their care. Furthermore, mathematizing is powerful because it undoes the idea that that there is one way of doing a math problem because it is about recognizing math learning opportunities anywhere. It also creates an opportunity to add math to children's typical learning environment. Traditional math instruction tends to focus on process because there are steps to follow or formulas to solve which reinforces the notion that that is one right way to solve a math problem. In this example Joyce in her role as a coach provided a different learning opportunity for the teacher to expand how she can teach math.

Summary of Implementing

The implementing action involved reviewing and reflecting on examples of teacher practice shared on the Facebook page which produced not only learning but also prompted the design team to collaborate in designing with peers and design the Math Moves resource. This prompted the evolution of the object to that of collaborating and codesigning with peers. The implementing action also highlighted several examples of transformative agency that expanded professional learning through assessment practices and incorporated their cultural professional identities cultural sustaining math practices. Ultimately, through this iterative process the design team expanded notions of how and what teachers should learn while implementing the object they created. Next, I wrap up my finding by exploring the last two actions in the expansive learning cycle, reflecting, and consolidating.

Reflecting & Consolidating Expanded Notions for Professional Learning

Engeström & Sannino (2010) describe these actions as, "…reflecting on and evaluating the process and consolidating its outcomes into a new stable form of practice" (p. 7). This was applied through moments of reflection and evaluation that occurred during design team meetings when reviewing the posts and more explicitly in interviews with team members. This section will explore the reflecting action in detail but first I will address consolidating. In terms of consolidating, the Facebook page continues as a resource for anyone interested in early learning math. Also, a community of practice was established as a stable form of practice in Teacher Toolbox and the Math Moves resource is available to participants in the Teacher Toolbox. This next section summarizes evidence of reflecting.

Reflecting: Designing as Professional Learning

Typically, this action is focused on reflecting on the process as it pertains to the object. However, in my study the subject-subject relations and subject-object relations were both part of the process. Therefore, the evidence for the reflecting action is not just about reflections on the process of developing the object but more so about how their professional identities and experiences shaped the objects. Reflecting occurred during design meetings and also from interviews. The following interview questions yielded more reflection results:

- How has being a part of the design team contributed to your own professional learning?
- What do you feel like this process did for you?
- What did you think about the final tools? What did you intend about the tool creation? What do you want these tools to communicate? What was the outcome for which you were hoping?

Several team members in their interviews expressed that being positioned as designers was a different learning experience for them. Dara shared,

> "I didn't come into this thinking that I was also going to learn too. It's like that activity we did in the first meeting about the best PD. This was good PD. When we were building

> the page and just chatting about what to put on the page, I wanted to come to the meetings just for that. Thinking about what posts to do that would help another teacher made me figure out what to do better" (Dara Interview, 9/24/2019).

Next, the process of creating professional learning made them more reflective and intentional about their own practice. Joyce shared,

> "This whole process is something I want to use when I'm coaching. I noticed in our meetings developing the vision and the posts it made me think about how I could do that with my programs. We can work on an area of their classroom, brainstorm, and design it together and check in about how it's going" (Joyce interview, 9/25/2019).

Mary an expressed a similar sentiment when sharing about what she learned from different types of programs.

> "I'm not in a family home, I'm in a center so what I need may be different than Diana or Rose but it's like when I had to think about what they need in that type of center and designing for them it was different. Like the assessment idea, thinking about what that could be assessing the kids so teachers will know better things to teach. It was nice you know because I had good ideas there too" (Mary Interview, 9/24/2019).

Dara, Sara, and Rose spoke about the benefit of learning from people in different program types as well not only on the design team but also through those they were able to connect with on the Facebook page. Dara shared about a post that a participant named Julie (pseudonym) made.

> "The fact that we're able to connect to different centers and different people with different teaching like Joyce's has been cool. The outdoor structures they're building and stuff like that was insane amazing. Rose had that contact and to bring that in with her people that are in her group was a huge plus because then we saw different you know different family styles. I felt like that was a huge thing you know" (Dara interview, 9/24/2019).

Sara moved out of state during the process and but spoke to the network.

> "Even though I moved to Iowa, and it is much later right now, I pretty much came back to keep connecting with the team. I'm learning from them too. My new boss says to me I love your coaching she said you have fresh way of doing things. I said let me show you something, so I showed her Facebook page and tell her about the project. She asks me to share my resources from the STEAM project and so I start coaching my new coworkers for a few weeks. We just had a check in, and she says I'm noticing a change

> you know, and I was like impressed and I was doing something right" (Sara interview, 9/17/2019).

Finally, Rose commented on the power of connecting for learning,

> "Rose it's that spiral of learning know where it goes another level deeper when you reengage with it and I think the Facebook page is similar you're reengaging with things that you've done because you're teaching them to someone else or you're sharing them with someone else or I think that makes it that makes us better teachers. We needed to be together to do this" (Design Meeting 11, 7/23/2019).

The team is sharing expanded notions of professional learning that they find valuable but are also impacted other educators as the work extended to the Facebook page. For Dara, she learned through planning with teachers in mind which also benefited her. Joyce intends to design with her coaching clients. They also spoke about the benefits of learning from an expanded network of teachers in different program types and having a broader source of professional learning that spans beyond local communities. Rose described it as a spiral and saw the Facebook page as an additional learning opportunity because she could re-engage with instruction when teaching someone else about it. Also, they indicate that designing for their peers also made them learn and grow in their own confidence in their abilities. These examples share the benefit of learning from each other which was clearly a value for them. Collaboration is another example of the relationality that the team valued and felt was necessary to the process. Both Diana and Sara saw the value of collaboration.

> "It never ever actually really gets to happen right like when you get to see another teacher or talk to this depth about what you're doing. I guess when you have other opportunities for that we went to visit someone else's home but through this process and really getting to know each other and having this collaboration and the team we've built that has really been helpful it's the difference. Like somebody was teaching in like a one room school room I think and then to see how they're doing things too that was cool. I like how all these different people come together and work together, you know. Now on Facebook, it's even more, it just added that too. It's in different homes and centers and you see how different people are doing things you know and the different

> ages. So, it's the community it's that community of practice I love it there we go support each other from that" (Diana interview, 9/18/2019).
>
> "Collaboration is the interesting part because I don't have the same history as Rose who has years of teaching and Diana has a different way of doing things the visual schedule thing made me think of that because I was like it was in a video it had shared our circle time it is it's on one of the episodes that's of her yes where the little girl is actually going through the schedule yeah so part of that like maybe think of her like that's like no I don't even know that like that was something I learned from her and you know like the collaboration and learning from each other is such a huge part of our field yeah you know and being able to do that is a huge plus yeah I love that part of it. Communities of practice you know that's like a next step for them to begin learning and they should be more like this where you can collaborate and build something together" (Sara Interview, 9/17/2019).

Diana is speaking to relationality as the thing that made the difference for her because the team had time to get to know each other and the collaboration amongst them was helpful which became even more powerful when expanded to a larger network on the Facebook page. It was a similar benefit for Sara to learn from people who have different professional experiences from her. They both speak to the value of being in community with each other and furthermore that there should be more opportunities for teachers to learn and design together. Sara highlights how this design space was different from that of a community of practice because here they were object oriented and could collaborate to build something together.

Chapter Summary

This design team of dedicated early learning professionals created two resources to support early math professional development and formed their own collective professional identity. The implementing action shed more light on their experiential expertise which they harvested into professional learning solutions for their peers. The team has remediated their role as professional learning designers and views themselves as leaders. These roles enable them to create with teachers in mind and for their benefit. Their reflections reveal the values

they hold for collaboration and learning from and expanded network of peers. Through their desire to connect and learn from peers the team evolved the object into that of collaborating and codesigning with others Finally, the design team has provided us with expanded notions of learning and valuable lessons for educating teachers. In the next chapter, I will discuss the findings in relationship to the literature and my conceptual framework yielding implications for theory and practice.

Chapter 6: Discussion and Implications

In this dissertation, I explored how early childhood teachers could codesign early childhood math professional learning, their collective professional identities, and agency. I sought to understand how the positionality of a group of ECE teachers whose role in professional learning is typically passive recipient was remediated by the design process. I argued that when teachers design professional learning, their expertise is elicited, creating an opportunity to surface and shine on valuable contributions to professional learning. The design process also allowed teachers to do a deep dive into the content area of focus and their own teaching practices. Collective engagement with other educators led to the evolution of codesign, cultivating their own individual transformational agency. In addition, by positioning teachers as designers, and welcoming them into that role, we move toward more equitable professional learning development. This research speaks to the diverse forms of learning that are possible, relating to my conceptual framework for expansive learning theory and PDR principles. Lessons learned on factors that aided ECE teachers designing professional learning and resulting recommendations of best practices lead to implications for the field. Facilitation was key in this process; thus, I offer emerging facilitation design principles. Finally, the implications for policy makers broaden the scope to how decision makers and systems folks in ECE can support teachers designing professional learning.

Implications for Theory

In this first section of my discussion, I offer theoretical insights into the use of iterative cycles in design-based research. I highlight two contributions to theory regarding relational dynamics and the forms of learning that emerge. Specifically, this study offers theoretical

implications that expand knowledge about how relationality can elicit experiential expertise and the necessary factors to facilitate processes of partnering.

Designing the Object

The findings explain in detail the tools that were designed to develop the object, how that development occurred, and the facilitation that supported the process. Within that context, the team utilized several approaches. One, we selected an expansive learning cycle to magnify an existing professional learning, and within that, the team employed iterative cycles to develop the object. Two, I illuminate the facilitative moves necessary for fostering epistemic heterogeneity, multivoicedness, and historicity in the design sessions. Third, the centrality of relationality in role remediation is underplayed in existing theory. The findings indicate that relationality impacted how the team generated a collective professional identity through role remediation, leading to transformative agency.

Iterative Cycles Within Expansive Learning

This study uses expansive learning theory (Engeström, 1987; 2001) to generate expanded knowledge about ECE math professional learning (Engeström, 2001). The design team engaged two different iterative cycles within expansive learning that allowed them to expand and innovate. The first was a reflect-brainstorm-articulate-model-refine process that aided in idea generation and composition of the Facebook page. This process emerged as necessary during the questioning, analyzing, and modeling learning actions because it allowed us to expand into something new within the existing PD intervention. We began with reflecting on meaningful learning experiences which opened the activity system to questioning. The reflecting promoted plentiful brainstorming, aided by the epistemic heterogeneity and

mulitovoicedness in the activity system. The articulation process involved sense-making and decision-making to narrow and articulate what tools to model and then refine. This iterative cycle proved fruitful and productive, reflected by completion of the design by the fourth meeting.

During the implementing action, findings revealed the team engaging with a slightly different iterative cycle in which they could be responsive. The iterative cycle during implementing (review-reflect-brainstorm-articulate-model) led to the creation of a second tool: the Math Moves resources. For this study, the implementing action included the design team reviewing the Facebook page posts, reflecting on the posts, and honing in on their own teaching practices. The intention for creating the Facebook page was twofold – to understand and learn from other methods for teaching math concepts and, as professional learning designers, to respond to and create ongoing posts and interactions. Furthermore, because the team believed in the experiential expertise of teachers, they sought to codesign resources with peers on the Facebook page, thereby evolving the object. The review and reflection on the posts helped them identify an additional tool to address the object which became the Math Moves resources. For example, as the data showed, in one meeting while reflecting on the posts they entered a discussion about 3D objects and identified a content gap in the existing PD intervention. As a result, they entered a brainstorm-articulate-model iterative cycle to create the Math Moves resource.

Facilitating Processes of Partnering

The facilitation employed was key to moving the process forward, and intentional moves focused on goals to promote PDR principles, ultimately resulting in increased agency for

the design team. Bang & Vossoughi (2016) offer this question that can be examined using PDR: "If and how did processes of partnering and enactments of new learning environments manifest heterogeneity and cultivate transformative agency?" (p. 184). Approaches to facilitation were key processes of partnering to foster the relationality, epistemic heterogeneity, multivoicedness, historicity, and agency necessary to develop the object. This facilitation was important for several reasons. One, the team needed to feel encouraged and safe to share their own experiences and perspectives. Two, ECE teachers are infrequently positioned as designers of professional learning; instead, their typical role in professional learning is passive recipient or, if given the opportunity, reviewer, and feedback provider. Thus, I argue it was necessary that this activity system used intentional facilitation moves to create a space where those elements were possible. For this study, I define intentional facilitation moves as planning prior to engagement, responsiveness during engagement, and guided by intentions or goals to achieve the object. In other words, if my goal is epistemic heterogeneity, there are specific facilitations moves I need to make to foster that goal. To that end, I will discuss my goals and how I addressed them using intentional facilitation Also, I offer emerging facilitator design principles and recommend facilitator reflection questions for self-examination.

Alcantara & Geller (2017) describe their experiences with PDR as a heart, not only because relational work requires heart, compassion, and empathy, but more specifically because – as they put it – "There is nothing accidental about the heart. It has been perfectly designed, whether by a higher power or evolution or both, to function exactly as it does. Every vein, artery, chamber, and valve is placed in the exact position it is meant to be" (Alcantara &

Geller, 2017, p.5). They go on to explain that this metaphor does not imply PDR is a precise process, rather that every aspect of the activity system is integral and dependent on the other. This quote resonates, capturing an eloquent description of the design space and constantly present relational activities, sometimes in the background but always essential to the functioning and health of the group and group process. The experience of conducting this research allowed me to compare this metaphor to the role facilitation played in the design process – always present and integral to the function of the activity system but varied in its approaches. Every question asked, every PowerPoint prepped, every activity planned was not only intentional, but meant to facilitate a design space of epistemic heterogeneity, multivoicedness, support, respect, and belonging to promote agency.

Intentional facilitation starts with planning prior to engagement to identify goals, consider best practices and determine approaches to aid in the creation of the object. Analyzing the data to address my research question about facilitation revealed that I had decided on some approaches to facilitating prior to engagement, informed by my own professional experience and findings from the literature review. Because ECE teachers are at times viewed as less prepared than other teachers, my goal was to take a philosophy of abundance (Brown, 2019) approach to facilitating, thus entering the process believing the team had valuable contributions to make for professional learning. The IOM NRC report (2015) suggested policy leaders need to take direction from the workforce in policy decisions, which amplified my goal for a teacher-led activity system. I personally decided that my role was to be of service to the group, meaning I would provide the support and resources they needed to design, and I would take their direction and follow their cues. Lastly, my goal was for the team to feel ownership of

and agency in the activity system, that it was their space to work within to achieve the objective. Ishimaru, Rajendran, Nolan, & Bang (2018) speak to the need for "…powered boundaries to become more permeable" because power is at play in the activity system. I sought to make the ownership over the space not only permeable but collective; when the space is theirs, the professional learning created is truly fueled by their input, and in response to their needs, not determined by outside forces.

Related to this notion, I want to highlight the roles of power and division of labor that made space for epistemic heterogeneity and agency. PDR moves to desettle normative hierarchies between researchers and those being researched (Bang & Vossoughi, 2016). In this study, it was not about power shifting from me to the team; from my perspective, my level of power never changed, nor did I have to cede my power. The teams' scope of what was possible and within their reach increased. For it to be more equitable, it was not about a shift in power, but rather about their increased agency. Asymmetrical, white, and normative assumptions about power indicate for others to be empowered something must be given up (Ishimaru & Takahashi, 2017). If it is transactional, there is power given and something else gained, or those in leadership roles must give power to uplift and empower others which is to assume they did not have power in the first place (Diamond & Spillane, 2016). I argue that intentional facilitation with the goal of fostering agency helps to recognize that the design team *already* had power and needed the time, space, and permission to enact it.

The relational processes of partnering helped to shepherd the enactment of their power and agency. As we continued meeting, the team evolved into facilitating itself and assigning tasks to any of us with ease; they felt more comfortable leading and asking for what they

needed. The team let me know how to support them, and I also offered ideas for how I could best support them as well. One of the powerful findings from this study involves the division of labor, as I purposefully did not enter the design process delegating pre-determined roles. From my perspective, that approach would be limited, not allowing for role remediation or opportunities for transformational agency. Thus, in this process, the team determined what was needed and asked for resources or tapped into each other's experiences to execute the work. For example, since Mary was familiar with Facebook groups, she took on writing the community rules, and in the implementation stage for creating planned posts, I was assigned the job of posting. This approach leaves space for increased agency, easing the role remediation process but also providing the freedom of possibility; this openness contributed to a space of epistemic heterogeneity.

Prior to the first design meeting, I was intentional in planning for epistemic heterogeneity, multivoicedness, and welcoming their historicity in the activity system to achieve our objective of designing together. In the recruitment email to participants, I set the expectation that we would be creating something new, and that everyone would be invited to share, bringing in their historicity and professional experiences for our introduction activity. My approaches to facilitating during engagement required awareness, creating space, and making the right responsive moves in the moment to achieve the goals and objectives. The "right" responsive moves are tied to intentions for the engagement. For example, when the team started facilitating the meeting themselves, it signaled that my intention for the team to feel ownership over the space was successful. During the fourth meeting when the team was focused on assessment, they discussed ways of assessing that made connections to curriculum

and learning outcomes. During the discussion as a facilitation move I asked, “Do you think it would be worthwhile to come up with something that talks about the whole cycle you’ve been talking about?” With this move, I was checking to see if I understood correctly while at the same time offering inquiry to help make this topic actionable. This facilitation modeled expansive epistemic heterogeneity, encouraging them to imagine what it would look like if action were taken. It was also strategic to pose it in the form of a question; it was not a decision on what to do, but a way to move the discussion forward to a desired outcome. Even though the activity system was rich in epistemic heterogeneity and multivoicedness, it was necessary to keep focused on moving towards the object.

For this discussion, I will not review all the facilitation moves since they are explained throughout the findings. Instead, I compiled the moves into a table aligned with the goals I sought to foster to illustrate the moves I made, and how they addressed my goals and intentions. I offer these as emerging facilitation design principles and recommend facilitator reflection questions.

Emerging Facilitation Design Principles

Intent/Goal to Foster…	**Facilitation Moves**
Relationality	• Have participants introduce themselves in a way that connects to the object for instance, “name one word that describes your favorite PD experience.” • By being warm and welcoming you send the message that the participants’ presence is welcomed. • Leave time for connecting on a personal level if participants initiate it. • Offer consistent communication and follow-up because routines can build security. • Your own transparency can put participants at ease. • Allow the freedom to address their needs and stay engaged such as eating, standing up, taking breaks, etc. Let people

	know they are free to eat, get up, do what they needed to do to engage. Begin and end on time.
Epistemic Heterogeneity	• Plan activities that elicit contributions from each person via a variety of means such as written reflections, small group discussions, think-pair-share, etc. • Show the team you are writing down what they say because it reinforces its importance. • Provide thinking time before responding.
Multivoicedness	• Ensure everyone can contribute. • Attend to non-verbal cues. • Set the expectation from the beginning and frequently that everyone needs to contribute. • Provide a variety of options and time to contribute. • Listen. • Making space and provide wait time. • Do not offer your ideas unless it is needed as a prompt or an example.
Historicity	• Ask for prompts about their experiences. • Identify and pull in their shared experiences to identify common ground. • Validate their expertise and experiences.
Agency	• Notice when the group starts to facilitate itself and cede the facilitation role. • Redirect the decisions to the team. • Encourage the direction the team was taking. • Follow their lead. • Do the tasks the team assigns.

Table 7 Intentional Facilitation Planning & Moves

Recommendation: Facilitator Reflection Questions

- When facilitating a particular group, what is your intention or goal for the group?
- What facilitation moves can you plan to achieve the goal?
- How will you create a space where everyone feels comfortable sharing or talking?
- What do you need to prepare? (resources)
- How do you want the participants to feel leaving the meeting?
- What would motivate the participants to participate again?

Relational Dynamics: Transformational Agency through Role Remediation and Collective Professional Identity

When addressing relational dynamics, Bang & Vossoughi (2016) assert, "By working to amplify subject–subject relations, we seek to open up a range of insights on learning that only become possible when we attend more deeply to the ways designs for learning and processes of partnering organize for particular kinds of interactions and relationships, as well as the ethics and values embodied in these relationships" (p. 179). In other words, by attending to subject-subject relations in design processes, we can understand more deeply the processes of partnering, organizing for interactions, and the values embodied in these relationships. In my study, I want to highlight two relational dynamics that helped me understand processes partnering, the values embodied within, and the transformational agency that was cultivated as a result. The first address's role remediation into professional learning designers and the second is about their collective professional identity.

The team's role was remediated into designer through positioning, but more specifically the processes of partnering cultivated their own and others' transformational agency. As the typical role for teachers in professional learning tends to be as passive receivers of such, this study sought to introduce and understand the role of teachers as professional learning designers. Through the process, they exhibited behaviors illuminating their role as designers, such as when, while discussing an issue, they shifted to developing solutions. Examples of this include, in the first meeting, when Joyce suggested developing a tool that focused on math terms, or Mary's suggestion to use materials as mini pre and post assessments to understand what children learned. In short, they understood the assignment was to develop professional Learning. More deeply, they truly embodied the designer role when embracing their agency to

design another tool, the Math Moves resource, and to do so by codesigning with other educators on the Facebook page. Their roles had been remediated to such a degree that the object evolved, and at that point in the process, during meeting six, the team truly felt the agency, motivation, and inspiration to design another tool for and with their peers. This agency was greatly influenced by the strong connection they felt as a team, as they seemed motivated to collaborate and continue designing together. Ishimaru, et al. (2019) describe transformative agency as breaking from and taking initiative to transform activity. The team sought to cultivate that with peers through creating the Math Moves resource. Being in an activity system where their historicity was welcomed, and epistemic heterogeneity was thriving cultivated transformative agency. The more time we spent brainstorming, building off each other's ideas, and truly valuing experiential expertise, the greater their sense of agency and ability to mirror those experiences with other educators.

Another aspect of role remediation is the way they perceived their own identity and purpose as a group; their collective professional identity is further evidence of transformational agency. Relationality was expanded by role remediation (Bang & Vossoughi, 2016), as the team members entered in as individuals, but during the process shifted to a collective, which was clearly articulated in the Facebook page vision statement. As Bang & Vossoughi (2016) argue, "the proposition here is that the expansive forms and configurations of relationships that produce transformative agency and enable new learning and ways of being will necessarily be characterized by engaging heterogeneity" (p. 184). In my study, through engaging in heterogeneity, the design team members came into the design space as individuals but along the way evolved into a collective professional identity that produced transformational agency.

> "We are a community of early learning professionals with beginning, moderate, and high math competence, coming together to ask questions, give feedback and encourage each other in using math through everyday activities with young children. You're all welcome here. We all teach in different settings. Let's learn from each other. Share what lights you up. This is a place where math can grow...teacher-to-teacher. It's a place to come when you're stuck to get unstuck. Teach math through play!" (Vision statement).

This speaks Bang & Voussouhi's statement about the "ethics and values embodied in these relationships" (2016) because the vision statement exemplifies what they value in their purpose, the relationship with each other, and the relationships they sought to build with participants in the Facebook group. This collective professional identity finding also resonates with the solidarity-driven codesign notion of multiplicities in identity (Ishimaru & Bang, 2022), where one holds and enacts various identities holistically, not switching from one to the other. In this study, the team's collective professional identity is representative of their professional identities, histories, knowledge, experiential expertise, and values about professional learning holistically brought into the activity system.

The design team valued community and connection as forms of professional learning which they cultivated for themselves as a team and mirrored in the creation of the Facebook group. Evidence for community and connection exist throughout the findings; for example, 22% of the ideas they brainstormed were about connection, the team continued to meet longer than expected, in the first meeting the idea of a blog site was mentioned, and the team members expressed how much they were learning from each other throughout the process. Further, their desire for connection and ease of access to the PD they could share through the Facebook page, made it possible to maintain that connection outside of design team meetings. The intentional facilitation moves to foster multivoicedness and epistemic heterogeneity

enhanced subject-subject relations that were incredibly valuable to the team. Edwards (2005) describes this as relational agency,

> "In CHAT terms relational agency is a capacity to work with others to expand the object that one is working on and trying to transform by recognizing and accessing the resources that others bring to bear as they interpret and respond to the object. It is a capacity which involves recognizing that another person may be a resource and that work needs to be done to elicit, recognize and negotiate the use of that resource in order to align oneself in joint action on the object." (Edwards, 2005 p. 172).

As Edwards highlights, the team saw not only themselves as resources but, by extension, the participants, and activities on the Facebook page. As Rose put it, "Isn't the best thing you've ever learned from another teacher" (Design Meeting 2, 10/30/2018)? In this way, the subject-subject relations shaped the objects which paralleled the design team's experience, and virtually, was able to reach a wider audience. Further, this desire to connect with a larger audience of teachers speaks to social capital as Russell, et al. (2017) describes, "Within the organization of the school, teachers can learn from others in their local contexts who have adapted innovations given similar students and other curricular elements and additional aspects of the organizational context and who have an interest in supporting others" (p. 172). This aspect of social capital highlights that when teachers share their knowledge with others, the collective capacity and knowledge benefits; I argue this team sought to spread that to an even larger network through the Facebook page.

I want to take a moment to distinguish how the design team functioned differently from a community of practice and briefly touch on the corresponding theoretical differences between activity and situated theory. Although the team members have experiences in communities of practice, there is a theoretical difference between an activity system and a

community of practice. I take up activity theory which is object driven whereas CofP's situate learning in community. Arnseth (2008), in their article distinguishing between the two theories explains, "Activity theorists emphasize that practice should be conceived in a broad sense, that is, as transformations of activity systems. Lave and Wenger (1991), on the other hand, tend to conceive of practice as pervasively social and relational" (p. 295). Addressing problems of practice, brainstorming, and pulling from your own experiences to offer solutions are similar processes at work in communities of practice. However, I argue, the act of planning and creating professional learning for peers made them designers because it required them to pull from their own experiences, tap into their experiential expertise, and compile that into a tool that communicated effectively with teachers. These activities differed, as their thinking shifted to designing for others, which necessitates understanding the needs of the audience and of which practicing teachers are obviously capable. The team realized the distinction themselves when Rose differentiated this experience from previous communities of practice. As designers, the team tapped into experiential expertise, previous knowledge, planned with intention, and utilized resources such as the design principles for the literature created and designed to address an identified problem of practice. The combination of these marries experiential knowledge with research knowledge, fundamentally resulting in a codesign process. Van den Akker & Nieveen (2021), in their description of teacher design teams (TDT) point out, "When TDTs do cooperate with (external) researchers in CDR, chances increase that these teams strengthen the relationship of the new curriculum with theory, the systematic way they collect their data, and the articulation of their lessons learned with the help of design principles" (Van den Akker & Nieveen, p. 52). These qualities place this study in activity theory since the focus is

designing, which differs from a community of practice that is situated in learning and changing practice through participation in community (Arnseth, 2008). The graphic below depicts the similarities and differences as applied to this study.

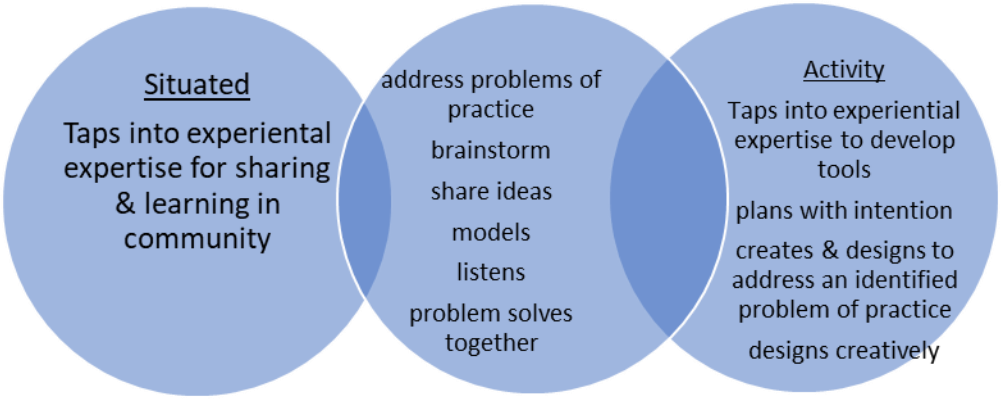


Figure 6 Situated vs. Activity Theory

Relationality Fosters Experiential Expertise and Produces Teacher Learning

Reflection, sharing, and modeling are relational learning processes that surfaced the team's experiential expertise and shed light on teachers' deep knowledge about how young children learn that is often untapped in professional learning development. I take up Bang & Vossoughi's (2016) approach to developing learning theory as a part of DBR research as they explain that PDR is committed to "…advancing fundamental insights about human learning and development through explicit attention to what forms of knowledge are generated, how, why, where, and by whom" (p. 174). Multi-faceted learning occurred throughout this study, but for this discussion I want to highlight aspects that were significant to this design process. These learning processes are also mirrored in the team's emerging design principles. Furthermore, I

couch their experiential expertise within the principle of historicity because it accounts for the past and present mental models of individual participants and their experiences in an activity system (Arnseth citing Engeström, 2008).

Reflection, Sharing, and Modeling as Vehicles for Teacher Learning

In this study, reflecting was a significant process for teachers learning about one's own practice and from reflections on seeing examples of teaching practice. The design team created professional learning that aligns with several elements that Schachter, Gerde, & Hatton-Bowers (2019) argue are quality PD. Their article providing guidance for selecting PD indicates that opportunities to observe teaching in action and opportunities for reflection, and using technology in appropriate ways, are PD formats for quality PD experiences.

I argue that in my study we expanded beyond the basic repertoire of professional learning experiences into teacher-centered and relevant experiences informed by experiential expertise. Of the team's 12 emerging design principles, six of those were about reflecting, sharing, and modeling such as, modeling is motivating, show me what it looks like, reinforce practices by sharing with other teachers, sense of community because it's not just what's happening to me it happens to others (Design Meeting 3, 11/6/2019). These design principles were developed as a result of the team's reflections on meaningful learning and valuable PD experiences for ECE teachers. Guided by these relational design principles, the design team developed professional learning opportunities that also centered their peer's experiential expertise and sought to surface it by creating activity and interaction on the Facebook page to promote reflection, sharing, and modeling. This type of professional learning experience moves beyond the typical attendance at a training to an *experience* where the teachers are learning

and growing through being designers and specifically from reflection and planning for their peers. Van den Akker & Nieveen (2021) explain a similar point regarding teacher design teams engaging in curriculum design research,

> "However, regardless of the specific education sector, the strong point of TDTs working along a CDR approach is that it matches the zone of proximal development of teachers. Lesson preparation and planning belong to the daily work of teachers. Expanding that basic repertoire of activities to more collaborative, curriculum-oriented and research-supported patterns is beneficial for both teachers' learning and curriculum quality" (van den Akker & Nieveen, p. 60).

The design team's theory of change for professional learning helped teachers realize math is all around them, and if they were given the time to reflect and notice, their peers would realize opportunities to mathematize and provide math instruction. This speaks to Johnston & Bull's (2021) argument that teachers need to feel more comfortable and confident about their own math skills and their ability to foster mathematical thinking in children. The team's professional learning solution to this issue was to promote sharing and reflecting on math practice to provide examples of math learning opportunities through posts on the Facebook page. Furthermore, I argue that the design team's efforts to codesign with their peers, thereby cultivating their transformative agency, opens the possibility that the learning can spread and "ripple across space, time and communities" (Ishimaru & Bang, 2022, p. 137). This notion comes from the solidarity-driven codesign principle of cultivating ongoing transformative possibilities, which I argue the team did by codesigning with peers.

This design process, through reflective learning discussions, surfaced experiential expertise that provided multiple specific and relevant examples of teaching practices from which we can learn and grow. Across multiple meetings about assessment, the team reflected

on how they as teachers understand what children know, concluding there must be multiple methods and opportunities within typical play activities for young children to demonstrate their understanding. For example, children can demonstrate knowledge by teaching a peer or by parents reporting observations from home. The team's discussion was an example of expanding the notion of assessment beyond compliance and illustrating how it is a natural component of the learning cycle for children. Furthermore, since they were positioned as designers, they provided examples that could be shared with others to broaden the knowledge and experience base.

Another example is the discussion between Sara and Joyce about cultural math practices, where historicity informs experiential expertise. Applied to my study, historicity acknowledges that design team participants bring in their accumulated histories, personal and professional experiences, as well as social and professional identities into the design space. This type of discussion, which brings out the learner's historicity, resulted in Sara feeling encouraged to mathematize her St. Patrick's Day celebration. Sharing that on the Facebook page motivated other teachers to do the same, like how Joyce's coachee was inspired to pull in math activities from her home country after Joyce modeled it for her. In this example, reflecting led to sharing and revealed an example of modeling from Joyce that was a learning experience for all of us. This dissertation would be much longer had I included the plethora of experiential expertise examples that not only offered me inspiration and insights but could make contributions to and impact on professional learning. I highlighted these examples about assessment and cultural math practices as examples of the kinds of reflective learning discussions that can happen when teachers are positioned as designers. These reflections pulled on their immediate experiential

expertise, adding increased relevancy to the design process, and offering tools that better reflect teacher's needs.

Implications for Policy & Practice

In this section, I share implications for professional learning policy and practice. I will discuss several lessons about developing professional learning with this design team that contributes to broader professional learning efforts. To that end, I offer recommendations for teacher-designed professional learning. I also make the argument for a shift in perspective about the professional learning needs of teachers and urge the field to increase opportunities to surface and value teacher expertise. Finally, I argue that in addition to continue receiving professional learning, ECE teachers' experiential expertise is a sufficient reason to consider them invaluable contributors to professional learning, and thereby creating more equitable professional learning development.

Professional Learning Policy & Practice

Typically, a teacher's role in professional learning is limited to that of recipient or feedback provider by request while it is being developed. This was evidenced by the scant amount of empirical evidence for teacher-designed professional learning. I argue that a more equitable approach to professional learning is to position teachers as designers and provide time, resources, and compensation for this collaborative process. The professional learning landscape for early childhood teachers is varied, complicated, and often comes at a financial cost. Yet, it is important that teachers have high-quality professional learning opportunities. The *Transforming the Workforce for Children Birth-8* report (IOM and NRC, 2015) emphasized the need to have a well-qualified workforce that can create high-quality early learning

environments because those environments produce the best outcomes for children. This study provides evidence that teachers' experiential expertise adds value and expanded forms of learning to professional learning opportunities. Teachers are honing their practice every day when planning learning for children; that same expertise can be harnessed to design professional learning for their peers. Teacher-designed professional learning increases the likelihood that the professional learning will meet the needs of practicing teachers. Educators can share their teaching practices and create opportunities for reflective learning expanding the potential range of what can be learned from teachers through virtual spaces.

Teachers need space, time, and compensation to engage in teacher-designed professional learning. Ishimaru and Bang (2022) emphasize that point, indicating that codesign teams that are rooted in their experiences need time and space for their work. Similarly, the design team made use of their time reflecting and accessing their experiential expertise. In this study with attendance varying, the team spent 20 hours in design meetings and some additional time engaging on the Facebook page. Also, given the high rates of teacher turnover in ECE and the long service hours of FCC programs (IOM and NRC, 2015), there are real challenges to engaging ECE teachers in design work. This behooves professional learning policymakers to develop strategies that can accommodate teacher participation, such as financial incentives for design work or utilizing substitute teachers to free up their time.

The Composition of Design Teams Present Codesign Equity Opportunities

Codesign presents opportunities for culturally rich math learning. Johnston & Bull (2021) call for more codesign in ECE math when they suggested that practitioner-oriented design processes are an effective means of professional learning about math for ECE educators. The

codesign literature is rich in studies about K-12 teachers and researchers designing math curricula for students while highlighting the learning that occurred for teachers as well. In some instances, there was an ECE focus, for example, Harper, Caudle, Flowers, Rainwater, & Quinn (2023) explored culturally relevant computational thinking harnessed from PreK families and teachers and found connecting computational concepts to familiar experiences rooted in families' and teachers' culture as an entry point for learning. Similarly, my study resulted in rich professional learning for the design team and included culture-based math activities as well when Joyce and Sara surfaced their experiential expertise and discussed math activities rooted in their own cultural experiences. This also speaks to the argument from Nasir & McKinney de Royston (2013) about the importance of attending to race, identity, and power in math learning because one's mathematical identity is shaped by race and power.

The composition of design teams shapes the outcome and pulling together a group of teachers to create professional learning is served by having a diverse group. Early childhood teachers serve in a variety of settings and as the literature review pointed out, are a diverse group of educators that can by age 18 start running a family childcare home. Taking the evidence for this study into account, ECE teachers who are more racially and linguistically diverse than the K-12 teaching population, have the potential to create relevant and engaging professional learning targeted to children's needs if engaged in teacher-designed professional learning opportunities. Potentially the group composition of teachers who are designing professional learning should capture the racial and linguistic diversity of the field. Providing bililngual teachers codesign opportunities creates enormous potential for developing professional learning in site-specific languages. The relevancy of their examples and

experiential expertise is needed and invaluable to advance our professional learning. Furthermore, the variety in settings and program types in ECE presents an opportunity unique from Teacher Design Teams as described by Van den Akker (2021) where the team composition is school based. Although physically located around the state, the design team members were in FCC's and centers in both urban and rural locations across the state with varying years of experience. This composition yielded learning experiences that they found valuable, connecting across different program types as Dara spoke to in the reflecting action, when she shared the value of learning from teachers who served in program types different from her own. Creating a group resume or expertise matrix would allow for discovering individual talents and collective benefits for each activity system. To further the idea of how to create opportunities for teachers to design, Penuel (2019) offers infrastructuring as an approach to support more equitable codesign by focusing on the structures and routines of systems to strengthen their sustainability, thereby supporting infrastructure for codesign. Following this logic, state systems focused on developing professional learning could examine their systems to create stable pathways for codesign. To that end, I offer recommendations for teacher-designed professional learning.

Recommendations for Teacher-Designed Professional Learning

1) Established knowledge in a content area, skilled in a particular teaching area, ardent desire to learn in a content area.
2) Object is established and clear – the object is the objective for professional learning.
3) Teachers determine tasks.
4) Needed supports and resources are provided as determined by the teachers.
5) Utilizes an iterative cycle.

Shifting Perspectives about Early Childhood Teachers

It is important to shift our perspectives about ECE teachers. I return to this quote from the introduction to point to a reason for the shift, "Although children are ready and eager to learn, many early childhood educators are not prepared to engage children in rich subject-matter experiences that lay the groundwork for success later in school and in the workplace" (Brenneman et al, 2009b; Clements and Sarama, 2009; NRC, 2001b, 2007; Sarama and Clements, 2009, as cited in IOM and NRC, 2015, p. 241). I agree that there is a need to prepare ECE teachers, but I argue for a shift in our thinking, that not only can we learn from teachers' experiences, but by positioning them as designers, we open doorways for important professional learning contributions in the workforce. While this study was specific to math, teachers can provide expanded approaches to teaching and learning in relevant and practical ways to enhance any rich subject-matter experience.

Another perspective I seek to shift is the deficit perspective, that teachers need to be filled with knowledge they do not yet have. Yes, of course everyone needs to grow and improve, especially those who educate others. However, disregard for the experiential knowledge and practices of many ECE teachers is often embedded in their professional learning, a source of injustice as they support the learning of an increasingly diverse population of young children, particularly from Black, Indigenous, and other People of Color communities. We do not create enough opportunity to learn from these vital educators. The philosophy of abundance toward policymaking would encourage policy makers to view teachers as holding experience and expertise, and would allow for them to be part of decision making and designing professional learning. Bang & Vossoughi (2016) argue that social

transformation needs to be a primary goal of design because it is through social transformation that equity goals can be achieved. The findings from this study expands our understanding of teacher professional identity, thus providing new possibilities for teacher positionality in the creation of professional learning and potential for social transformation.

Conclusion

This study explored a codesign opportunity for a design team of ECE educators to create math professional learning virtually and expanded not only their own practice but also that of their peers. The evidence supports that the design process was successful at, '…provoking and sustaining an expansive transformation process led and owned by the practitioners" (Engeström, 2011 p. 606). The design team met the original object of an expanded form of early childhood math professional learning designed to meet the literature-based outcome of professional learning for teachers which in turn, supports children's learning and development. In addition, this study yielded more outcomes. The process cultivated transformative agency as designers, the team solidified a collective professional identity, and the object evolved into codesigning professional learning with peers virtually. The codesign processes pushed the team to consider what and how children learn math and how teachers can recognize children's knowledge. As the object evolved into codesigning with peers, the team recognized they themselves and the children in their care were exploring learning how to learn. Valuable lessons materialized about what teachers choose to create insights into what teachers' value and want out of professional learning experiences, and evidence of emerging design principles heavily focused on sharing and learning from each other. Furthermore, it suggested that teachers themselves play a crucial role in developing the profession and training new teachers.

This research contributes to theoretical understandings about the learning that results from experiential expertise and through relational and reflective learning activities. Relational and collaborative learning opportunities illustrated how powerful it can be for teachers to be invited to design their own professional learning and, in this case, to define their own collective professional identity. I also included lessons about the importance of goal-driven intentional facilitation moves that support processes of partnering. Further, this study provides a new potentiality for how state ECE agencies can develop, partner, listen, learn, and fund professional learning differently. The argument could be made that more equitable professional learning is possible when teachers are positioned as expert knowledge holders and given the opportunities to design professional learning. Going forward, new possibilities for professional learning are available if the untapped potential of ECE teacher's experiential expertise is realized through codesign efforts to create professional learning as an answer to the call for high-quality professional learning in support of young children's learning and development.

Appendices

Literature Based Professional Development Design Principles

Literature Indicates Effective Professional Learning is:

- Sustains over time (Darling-Hammond & Gardner, 2017; Yoon, Duncan, Lee, Scarloss, Shapley, 2007; Buyesse et al citing Hill, 2007; Winton & McCollum, 2008).
- More beneficial when it is focused on specific content rather than general instruction (Darling-Hammond & Gardner, 2017; Buyesse et al citing Hill, 2007; Winton & McCollum, 2008).
- Developed using evidence-based best practices (NAEYC & NACCRA Training and Technical Assistance Glossary, 2011).
- Addresses the continuum of young children's abilities and needs (NAEYC & NACCRA Training and Technical Assistance Glossary, 2011).
- Incorporates adult learning theory in its delivery and provides opportunities for active learning (Darling-Hammond & Gardner, 2017; NAEYC & NACCRA Training and Technical Assistance Glossary, 2011; Sun et al, 2013 citing (Desimone, Porter, Garet, Yoon, & Birman, 2002).
- Aligns with standards and materials practitioners already use (Buyesse et al citing Hill, 2007; Winton & McCollum, 2008; Sun et al, 2013, citing D. Cohen, Raudenbush, & Ball, 2003; Correnti, 2007; Garet et al., 2001).
- Makes the link between research, theory, and practice explicit, grounded, and relevant (NAEYC & NACCRA Training and Technical Assistance Glossary, 2011).
- Responds to each learner's personal background, professional experiences, and the current context of their role (NAEYC & NACCRA Training and Technical Assistance Glossary, 2011).
- Uses models and examples of teaching practice (Darling-Hammond & Gardner, 2017).
- Continues the learning and is supported by guidance and feedback provided through coaching, consultation, and COP's (Darling-Hammond & Gardner, 2017; Buyesse et al citing Hill, 2007; Winton & McCollum, 2008).
- Fosters collaboration between colleagues in job-embedded contexts (Darling-Hammond & Gardner, 2017).
- Includes resources to ensure access for all (NAEYC & NACCRA Training and Technical Assistance Glossary, 2011).

Recruitment Email

Math Study Design Team (10/9/2018) – Email sent asking participants to be a part of the study.

Dear _____,

I'm writing to find out if you would like to be a part of the design team that is redesigning the content for the next math study. Instead of doing a study on positive behavior supports our executive director wants to dig deeper into math. This time around we are reaching out to teachers who were in the last study to design the professional development about math that the next set of participants in the study will use. It's an exciting opportunity to shape what that content will look like for many early childhood teachers and I'm thrilled to design something with teachers who do this work everyday!

Since there are teachers all across the state participating in the design team we will hold our meetings online using a video conferencing system called Zoom. There will be 4 meetings that will last for 90 minutes in Late October & November. There will be a bit of work in between meetings to try out the designs. We can offer $300 for being on the design team. Do Tuesday evenings work for you?

Take care,
Dawn

Confirmation and details for the first team meeting (10/18/2018)

Hello Design Team!

I am excited to get started next Tuesday Oct. 23 at 6:30-8:00. We will be meeting on a video conferencing system called Zoom. If you don't have a computer that's okay you can call in on your phone. I'll be on 15 minutes early so if you're concerned about connecting hop on early and I can help with troubleshooting.

In this first meeting we'll do several things:

1. Explain why there is a design team and what we hope to accomplish.
2. Get to know each other a bit better.
3. Reflect on a meaningful learning experience.
4. Review preliminary results from the pilot study
5. Next steps

Here's how to connect the meeting. Zoom also works on cell phones!

Computer:
Join from PC, Mac, Linux, iOS or Android: https://washington.zoom.us/j/364178639

Telephone:
Dial(for higher quality, dial a number based on your current location):
US: +1 669 900 6833 or +1 646 876 9923
Or iPhone one-tap :
US: +16699006833,,364178639# or +16468769923,,364178639# Or
Meeting ID: 364 178 639
International numbers available: https://zoom.us/u/acnMUqLmI

Interview Protocol

Semi-Structured Interview Protocol

Background

How long have you been teaching?

What ages of children do you teach?

Are you a: (These are populations that traditionally have lower access to PD & higher ed)

- Working parent
- Member of a marginalized group
- Low-income
- First-generation college
- immigrant

Describe your center? (Asking this question to get at the critical historicity to fully understand who these participants are)

What motivates you to teach young children? (Critical historicity)

Design Process (How do these teachers experience their own agency & growth in their personal development as professionals)?

What are your prior experiences with professional learning?

How has being a part of the design team contributed to your own professional learning?

How do you identify racially, culturally, gender, age, and to what extent does that matter in this process? Can you talk about a time when that mattered? What elements of your own identity did you bring to this process, culture, history, years of teaching experience, type of program you've been teaching in?

What piqued your interest about the opportunity to design math professional learning?

Think about a moment from our meetings that was particularly enlightening or impactful and why was it? Was there a particular moment that was challenging and why? Did you feel empowered & disempowered?

How were you able to contribute & collaborate in the design process?

- What supported or hindered that?

What if any were the moments you felt empowered or disempowered?

- Did you feel heard?
- We're their opportunities for you to express your views or desires?
- Let's think about the point in the process where we decided that we would have a Facebook group. Did you feel empowered? Did you feel heard?

What do you feel like this process did for you?

Tool Creation

What did you think about the final tools? What did you intend about the tool creation? What do you want these tools to communicate? What was the outcome you were hoping for?

What's the utility of the Facebook page for your own professional learning?

Codebook

- Questioning – Instances when questions are raised about the process.
- Analyzing - Following the process and flow of conversation and decisions that influenced what is developed/modeled.
- Modeling - The details of creating the tool. Specifically, how, and what was created.
- Examining the model - Instances of testing out the tool, reflecting on how it went and making any adjustments deemed necessary by the group.
- Implementing - What happened when things were implemented or tried out.
- Reflecting – Reflections on the object and design process.
- Consolidating - Instances when we came to agreement, resolved contradictions, and finalized the objects.
- Agency/role remediation – Any instance where a teacher mentions a shift or change in their role as a creator. Or there is a demonstrated shift in power.
- Brainstorming – Instances when ideas were generated about objects.
- Decisions - Moments when the group made decisions.
- Practices - Identify any time a practice is mentioned and whether that practice is currently in use, being refined, being examined, or is new or a refinement of a practice.

Characteristics of Meaningful Learning

What made the learning meaningful?

Being interested
Interacting in a playful manner made it stick
Music
Moving while you're singing made it the learning stick
Finding your own opinion and voice
Figured out how I learned best
Allowing yourself to have a perspective. Makes me think about how children see the world.
Affirmations about your work.
Positive feedback that made you feel heard
Made you feel confident
Choose your own topic
Hands-on activities
Learned from stories from tribes that were related to the real world. A holistic learning experience.
Movement & singing
Teacher recognized that you liked something and used that to help you learn.
Child-led example that demonstrated mastery of the concepts.
Child speaking up and advocating for what he needs as a learner
Communicating the learning back to the families and the value

Math Moves Resource

These will be reference cards we create that help teachers understand a math concept

Counting

Term	**Examples**
Cardinality: The last number counted is the total number of objects in a group	How many kids are here today?
Subitizing: Recognizing without counting how many objects are in a group.	Rolling dice and knowing instantly how many, layout 3 bears, blindfold child, remove one bear ask the child how many bears present or was removed?
Counting sequence: Counting words are always said in a specific order.	Countdown to blast-off!, dressing;
One-to-one correspondence: Understanding that you can assign only one number to an object.	Playing path games, setting the table, tray sorting. One sock for that foot. That's ONE. one sock for other foot. That's TWO feet!
Combining and separating: Putting together and taking apart sets to create new sets.	Separate boys and girls in the class. Count each group then put them back together and count again.

.

Measurement

Standard Measurement - tools that use standard measurements such as the metric system (meters, liters, etc.) or the imperial system (inches, quarts, etc.).

Non-Standard Measurement - using anything to measure such as ribbon or cups.

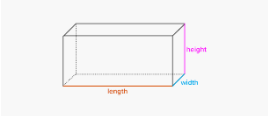
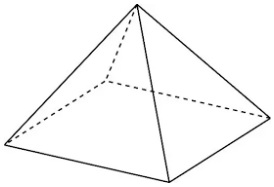
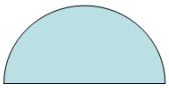
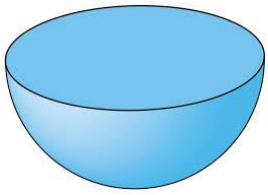
Measurement Attribute	Math Moves - Things teachers would say or do
Time	When is lunch? When will it be my turn?
Length	How long? How far?
Width	How wide?
Height	How tall?
Weight	How heavy? How light?
Volume	That cup is very full. How much rain did we get? Your cup is half full. Fill a cup ¼ full and say I'm filling your cup ¼ full.

	Introducing	**Emerging**	**Knowledgeable**
Time - using a visual daily schedule	Visual sequence cards that show the daily schedule. Could also add words to the visual. The most important part is the teacher talking about the visual schedule.	Adding time or a clock to the visual sequence card. Beginning to understand that parts of the day happen at a certain time. For example "mom will pick you up at the end of snack"	They know the schedule so well they can help another friend
Time - using a timer	Teacher sets the timer, talks about the amount of time that was set, and sticks to the time. The goal is to begin to help kids understand how long 1, 5, 20,	Children begin to understand how long something takes.	They would ask to set the timer and know how long to set if for an activity

	etc. minutes are.		
Time - vocabulary	Introducing time vocabulary and using it such as seconds, minutes, day, week, month, year, seasons	Teacher doing activities including time vocabulary words such as, the Montessori birthday song.	Using the vocabulary accurately

Geometry

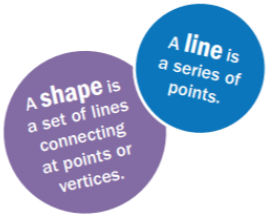
A poster for kids could have the examples and pictures of what to think of and post it in the block areas or others.

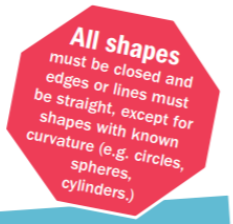
Shape Name	**Properties**	**Example**	**Teaching Moves- Think of..**
Rectangular prism (3-D)	3-D solid shape with 6 rectangular faces, 8 vertices & 12 edges Boxlike shape. Opposite faces are identical		Chest of drawers, trunk, box of crayons, cereal box, books
Rectangular Pyramid (3-D)	3-D solid shape with 4 triangular faces		Tent, architectural pyramids, some roofs
Semi-circle (2-D)	Half of a circle		Activity table, cheese, rainbow, a fan
Hemisphere (3-D)	Half of a sphere		A cereal bowl, half of the earth, half of a watermelon

Name That Shape!

2-D Shape Name	Properties	Example	Teaching Moves—Think of...
Circle	Curved line that closes		A full moon or drawing a sun
Triangle	3 sides, 3 corners		Tri = 3: A tricycle with 3 wheels
Square	4 equal sides, 4 corners		Quad = 4: Windows and houses
Rectangle	4 sides (2 longer than the other 2), 4 corners		A mirror, the side of a cereal box, or a graham cracker
Pentagon	5 sides, 5 corners		Pen = 5: Spelling P-E-N-T-A with 5 fingers, or holding a pen with 5 fingers
Hexagon	6 sides, 6 corners		Hex = 6: The "X" in six
Octagon	8 sides, 8 corners		Octo = 8: An octopus, October (the eighth month of the year), or a stop sign

3-D Shape Name	Properties	Example	Teaching Moves—Think of...
Sphere	Curved face		A ball, the earth, a marble
Cylinder	2 flat circular faces, 1 curved face, 2 curved edges		A can of food or drink, a straw, or a roll of paper towels
Cube	6 square faces, 12 edges, 8 corners		Blocks, a dice, or an ice cube
Cone	1 flat curved face (base), 1 curved face, 1 curved edge, 1 apex (top)		A party hat, a cone for ice cream, a traffic cone





When discussing or showing examples, it's important that children can differentiate non-examples (rounded corners or gaps where lines do not connect) from genuine examples of shapes.

childcare quality & early learning
CENTER FOR RESEARCH AND PROFESSIONAL DEVELOPMENT
University of Washington

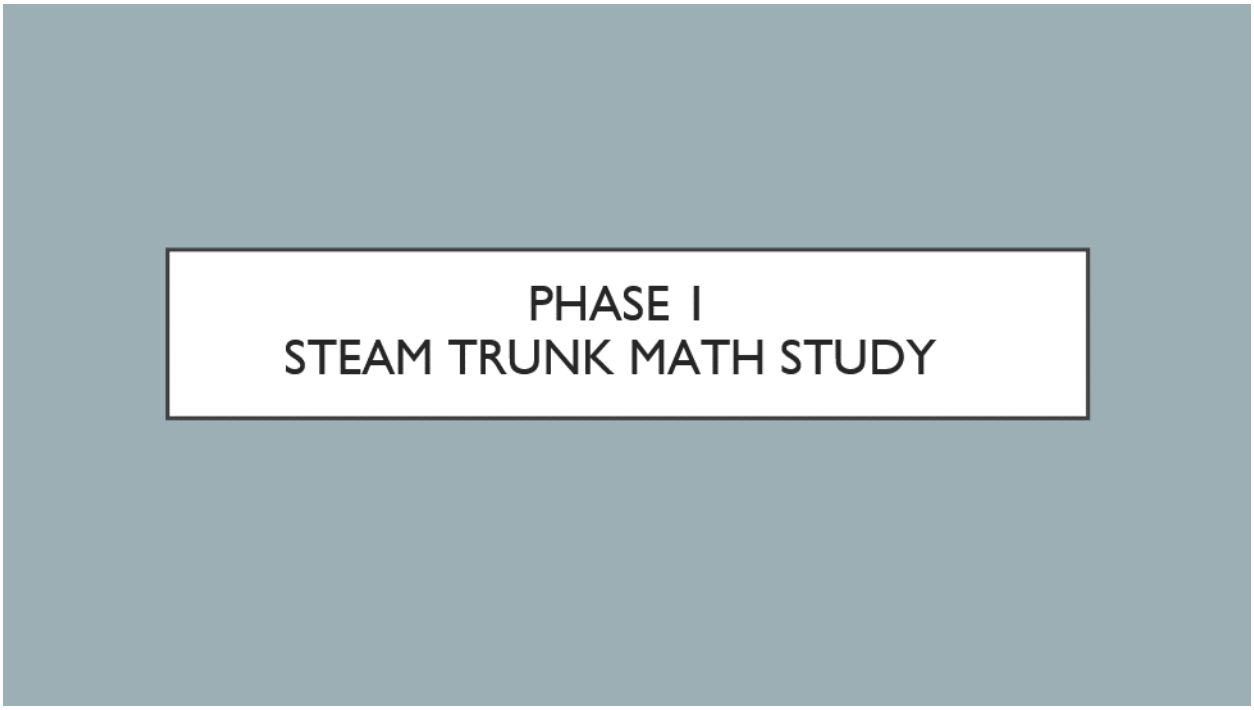
STEAM Trunk

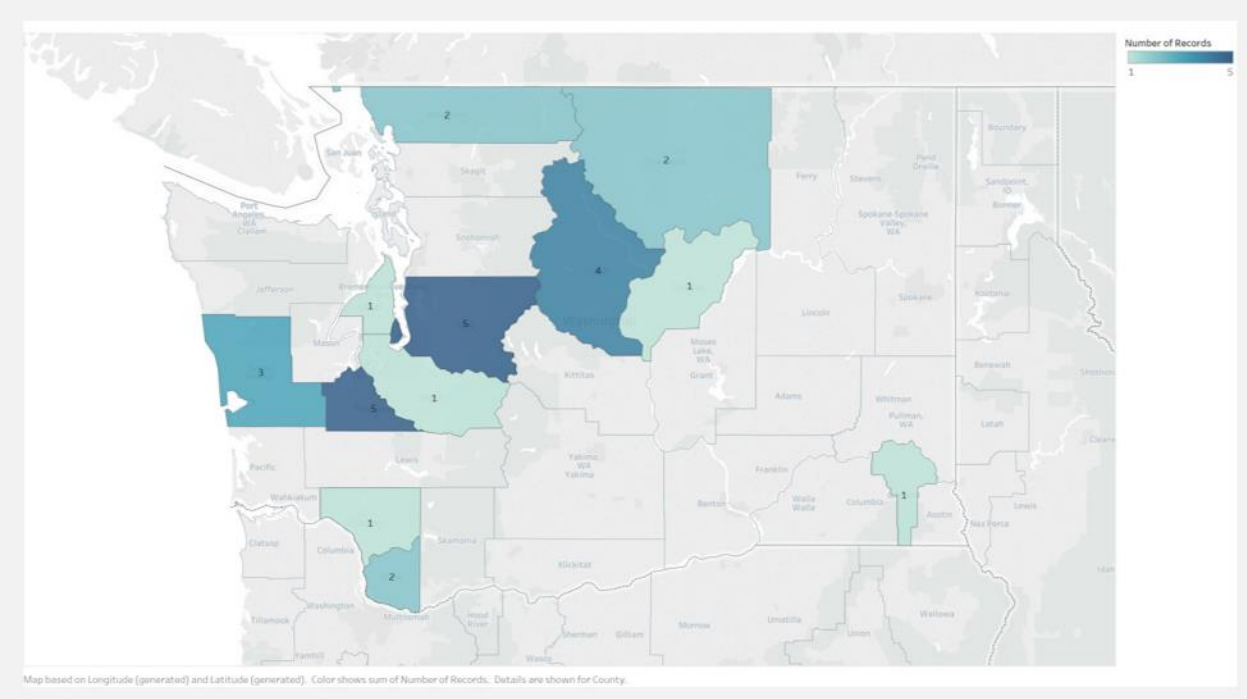
Patterns

Term	Picture	Examples
Repeating Patterns: These patterns contain a sequence of elements that repeats again and again.		Honey comb, flowers, clothing, sounds! Try taking a patterns hunt around the room or out on a walk. Draw attention to the patterns in everyday life.
Growing patterns: These patterns change, increasing by a same amount. Children can create a growing pattern by adding one more or		

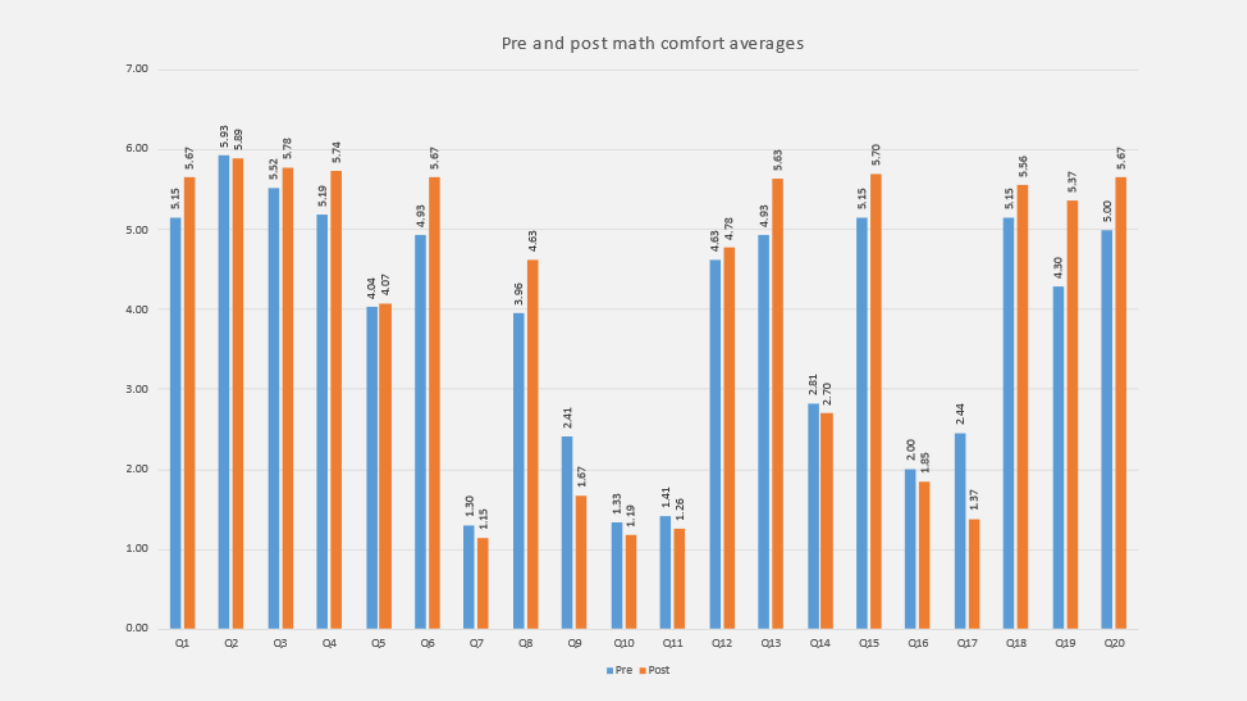
counting by 2’s or 5’s.		

STEAM Trunk Math Study Pilot Data





Counties where participants were from



Graph to show her that average comfort level went up for just about every question from pre to post

	I feel comfortable planning and demonstrating classroom activities related to counting (e.g. knowing number names and counting sequence)		I feel comfortable doing math activities with the young children in my care.		I feel comfortable planning and doing classroom activities related to math operations (e.g. addition, subtraction)		I feel comfortable planning and doing classroom activities related to measurement and data (e.g. describing and comparing things that are smaller or bigger, more or less, etc.)		I feel comfortable planning and doing classroom activities related to geometry (e.g. exploring and describing spatial relationships and shapes).		I feel comfortable planning and doing classroom activities related to patterns (e.g. creating a pattern of shapes triangle, square triangle, square, etc).	
	PRE_1	POS_1	PRE_4	POS_4	PRE_6	POS_6	PRE_13	POS_13	PRE_19	POS_19	PRE_20	POS_20
Average	5.15	5.67	5.19	5.74	4.93	5.67	4.93	5.63	4.30	5.37	5.00	5.67
Min	4	5	4	4	4	4	3	4	1	2	4	4
Max	6	6	6	6	6	6	6	6	6	6	6	6
SD	0.72	0.48	0.79	0.53	0.83	0.55	0.87	0.56	1.20	1.01	0.73	0.55
Paired TTest	0.001		0.001		0.000		0.000		0.000		0.000	
Change	**+0.52**		**+0.56**		**+0.74**		**+0.70**		**+1.07**		**+0.67**	

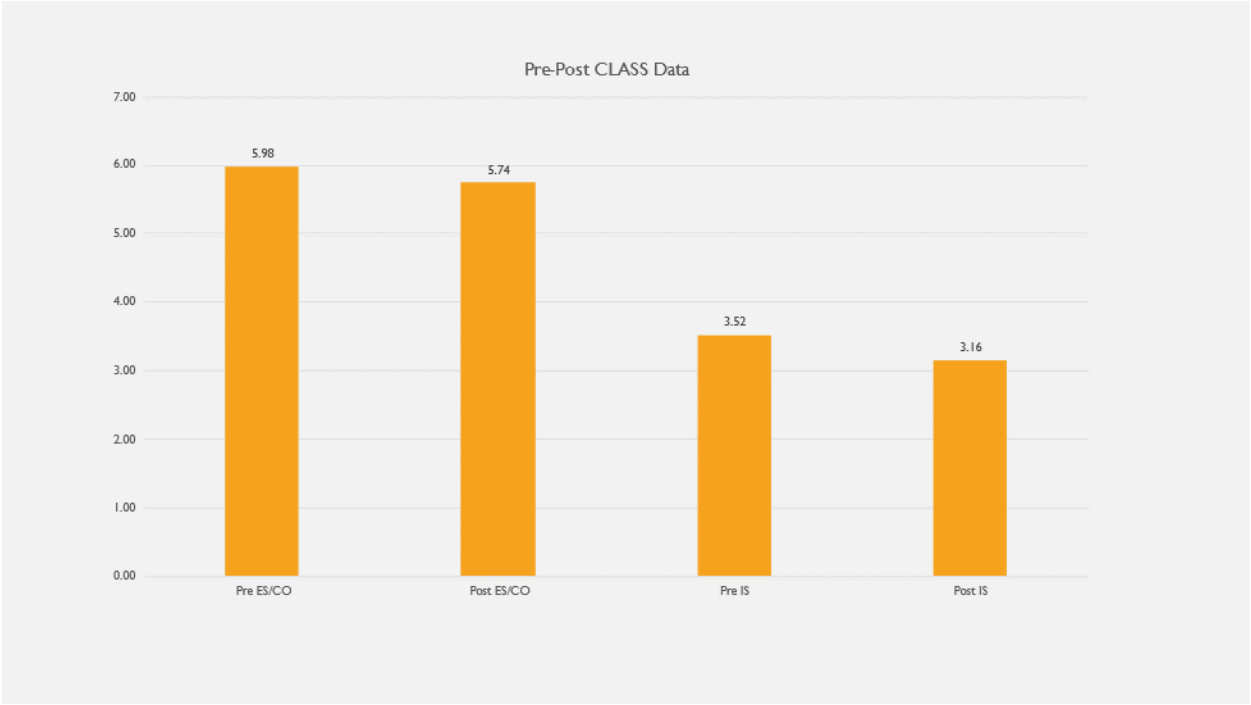
The pre and post scores for the six comfort questions that have to do specifically with “I feel comfortable…”

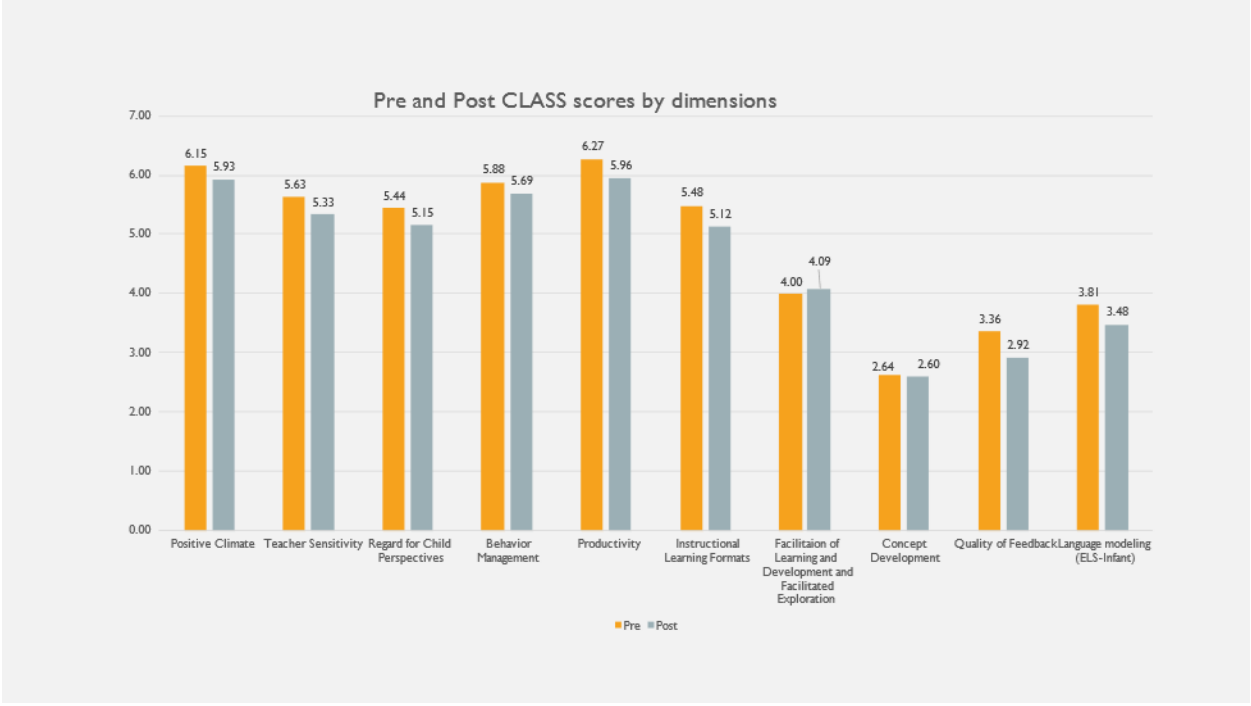
Do you use math materials during any of these daily activities? If so, check all that apply.

	Arrival / departure	Transitions	Large group time	Small group time	Meal time	Free choice	Outside
Pre	12	18	22	26	22	24	16
Post	17	24	24	24	24	24	21
Change	5	6	2	-2	2	0	5

On average, how many math activities do you do with children each week?

Activities	PRE	POST
1-2	8	3
3-5	10	8
5-10	3	11
10+	6	5


Pre-Post CLASS Data
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
5.98
5.74
3.52
3.16
Pre ES/CO
Post ES/CO
Pre IS
Post IS


Pre and Post CLASS scores by dimensions
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
6.15
5.93
5.63
5.33
5.44
5.15
5.88
5.69
6.27
5.96
5.48
5.12
4.00
4.09
2.64
2.60
3.36
2.92
3.81
3.48
Positive Climate
Teacher Sensitivity
Regard for Child Perspectives
Behavior Management
Productivity
Instructional Learning Formats
Facilitaion of Learning and Development and Facilitated Exploration
Concept Development
Quality of Feedback
Language modeling (ELS-Infant)
Pre
Post

References

Aguirre, J., Herbel-Eisenmann, B., Celedón-Pattichis, S., Civil, M., Wilkerson, T., Stephan, M., Pape, S., & Clements, D. (2017). Equity Within Mathematics Education Research as a Political Act: Moving From Choice to Intentional Collective Professional Responsibility. *Journal for Research in Mathematics Education*, 48(2), 124–147.

Alcantara, V. & Geller, J. D. (April, 2017*). Moving from "this Is how it's always been" to "this Is how it must be": Lessons from participatory design research.* Paper presented at the annual meeting of the American Educational Research Association (AERA), San Antonio, TX. Retrieved from: https://familydesigncollab.org/wp-content/uploads/2020/12/FLDCPaper_Lessons-from-Participatory-Design-Research.pdf

Ackerman, D. (2004). *States' efforts in improving the qualifications of early care and education teachers*. *Educational Policy*, 18(2), 311-337.

Arnseth, H. C. (2008). Activity theory and situated learning theory: contrasting views of educational practice. *Pedagogy, Culture & Society*, 16(3), 289–302.

Baker, M. Early Childhood Teachers at the Center: A Qualitative Case Study of Professional Development in an Urban District. *Early Childhood Education Journal* (46), 231–240 (2018).

Bang, M. & Vossoughi, S. (2016) Participatory design research and educational justice: Studying learning and relations within social change making, *Cognition and Instruction*, 34(3), 173-193.

Banks, J. (1998). The lives and values of researchers: Implications for Educating Citizens in a Multicultural Society. *Educational Researcher*, 27(7), 4-17

Barnett, W. S. (2003). Low wages = low quality: Solving the real preschool teacher crisis. *Preschool Policy Matters, #3* National Institute for Early Education Research.

Bevan, B., & Penuel, R. (2018). Connecting research and practice for educational improvement : ethical and equitable approaches (B. Bevan & W. R. Penuel, Eds.). Routledge, Taylor & Francis Group.

Birkland, T. (2001). *Putting it all Together: Models of the Policy Process.* In *An Introduction to the POLICY PROCESS* (1st ed., pp. 194-229). Routledge.

Borko, H., (2004). Professional Development and Teacher Learning: Mapping the Terrain. *Educational Researcher* 33(8), 3-15.

Brown, C. (2019) Introducing the Text and Examining the Emergence, Maintenance, and Expansion of Gaps, Deficits, and Risks Through Early Childhood Policy Disrupting and Countering Deficits in Early Childhood Education. In Fikile Nxumalo and Christopher P. Brown (Eds.) *Disrupting and Countering Deficits in Early Childhood Education*. (pp. 1-19). Routeledge.

Bryk, A.S., Sebring, P., Allensworth, E., Luppescu, S., & Easton, J.Q. (2010).*Organizing Schools for Improvement: Lessons from Chicago*. University of Chicago Press.

Bryk, A. S., Gomez, L. M., Grunow, A., & LeMahieu, P. G. (2015). Learning to Improve: How America's Schools Can Get Better at Getting Better. Harvard Education Press.

Bryk, A. S. (2015). 2014 AERA Distinguished Lecture: Accelerating How We Learn to Improve. *Educational Researcher*, 44(9), 467–477.

Burton, A., Whitebook, M., Young, M., Bellam, D., Wayne, C., Brandon, R. N., & Maher, E. (2002). *Estimating the size and components of the U.S. child care workforce and caregiving population: Key findings from the child care workforce estimate (Preliminary report)*. Washington, DC: Center for the Child Care Workforce.

Buyesse, V., Winton, P., & Rous, B. (2009). Researching Consensus on a definition of Professional Development for the Early Childhood Field. *Topics in Early Childhood Special Education*, 28(4), 235-243.

Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook, Preschool Teachers, (visited September 01, 2020). https://www.bls.gov/ooh/education-training-and-library/preschool-teachers.htm

Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook, Kindergarten and Elementary School Teachers, (visited September 01, 2020). https://www.bls.gov/ooh/education-training-and-library/kindergarten-and-elementary-school-teachers.htm

Cabusao, J., Fleischer, C., & Polson, B. (2019). Shifting from Professional Development to Professional Learning: Centering Teacher Empowerment. National Council of Teachers of English. Retrieved from: https://ncte.org/statement/proflearning/

Chen, J., Hynes-Berry, M., Abel, B., Sims, C., & Ginet, L. (2017) Nurturing mathematical thinkers from birth: The why, what and how. *Zero to Three Journal* 37(5): 23–26.

Clements, D., & Sarama, J. (2018) Myths of early math. *Education Sciences* 8(2): 71.

Collins, A., Joseph, D., & Bielaczyc, K. (2004). Design research: Theoretical and methodological issues. *Journal of the Learning Sciences, 13*(1), 15–42.

Correnti, R. (2007). An Empirical Investigation of Professional Development Effects on Literacy

Instruction Using Daily Logs. *Educational Evaluation and Policy Analysis*, 29(4), 262–295.

Darling-Hammond, L., Hyler, M., Gardner, M., Espinoza, D., (2017). Effective Teacher Professional Development. Palo Alto, CA: Learning Policy Institute.

Derry, S., Pea, R., Barron, B., Engle, R., Erickson, F., Goldman, R., Hall, R., Koschmann, T., Lemke, J., Sherin, M. G., & Sherin, B. (2010): Conducting Video Research in the Learning Sciences: Guidance on Selection, Analysis, Technology, and Ethics, *Journal of the Learning Sciences*, 19(1), 3-53.

Diamond, J.B., & Spillane, J.P. (2016). School leadership and management from a distributed Perspective: A 2016 retrospective and prospective. *Management in Education* 30(4), 147–154.

Dudley-Marling, C. (2020). Rejecting Deficit Views of Children in Poverty in Favor of a Philosophy of Abundance. In Fikile Nxumalo and Christopher P. Brown (Eds.) *Disrupting and Countering Deficits in Early Childhood Education*. (pp. 53-66). Routeledge.

Edwards, A. (2005). Relational agency: Learning to be a resourceful practitioner. *International Journal of Educational Research*, 43(3), 168–182. https://doi.org/10.1016/j.ijer.2006.06.010

Engeström, Y. (1987) Learning by Expanding: an activity-theoretical approach to developmental research (Helsinki, Orienta-Konsultit).

Engeström, Y. (2001). Expansive Learning at Work: Toward an activity theoretical reconceptualization. *Journal of Education and Work, 14*(1), 133-156.

Engeström, Y. (2011). From design experiments to formative interventions. *Theory & Psychology, 21*(5), 598-628.

Engeström, Y., Sannino, A. (2010). Studies of Expansive Learning: Foundations, findings, and future challenges. *Educational Researcher Review 5*, 1-24.

Erickson, F. (2006). Definition and analysis of data from videotape: Some research procedures and their rationales. In J. L. Green, G. Camilli, & P. B. Elmore (Eds.), *Handbook of complementary methods in education research* (pp. 177–205). Mahwah, NJ: Erlbaum.

Fishman, B., Konstantopoulus, S., Kubitskey, B., Vath, R., Park, G., Johnson, H., & Edelson, D., (2014). The Future of Professional Development will be Designed, Not Discovered: Response to Moon, Passmore, Reiser, and Michaels, "Beyond Comparisons of Online Versus Face-to-Face PD" *Journal of Teacher Education,* 65(3), 261-264.

Franzén, K., (2014) Under-threes' mathematical learning – Teachers' perspectives. *Early Years* 34(3): 241–254

Friedman-Krauss, A., Barnett, S., Garver, K. Hodges, K. Weisenfeld, G. DiCrecchio, N. (2019). The State of Preschool 2018. National Institute for Early Education Research. Retrieved from http://nieer.org/wp-content/uploads/2019/08/YB2018_Full-ReportR3wAppendices.pdf

Garet, M. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal*, 38(4), 915–945.

Gutiérrez, K., Higgs, J., Lizárraga, J., & Rivero, E. (2019). Learning as Movement in Social Design-Based Experiments: Play as a Leading Activity. *Human Development*, 62(1/2), 66–82.

Gutiérrez, K., & Vossoughi, S. (2010). Lifting Off the Ground to Return Anew: Mediated Praxis, Transformative Learning, and Social Design Experiments. *Journal of Teacher Education*, 61(1-2), 100–117.

Hamre, B., Partee, A., Mulcahy, C., (2017). Enhancing the Impact of Professional Development in the Context of Preschool Expansion. *AERA Open* 3(4), 1-16.

Harper, F., Caudle, L., Flowers, C., Rainwater, T., & Quinn, M. (2023). Centering teacher and parent voice to realize culturally relevant computational thinking in early childhood. *Early Childhood Research Quarterly,* 64, 381–393.

Head Start Program Performance Standards, (2016). Washington, D.C.: U.S. Dept. of Health and Human Services, Administration for Children and Families, Office of Head Start. https://eclkc.ohs.acf.hhs.gov/policy/45-cfr-chap-xiii/1302-24-locally-designed-program-option-variations

Head Start Program Information Report. (2016). Washington DC: U.S. Dept. of Health and Human Services, Administration for Children and Families, Office of Head Start. https://eclkc.ohs.acf.hhs.gov/data-ongoing-monitoring/article/program-information-report-pir

Helterbran, Valeri & Fennimore, Beatrice. (2004). Collaborative Early Childhood Professional Development: Building from a Base of Teacher Investigation. *Early Childhood Education Journal*. (31), 267-271.

Hunting R., Mousley, J., & Perry, B. (2012) A study of rural preschool practitioners' views on young children's mathematical thinking. *Mathematics Educational Research* 24: 39–57.

Institute of Medicine and National Research Council. (2015) Transforming the workforce for children birth through age 8: A unifying foundation. Washington, DC: The National Academies Press. Retrieved from: http://www.nationalacademies.org/hmd/Reports/2015/Birth-To-Eight.aspx

Ishimaru, A., & Bang, M. (2022). Designing with Families for Just Futures. *Journal of Family*

Diversity in Education, 4(2).

Ishimaru, A. M., Barajas-López, F., & Bang, M. (2015). Centering Family Knowledge to Develop Children's Empowered Mathematics Identities. *Journal of Family Diversity in Education*, 1(4), 1–21.

Ishimaru, A., Lott, J., Torres, K., & O'Reilly-Diaz, K. (2019). Families in the Driver's Seat: Catalyzing Familial Transformative Agency for Equitable Collaboration. *Teachers College Record* 121(11), 1–39.

Ishimaru, A., Rajendran, A., Nolan, C., & Bang, M. (2018). Community Design Circles: Co-designing Justice and Wellbeing in Family-Community-Research Partnerships. *Journal of Family Diversity in Education*, 3(2), 38–63.

Ishimaru, A. M., & Takahashi, S. (2017). Disrupting racialized institutional scripts: Toward parent–teacher transformative agency for educational justice. *Peabody Journal of Education*, *92*, 343-362.

Johnston, K., & Bull, R. 2022). Understanding educator attitudes towards and perceptions of mathematics in early childhood. *Journal of Early Childhood Research* 20(3), 341-356.

Jordan, B., & Henderson, A. (1995) Interaction Analysis: Foundations and Practice, *Journal of the Learning Sciences*, 4(1), 39-103.

Joseph, G. (2016) Circle Time Magazine. Cultivate Learning at the University of Washington. Retrieved from: https://cultivatelearning.uw.edu/circle-time-magazine/

Kendi, I. (2019). *How to be an antiracist*. New York: One World.

Lavigne, H., Lewis-Presser, A., & Rosenfeld, D. (2020). An exploratory approach for investigating the integration of computational thinking and mathematics for preschool children. *Journal of Digital Learning in Teacher Education*, 36(1), 63–77.

Lotan, R. A., Burns, D., & Darling-Hammond, L. (2019). The Instructional Leadership Corps: Entrusting professional learning in the hands of the profession. Palo Alto, CA: Learning Policy Institute. Retrieved from: https://learningpolicyinstitute.org/product/instructional-leadership-corps-professional-learning-report

Mayfield, W. & Cho, I. (2019). The National Workforce Registry Alliance's 2019 Workforce Dataset: Early childhood and school-age workforce characteristics. *National Workforce Registry Alliance.* Retrieved from https://www.registryalliance.org/our-resources/

McLean, C., Whitebook, M., & Roh, E. (2019). From Unlivable Wages to Just Pay for Early Educators. Berkeley, CA: Center for the Study of Child Care Employment, University of

California, Berkeley

Merriam, S. B. (2009). *Qualitative research: A guide to design and implementation (3rd ed.)* San Francisco, CA: Jossey-Bass.

Miles, M., Huberman, M.A., & Saldana, J. (2014). *Qualitative data analysis: A sourcebook of new methods*, (*3rd ed.)* Thousand Oaks, CA: SAGE.

National Academies of Sciences, Engineering, and Medicine. (2018). How People Learn II: Learners, Contexts, and Cultures. Washington, DC: The National Academies Press.

National Association for the Education of Young Children, (2020). *Professional Standards and Competencies for Early Childhood Educators*. Retrieved from: https://www.naeyc.org/sites/default/files/globally-shared/downloads/PDFs/resources/position-statements/professional_standards_and_competencies_for_early_childhood_educators.pdf

National Association for the Education of Young Children, National Association of Child Care Resource & Referral Agencies Early Childhood Education Professional Development (2011). Training and Technical Assistance Glossary.

O'Brien, J., & Jones, K. (2014). Professional learning or professional development? Or continuing professional learning and development? Changing terminology, policy, and practice. *Professional Development in Education*, 40(5), 683-687.

Palmer, J. (2018). *Building a Qualified and Supported Early Care and Education Workforce: A Primer for Legislators*. National Conference of State Legislators.

Penuel, W. R., Fishman, B. J., Haugan Cheng, B., & Sabelli, N. (2011). Organizing Research and Development at the Intersection of Learning, Implementation, and Design. *Educational Researcher*, *40*(7), 331–337.

Penuel, W., Coburn, C., & Gallagher, J. (2013). Negotiating Problems of Practice in Research–Practice Design Partnerships. *Teachers College Record*, 115(14), 237–255.

Penuel, W. (2019). Infrastructuring as a Practice of Design-Based Research for Supporting and Studying Equitable Implementation and Sustainability of Innovations. *The Journal of the Learning Sciences,* 28(4-5), 659–677.

Perry, B., MacDonald, A. (2015) Educators' expectations and aspirations around young children's mathematical knowledge. *Professional Development in Education* 41(2): 366–381.

Reinking, D., (2021) Foreward. In Philippakos, Z.A., Howell, E., Pellegrino, A. (Eds.), *Design-Based Research in Education Theory and Applications* (pp. ix-xix). New York, NY: The Guilford Press.

Reynolds, A., Temple, J., Ou, S., Arteaga, I., White, B. (2011). School-based early childhood education and age-28 well-being: effects by timing, dosage, and subgroups. *Science*, 333(6040) 360-364.

Ribner, A., Ahmed, S., Miller-Cotto, D., & Ellis, A. (2023). The role of executive function in shaping the longitudinal stability of math achievement during early elementary grades. *Early Childhood Research Quarterly*, 64, 84–93.

Russell, J. L., Bryk, A. S., Dolle, J. R., Gomez, L. M., Lemahieu, P. G., & Grunow, A. (2017). A Framework for the Initiation of Networked Improvement Communities. *Teachers College Record,* 119(5), 1–36.

Ryan, S., Ackerman, D. (2004). Creating a Qualified Preschool Teaching Workforce Part I Getting Qualified: A Report on the Efforts of Preschool Teachers in New Jersey's "Abbott" Districts to Improve the Qualifications. National Institute for Early Education Research.

Saluja, G., Early, D. M., & Clifford, R. M. (2002). Demographic characteristics of early childhood teachers and structural elements of early care and education in the United States. *Early Childhood Research & Practice, 4*(1),

Schachter, R., Gerde, H., Hatton-Bowers, H., (2019). Guidelines for Selecting Professional Development for Early Childhood Teachers. *Early Childhood Education Journal* 47:395-408.

Snyder, P., Hemmeter, M. L., Meeker, K. A., Kinder, K., Pasia, C., & McLaughlin, T. (2012). Characterizing Key Features of the Early Childhood Professional Development Literature. *Infants and Young Children,* 25(3), 188-212.

Sun, M., Penuel, W., Frank, K., Gallagher, H., & Youngs, P. (2013). Shaping Professional Development to Promote the Diffusion of Instructional Expertise Among Teachers. *Educational Evaluation and Policy Analysis*, 35(3), 344-369.

Ullrich, R.; Hamm, K.; Herzfeldt-Kampath, R. (2016). Underpaid and Unequal: Racial Wage Disparities in the Early Childhood Workforce. Center for American Progress. Retrieved from: https://cdn.americanprogress.org/wp-content/uploads/2016/08/01073800/NSECE-report2.pdf

Power to the Profession (2020). *Unifying Framework for the Early Childhood Education Profession*. American Federation of State, County and Municipal Employees; American Federation of Teachers; Associate Degree Early Childhood Teacher Educators; Child Care Aware of America; Council for Professional Recognition; Division for Early Childhood of the Council for Exceptional Children; Early Care and Education Consortium; National

Association for Family Child Care; National Association for the Education of Young Children; National Association of Early Childhood Teacher Educators; National Association of Elementary School Principals; National Education Association; National Head Start Association; Service Employees International Union; ZERO TO THREE. Retrieved from: http://powertotheprofession.org/wp-content/uploads/2020/03/Power-to-Profession-Framework-03312020-web.pdf

Van den Akker, J. & Nieveen, N. (2021) Combining Curriculum and Teacher Development through Design Research. In Philippakos, Z.A., Howell, E., Pellegrino, A. (Eds.), Design-Based Research in Education Theory and Applications (pp. 45-63). New York, NY: The Guilford Press.

Voogt, J., Laferrière, T., Breuleux, A., Itow, R. C., Hickey, D. T., & McKenney, S. (2015). Collaborative Design as a Form of Professional Development. *Instructional Science*, 43, 259-282.

Vygotsky, L. (1978). Interaction between learning and development. From: Mind and Society p. 79-91 Cambridge, MA: Harvard University Press

Walter, C., & Briggs, J. (2012). What professional development makes the most difference to teachers. A report sponsored by Oxford University Press.

Whitebook, M., McLean, C., Austin, L.J.E., & Edwards, B. (2018). *Early Childhood Workforce Index – 2018*. Berkeley, CA: Center for the Study of Child Care Employment, University of California, Berkeley. Retrieved from: http://cscce.berkeley.edu/topic/early-childhood-workforce-index/2018/ .

Whitebook, M., (2014) Building a skilled teacher workforce: Shared and Divergent Challenges in Early Care and Education and in Grades K-12. Center for the Study of Child Care Employment Institute for Research on Labor and Employment, University of California, Berkeley. Retrieved from: https://cscce.berkeley.edu/publications/report/building-a-skilled-teacher-workforce/

Winton, P. J., & McCollum, J. A. (2008). Preparing and supporting high-quality early childhood practitioners: Issues and evidence. In P. Winton, J. McCollum, & C. Catlett (Eds.), Practical approaches to early childhood professional development: Evidence, strategies, and resources (pp. 1-12). Washington, DC: ZERO TO THREE.

Yoon, K., Duncan, T., Lee, S., Scarloss, B., Shapley, K. (2007). Reviewing the evidence on how teacher professional development affects student achievement. Regional Education Laboratory No. 033. Retrieved from: https://ies.ed.gov/ncee/edlabs/regions/southwest/pdf/REL_2007033.pdf

Zaslow, M. & Tout, K. (2014). Reviewing and Clarifying Goals, Outcomes and Levels of Implementation: Toward the Next Generation of Quality Rating and Improvement Systems (QRIS). OPRE Research Brief #2014-75. Washington, DC: Office of Planning, Research and Evaluation, Administration for Children and Families, U.S. Department of Health and Human Services.