YOUNG CHILDREN’S EMBODIED MATHEMATICAL PRACTICES IN AND OUT OF SCHOOL CONTEXT: A VIDEO-ETHNOGRAPHY INQUIRY

by

ELIF KARSLI

(Under the Direction of Martha Allexsaht-Snider)

ABSTRACT

This dissertation, which is a video-ethnography study, includes three articles that contribute complementarily to the understanding of young children’s mathematical practices in and out of school. The dissertation starts with a rationale and a subjectivity statement and an overview of the three articles. Then, the first article, eliciting parental voices through multi-vocal video-cued interviews, shows parental insight about the processes of their four and five year old children engaging with mathematics out of school. The focus is parents’ particular interest in mathematics content ranging from number sense to data analysis, parents’ pedagogical ways of teaching mathematics, and parental concerns about contextual aspects of their children’s mathematics engagements. The second article reveals ways in which discipline is institutionalized within the contexts of schools, and how a school’s disciplinary mechanisms are infused in mathematical practices in a classroom of young children. As mathematics was enacted in multiple discourses, key scenes from the study show verbal and bodily rules inserted in mathematical curriculum times, and demonstrate ways in which mathematics becomes a disciplinary tool itself during the course of the day, with its authoritative and classificatory nature. Also evident are the ways in which all actors in a classroom draw on mathematics for
problem solving in real life situations within a power/resistance dynamic. Embracing a multimodal perspective, the last article introduces data on young children’s embodied mathematical practices in the outdoor play area of a prekindergarten classroom. The findings from the third article help us to see that recognizing children’s spontaneous bodily techniques has potential to reshape researchers and educators’ agendas on what it means to engage in mathematical learning in early childhood education classrooms. The dissertation ends with an implications discussion, emphasizing the need for shaping formal mathematics education in early childhood education classrooms based on children’s embodied potentials that they bring to school and develop within the school. Also discussed are possibilities incorporating a consideration of families’ insights about children’s mathematics in and out of school into teachers’ and educators’ thinking about young children’s mathematics learning.

INDEX WORDS: Family Engagement, Early Childhood Mathematics, Embodied Mathematical Practices, Video-Ethnography
YOUNG CHILDREN’S EMBODIED MATHEMATICAL PRACTICES IN AND OUT OF
SCHOOL CONTEXT: A VIDEO-ETHNOGRAPHY INQUIRY

by

ELIF KARSLI

B.S., Middle East Technical University, Turkey, 2009

A Dissertation Submitted to the Graduate Faculty of The University of Georgia in Partial
Fulfillment of the Requirements for the Degree

DOCTOR OF PHILOSOPHY

ATHENS, GEORGIA

2014
YOUNG CHILDREN’S EMBODIED MATHEMATICAL PRACTICES IN AND OUT OF SCHOOL CONTEXT: A VIDEO-ETHNOGRAPHY INQUIRY

by

ELIF KARSLI

Major Professor: Martha Allexsaht-Snider
Committee: Amy Noelle Parks
            Melissa Freeman

Electronic Version Approved:

Julie Coffield
Interim Dean of the Graduate School
The University of Georgia
August 2014
DEDICATION

To my father Hulusi Karslı,
and to those like him who dedicate themselves to revolutionizing education
for all children, and for the sake of human dignity

Babam Hulusi Karslı'ya,
ve onun gibi kendini hiçbir ayrım olmaksizin bütün çocuklar için ve insanlık onuru için
eğitimde devrim yaratmaya adamış herkese
ACKNOWLEDGEMENTS

“To live like a tree alone and free! To live like a forest in brotherhood!” the ending for Nazım Hikmet Ran’s beautiful poem about Anatolia, leads me to think how my doctoral education journey was a lonely one; I was like a tree standing by itself, putting in effort to free my mind and create my ideas about my research. Also I was like a tree in a forest amongst the loved ones who surrounded me with their unconditional support. Among all these special people, first and upmost, I would like to acknowledge my love, Görkem Aksaray, for the strength he instilled in both of us, and for his big dreams for me and for himself. I wish for nothing but his music becoming the background tune of our life. With all my heart, I would like to acknowledge the beloved members of the Karslı and Can Families; my mother Günay Karśli, my father Hulusi Karśli, and my amazing sister and brother Cansu Karśli and Onur Karśli. I am who I am because of the four of you. You are the source of love, trust, and fun in my life. Thank you for everything.

I would like to show my greatest appreciation to my major professor Dr. Martha Allexsaht-Snider. She is a special person. The ability to show my appreciation for her is way beyond my limits of expression. The best decision I made in my life was to be her doctoral student, and being mentored by her so that I could stay close to her, follow her closely, and discover the meaning of being a strong, sensitive, and critical scholar. I feel content that I recognized the value of each moment I was learning from and with you. Thank you with all my heart…”
During my doctoral study, I was so lucky to have Dr. Melissa Freeman and Dr. Amy Noelle Parks as my committee members. Dr. Melissa Freeman, thank you for each piece of effort you invested in me during these four years. I enjoyed so much learning from you when we were closely working for hours. Dr. Amy Noelle Parks, your powerful and critical perspective on research with children’s mathematics guided my dissertation study, and will always guide my future studies. Thank you so much. I also would like to acknowledge two of my UGA professors Dr. Cory Buxton and Dr. Joseph Tobin. Dr. Cory Buxton, I generated the meaning of a strong, professional, and humble scholar by working with you. Thank you for making me a part of the Language Rich Inquiry Science with English Language Leaners (LISELL) project with you and Dr. Martha Allexsaht-Snider. I feel content to be a part of LISELL family. Dr. Joseph Tobin, your sharings and insights on your Preschools in Three Cultures study and your dedication for reconceptualization of our field of early childhood education enlightened my dissertation study. Thank you.

I also would like to acknowledge my former professors Dr. Feyza Erden and Dr. Zeynep Berna Erdiller who inspired me with their scholarship, and with whom I stepped into the world of early childhood education. I am grateful for your knowledge and guidance embedded in the Middle East Technical University (METU) spirit. I am proud to be your student, and I will always be proud to be a METU alumna.

And my friends…Demet Kesim and Burak Tanyurt. Before I came to the United States until the day I am leaving soon, you cannot imagine the meaning of your support for me. You were the ties that made me stay close to Turkey. I was happily living in the U.S. knowing that once I come back to Turkey you would be there for me. Thank you for firmly checking me and closely watching my doctoral studies. I am thankful to have the two of you in my life. My friend
Bahadir Namdar, our friendship that goes beyond the walls of Aderhold, is a gift. Thank you for your friendship and your support. Shakhnoza Kayumova, it is our differences that have been turning us into stronger scholars. Let our disparate positionalities continue to enrich our work.

Keon-Ryeong Park and Jaehee Kwon, I feel so lucky to have you as my doctoral cohort, and to collaborate with you. Thank you. And, Emre Ebtürk, Irem Ebtürk, and Nastassja Pugliese. We have a story. A story worth remembering until the end of our lives; a story worth sharing with our next generations. It’s a story of solidarity; a story of new beginnings. I believe that our story helped each of us to discover ourselves better. Our story turned each of us into better human beings. I love each of you so much.

With the happiness of having many people in my life to acknowledge, I also would like show my appreciation to the great composer Antonio Lucio Vivaldi whose music accompanied my writing hours for the last years. It was only later on I learned that he composed those beautiful tunes for orphaned children, surprised me about how we, two human beings deeply caring about children, could meet without time, form, and space limitations. Lastly, I would like to acknowledge the Fulbright Program for supporting the first two years of my doctoral study. I was grateful to study under the auspices of the Fulbright scholarship, and now I am proud to be a Fulbright alumna.

Elif Karsh
## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>v</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>x</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>xi</td>
</tr>
<tr>
<td>CHAPTER</td>
<td></td>
</tr>
<tr>
<td>1 INTRODUCTION AND LITERATURE REVIEW</td>
<td>1</td>
</tr>
<tr>
<td>References</td>
<td>11</td>
</tr>
<tr>
<td>2 VIDEO-CUED PARENTAL DIALOGS: A PROMISING VENUE FOR</td>
<td>15</td>
</tr>
<tr>
<td>EXPLORING EARLY CHILDHOOD MATHEMATICS</td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>16</td>
</tr>
<tr>
<td>Introduction</td>
<td>17</td>
</tr>
<tr>
<td>Literature Review</td>
<td>18</td>
</tr>
<tr>
<td>Theoretical Framework</td>
<td>22</td>
</tr>
<tr>
<td>Methodology</td>
<td>25</td>
</tr>
<tr>
<td>Conclusion</td>
<td>46</td>
</tr>
<tr>
<td>References</td>
<td>52</td>
</tr>
<tr>
<td>3 MANIFESTATIONS OF MATHEMATICS WITHIN THE DISCIPLINARY DYNAMICS OF A</td>
<td>62</td>
</tr>
<tr>
<td>PRE-K CLASSROOM</td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>63</td>
</tr>
<tr>
<td>Introduction</td>
<td>64</td>
</tr>
</tbody>
</table>
LIST OF TABLES

Table 2.1: Information on the Participants .................................................................28
Table 3.1: Information on Focus Children and Classroom Teachers ...............................78
Table 3.2: Multimodal Analysis of Aeron’s Engagement ..............................................87
Table 3.3: Multimodal Analysis of Clayton’s Engagement ...........................................91
Table 3.4: Multimodal Analysis of Octavia and Amy’s Engagement ............................96
Table 4.1: Multimodal Analysis of Clayton, Octavia and Amy’s Engagements .............125
Table 4.2: Multimodal Analysis of Octavia and Amy’s Outdoor Engagements ............130
Table 4.3: Multimodal Analysis of Octavia and Amy’s Second Outdoor Engagements ....132
Table 4.4: Multimodal Analysis of Clayton’s Outdoor Engagement ............................135
LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Sophie’s drawing “<em>My favorite mathematics activity, estimation</em>”</td>
<td>6</td>
</tr>
<tr>
<td>2.1</td>
<td>Parental insights on young children’s mathematics</td>
<td>32</td>
</tr>
<tr>
<td>3.1</td>
<td>Appearances of mathematics in the Pre-K classroom within the power-resistance dynamics</td>
<td>84</td>
</tr>
</tbody>
</table>
CHAPTER 1
INTRODUCTION AND LITERATURE REVIEW

This dissertation is a video-ethnography study that provides insights on parental perspectives on young children’s mathematical practices. In addition, it also explores young children’s embodied mathematical practices that are initiated both by children and their teacher, and that may appear at any time and in any settings within the disciplinary dynamics of a Pre-Kindergarten (Pre-K) classroom. The process of design, implementation, and interpretation of this study, which overall took around two years, was also a process for me to realize how this dissertation research has strong connections with my changing and evolving identities as a daughter of an elementary school teacher, a former Pre-K teacher, a novice researcher, and a doctoral student in the early childhood education program of the University of Georgia.

Most of my home-related memories during my elementary education period involve mathematics study times with my father, who is an elementary school teacher, defining himself particularly as a good one at teaching mathematics. It was the time when the nation-wide standardized test at the end of 5th grade exerted extreme stress on all of us as young students, families, and teachers. Mathematics was the most important subject of this standardized test, which determined our acceptance to good schools serving from 6th grade to 12th (these schools were a combination of middle and high schools). In other words, our performances in one test at the end of the 5th grade would determine almost our whole educational lives; therefore, our future professional lives indeed.
During those times I was probably not aware of how privileged I was to have a father at home who supported me to learn mathematics and made sure that each and every night I completed mathematics homework perfectly, which literally took at least a couple of hours to complete. For me as a child, these mathematics study times were a mixture of cheers, and tears; feelings of accomplishment and incompetency, but overall definitely stressful. The mathematical content we were supposed to acquire was developmentally inappropriate, relying heavily on advanced algebra word problems. I grew up by seeing my elementary school teacher and my father working closely together to be able to solve some of these problems and discussing appropriate methods to teach us the mathematics material. I reflect now about how it could be difficult for most families to support their children’s education in this way, particularly for those lacking the necessary cultural, social and economic capital to be able to keep up with schools’ unrealistic expectations.

Living in a community in which providing unequivocal support was a common cultural practice, my father was a good support also for other families and children, some of whom were our relatives, and some of whom were families from our neighborhood. I have clear memories of my father welcoming families at our home, providing help for mathematics homework, and materials such as mathematics tools, and books, and even receiving calls and helping families to solve algebra word problems over the phone. Today I can better understand that, although my father was always generous with his time and energy, this may have been an unpleasant and stressful overall situation for families and children.

All these memories came back to me, as I have been researching, reading, and writing about family engagement in education as a doctoral student. However, the real feelings and sensitivities about those days emerged as I have been working as a research assistant in the
Language-Rich Inquiry Science with English Language Learners (LISELL) research project, where I had the chance to work closely with immigrant families and their children. This time it was not mathematics, but another subject needed to be accomplished for future educational success, which is science. As I work with these families in terms of supporting their children’s science education, and seeing their great enthusiasm both in learning science and supporting their children’s science learning, I remember the families from my childhood, who were putting effort to support their children’s mathematics with great interest but also with distress and hesitancy.

I could see connections between the arguments in the current literature on families and mathematics and my own experiences with immigrant families. Looking at the current literature, particularly researching family engagement in mathematics, we can see that research with diverse families and children examines the wide range of influences in mathematics learning processes such as social class, ethnicity, race, and gender; therefore, provides unique and important insights (Allexsaht-Snider, 2006; Anderson & Gold, 2006; Baker, Street, and Tomlin, 2006; Civil, Planas, Quintos, 2005). Especially, ethnographic research on the lives of the young children has been critically questioning the gaps between the school’s expectations, and family resources with a focus on the differences between home and in school perspectives in terms of what mathematics is, what kind of mathematics is important, and how mathematics should be taught (Acar, 2010; Anderson & Gold, 2006; Baker, Street, and Tomlin, 2006; Parks & Bridges-Rhoads, 2009). The shared argument of these studies is that recognition of familial resources is needed when shaping expectations for children’s mathematics and making curricular decisions at school.

Another body of research also shows that regardless of their backgrounds, parents are engaged in effective mathematical engagements with their children (Saxe, Guberman, and
Gerhalt, 1987; Ginsburg & Russell, 1981; Starkey & Klein, 2000). However, there has been an increasing trend in the current literature to speak of young children’s lack of readiness in mathematics or mathematical difficulties and associate it with their families’ social class and racial backgrounds, which is a trend that should be questioned because the research results on this issue are not conclusive (Parks, 2014).

In short, research literature to date provides initial insights into the mathematics of young children developed within the context of family. Drawing on my own experiences and this previous work, the starting point in my dissertation was to position families as intellectual resources (Civil & Andrade, 2003) and to generate dialogs with them about the idea of what is valuable in terms of mathematics in children’s daily lives.

Later on, as I became a Pre-K teacher with a special interest in the mathematics of young children, I was careful about meeting curricular goals for cognitive development with mathematics emphasis, enthusiastically devoting instructional times for teaching mathematics. I also created times that I could share my mathematics-related observations with families. Along with these experiences, as a first year teacher, who was supposed to teach around 20 three to four-year-olds by myself, I had concerns with my teaching, particularly because of classroom management worries. Later on, as I have been reading and thinking about disciplinary classroom practices and young children’s embodied mathematical practices as a doctoral student, I started to think about how my classroom management practices could have been interfering with my teaching, and preventing me from setting an environment in which children could explore and experiment with mathematical ideas. Thinking about a particular example from my own classroom, for example, during free-play time, my children were using plastic blocks to construct high buildings. A high building referred to a block construction that was taller than each of their
bodies. In this mathematical practice, they were using their bodies as a reference point for conceptualizing the concepts of tall and short. Reflecting on my own teaching practice, without realizing how their bodies may have a central role in understanding and experimenting with mathematical concepts, I intervened in their work and tried to control their game. My main concern was to ensure security and order in the classroom, for high stacks of blocks could create chaos, noise, and conflicts, which is true to some extent. However, I had an unreasonable desire to ensure “the silent and peaceful routine”, and I exerted power on the children’s physical actions accordingly.

As I was examining my own teaching and generating these ideas related to the influences of classroom management practices on young children’s content-related educational processes, an insight of a four-year-old girl, Sophie, encouraged me to follow this path as a research focus.

During a fieldwork internship in which I was gaining experience to engage in interpretive research with young children, I requested that the children draw their favorite mathematics activity. Four-year-old Sophie (pseudonym) created the painting below in Figure 1, titled “My favorite mathematics activity, estimation.”

During my dialog with Sophie over her drawing, she was not only telling me about her favorite mathematics activity, but also about the disciplinary classroom setting in which their mathematical practices took place. I could also observe this in her painting, which makes certain rules of this classroom very visible. As Sophie told me, in this picture, the teacher is holding the zip lock bag, which has leaves in it, and the children try to guess the actual number of leaves in the bag. The children are all sitting on their blue rug, which has letters on it. Since the teacher assigned a letter to each child and put their names on the letters with a sticky note, they always have to sit on the same place and stay within their boundaries. Sophie represents this rule in her
painting in a very clear way. As we can see, each child is fixed in his/her space and they all have certain distances among them. Children have their arms stuck to their bodies, which shows their readiness for mathematical activity through their bodies. Overall, this drawing of Sophie’s was a clear depiction of the context that I was interested to explore and question the basic taken-for-grounded assumptions about appropriate ways of being to engage in mathematics.

![Figure 1.1 Sophie’s drawing “My favorite mathematics activity, estimation”](image)

Along with all these diverse experiences, my previous identity as a Pre-K teacher who was enforcing power without realizing I was doing so is one of the reasons that has inspired me to engage in this dissertation research. What motivated me to conduct this research was to give meaning and explanation to these feelings and practices related to control of children’s bodies and also to closely investigate the perspective that may prevent us from situating children’s
bodies at the center of mathematical interactions and to create spaces in which they could freely
use their bodies to experiment with mathematical ideas.

In particular, from a critical perspective (Foucault, 1990; 1995; Walkerdine, 1988),
conceptualizing Pre-K classrooms as institutions, which are meant to regulate children’s actions
and interactions, the original research question guiding this dissertation was, “What are the
bodily demands of engaging in mathematics in a Pre-K classroom?” and “What are the
discursive practices in a Pre-K classroom that regulate the bodily experiences of children
engaging in mathematics?” Therefore, in this study, my central emphasis was on children’s
individual and collective bodies and their process of becoming pre-k students engaging in
mathematics through constructing certain bodily dispositions.

In my review of literature, I found only a few empirical studies connecting children’s
bodily engagements during content-related learning from a critical perspective, but many
conceptual pieces written on the power dynamics of learning environments. Therefore, my
dissertation has the potential to be a contribution to the literature through the means of an
empirical study concerning video-taped mathematical practices within the disciplinary dynamics
of a Pre-K classroom. An interesting study from earlier research comes from Kamler, MacLean,
Reid and Simpson (2001) in which they show how ritualized songs, rhymes, and routines in a
kindergarten classroom can be examples of systems operating as forms of power, can shape
children’s bodily dispositions, and becomes a disciplinary practice. The movements called for in
these songs and the rhymes (e.g. hands on shoulders, hands to yourself, lips buttoned) are related
to controlling bodily movements and sustaining order in the classroom. Students follow these
practices in a joyful manner while these texts constrain their bodily dispositions (Kamler et al,
2001).
Focusing particularly on mathematics, in their study with children from a marginalized community, Parks and Schmeichel (2014) show that by attending to the details of children’s bodily movements, power dynamics between the researcher and the child can be reconciled and more meaningful interpretations can be made to evaluate children’s mathematical understandings evolving over time. In another ethnographic study, children’s understanding of the qualitative passage of time, Jenks (2011) claims that the dominant discourse is situated around the notion of time in the context of school in relation to children’s bodies. For example, the discourse of time is produced in a variety of ways, such as grouping children according to their chronological ages, labeling them as being mature or not with respect to the passage of time in their lives, and imposing particular bodily movements on children according to their developmental levels or stages (Jenks, 2011).

Drawing on my own previous experiences as a Pre-K teacher, and on the insights of these few studies, I am assuming that educational processes, including mathematical ones, are under the constant influence of many disciplinary discourses uniquely produced within the dynamics of classrooms. Considering Pre-K classrooms as one of the first spaces where bodies are subjected to institutional regulations, my research traces the mathematical practices in a Pre-K context, in which I take into consideration the issues of power relations and control, along with sociocultural assumptions about how, when, and why children might be encouraged or discouraged from engaging their bodies in their mathematical learning activities.

Although the original aim of the dissertation generated insights about how discipline is institutionalized within the context of a school and how a Pre-K classroom’s disciplinary mechanisms are infused in embodied mathematical practices in a classroom of a young children, the potential of data I generated in the classroom was not limited to this scope of the original
research. The observations I conducted during my field work provided a larger focus with various interpretations about young children’s mathematics, so that in line with the ethnographic nature of the study, I re-constructed my inquiry in a way to follow different perspectives. Therefore, at the end, this dissertation emerged as three distinct but interrelated articles, including this initial research.

As I was participating in the ordinary life of the Pre-K classroom with an eye on bodies and mathematics, I started to realize that in this classroom mathematical practices were not manifesting themselves only in the forms of bodily demands, but included many instances in which children were using bodies creatively and freely and engaging in mathematics at the same time. This is a suggested practice in early childhood education, which is supported by research studies from diverse theoretical perspectives, showing the role of the body as supportive to mathematical understandings (Clements 2004a, Dávila-Coates & Franco, 1999; Goodway, Rudisill, Hamilton, Hart, 1999). These studies argue that physically active and playful learning environments support young children’s mathematics (Seo and Ginsburg, 2004; Clements & Sarama, 2007), particularly when learning geometry (Clements, 2004a). Bodily rich engagements can also support children’s spatial skill development (Clements, 2004b) and counting abilities (Dávila-Coates & Franco, 1999) when integrated with play (Cross, Woods, Schweingruber, 2009) and music (Lim-Kim, 1999). Therefore, in the midst of the critical research, these observations opened up a different space to think about the rich possibilities manifesting themselves in a Pre-K classroom with respect to children’s embodied mathematical practices, which I included in a separate article within this dissertation.

During the video-ethnography process over one semester in the Pre-K classroom, my videotaped recordings provided a multitude of opportunities to closely and vividly attend to the
lives of my four participant children Amy, Aeron, Clayton and Octavia (pseudonyms) along with their mathematical practices. Because of my interests in family involvement in mathematics education, the rich observations of four young children inspired me to share the videos with their families to elicit their perspectives about young children’s mathematics. This would not only contribute to the field in terms of bringing the family perspective in early childhood mathematics education, which is a limited but growing area of research, but also would enrich the interpretations of my own dissertation in terms of knowing my participant children beyond their school-related experiences. Therefore, one of the articles of the dissertation is about families’ perspectives on early childhood mathematics elicited through the videos I recorded in their children’s classroom.

In conclusion, the structure of this dissertation is as follows: I placed the article about family perspectives on early childhood mathematics learning at the beginning, which would provide rich insights on participant children both from my own perspective as a researcher, and from their families’ perspectives. Then, I placed the core article about appearances of embodied mathematical practices within the disciplinary dynamics of a Pre-K classroom. The last article is about children’s rich embodied practices with high potentials to be mathematized, followed by a research implications chapter at the end.
References


CHAPTER 2

VIDEO-CUED PARENTAL DIALOGS:

A PROMISING VENUE FOR EXPLORING EARLY CHILDHOOD MATHEMATICS

1 Karsli, E. and M. Allexsaht-Snider. To be submitted to Australasian Journal of Early Childhood.
Abstract

Research literature to date provides limited insights about the mathematics learning of young children developed within the context of family, and families’ perspectives on young children’s mathematics. As we push to develop better mathematics learning opportunities for young children, parents seem to be left out of the picture. This study, eliciting parental voices through multi-vocal video-cued interviews, showed parental insight about the processes of their four and five year old children engaging with mathematics out of school, with particular interest in mathematics content ranging from number sense to data analysis, and parents’ pedagogical ways of and concerns about contextual aspects of their children’s mathematics. Findings from this research indicate that teachers’ video-cued dialogs with parents could have potential to inform practice, at first in acknowledging parents-as-intellectual resources, and then, in creating spaces where teachers and parents might come together and engage in learning from each other about ways to create more diverse mathematics learning opportunities for young children in and out of school. These dialogues could help teachers to make curricular connections with parents, as they inquire together about how children engage in and transform mathematical practices as they move back and forth between home and school.
Introduction

A growing body of research has demonstrated that children develop significant mathematical understandings in their early years (Baroody, 1987; Clements, Sarama, & DiBiase, 2004; Charlesworth, 2005; Gingsburg, Klein, Starkey, 1998; Strauss & Curtis, 1981) and that these early experiences greatly affect children’s later mathematical learning (Clements & Sarama, 2000; Duncan et al., 2007; van Hiele-Geldof, 1959). These studies have shaped our thinking about young children’s potential and the manner in which they develop mathematical thinking in their early years. Given this work, the importance of high quality mathematics education during the early childhood period has gained greater prominence.

In the last decades, interdisciplinary research has revealed that beyond the earlier conceived notion of developmental stages (Kamii & DeClark, 1985), the way in which young children experience mathematics is a complex and multifaceted process that is situated within the dimensions of the socio-cultural contexts of learning. In particular, in the last decades there has been a resurgence of interest in these socio-cultural aspects of children’s mathematics learning processes and an expansion of the ways in which cultural context, equity issues, race, social class, and politics are theorized and studied (Allexsaht-Snider & Hart, 2001; Apple, 1992; Parks, 2010; Tudge & Doucet, 2004). The literature that draws on these broad issues has brought an extended understanding to children’s mathematics to the dynamics of our understandings of the contexts in which the mathematics learning process takes place within the interactions among children, teachers, parents, and the community.

In the search for new directions and re-conceptualizations of early childhood mathematics education, calls are made with the hopes of discovering approaches to better teaching of mathematics for young children (National Association for the Education of Young
These calls for advancements in early childhood mathematics education are centered around the idea of supporting teachers of young children. These calls have foregrounded the idea that meaningful mathematical opportunities for young children can be created by equipping teachers with the skills to recognize everyday mathematically rich moments of young children and turn them into learning moments, as well as by developing purposeful instruction of mathematics in early childhood classrooms (Hachey 2013; Stipek, 2013). Although these are promising paths to follow, this perspective confines our view of rich mathematical learning opportunities for children to their social interactions with their teachers in the context of schooling. In other words, the family context for mathematically rich learning opportunities for young children seems to be missing from the picture in the effort to envision better mathematics learning opportunities for young children.

The research I present in this paper considers the possibility of ways in which parents of young children might contribute to our understanding of children’s mathematical potentials and ways to support their mathematics learning. In this study, I was interested in eliciting parents’ visions of their children’s mathematics in order to re-envision what might constitute meaningful mathematical practices and learning environments for young children. To elicit parental dialogs on early childhood mathematics, in this research I conducted multivocal video-cued interviews (described later) with families. In short, I recorded children’s mathematical engagements in a Prekindergarten (Pre-K) classroom in Spring 2013 and then, shared these videos with their families to generate dialogs about children’s mathematics both at home and in school.

**Literature Review**

Young children’s mathematical practices both in and out-of school contexts is highlighted in the educational literature; however, much of this research has underestimated the
potential role of parents in mathematics education. The National Council of Research Committee on Early Childhood Mathematics (2009) points to the gap in the literature in terms of empirical research on parental beliefs about young children’s mathematics at the same time recognizing that parents play important roles in supporting children’s mathematics, in particular numeracy-related learnings at home, developing attitudes towards mathematics, and preparing an appropriate learning environment through providing rich materials in out-of-school contexts. Similar calls for parental engagement in children’s mathematical learning have echoed in the educational literature, reflecting the recognition of the importance of mathematics in children’s lives and the instrumental role of mathematics in society (Cai, 2003; Goos & Jolly, 2004; Dávila-Coates & Franco, 1999; Saxe, Guberman, Gearhart, 1987; Sheldon & Epstein, 2005). These calls are foregrounded in the recent research on family engagement in mathematics, which presents positive outcomes for both children and diverse families, as well as for teachers (Allexsaht-Snider, 2006; Baker, Street, & Tomlin, 2006; Blevins-Knabe & Musun-Miller, 1996; Civil, Planas, & Quintos, 2005; Martin, 2006).

In a review of the limited but growing body of research on family engagement in mathematics during the early childhood period, a number of studies claim that the dominant discourse about young children’s language and literacy development inhibits families’ engagement in their children’s mathematical development and limits the valuing of mathematics in the early years (Barbarin, Early, Clifford, Bryant, Frome, Burchial, Howes, and Pianta, 2008; Blevis-Knabe & Musun-Miller, 1996; Cannon & Ginsburg, 2008; Plewis, Mooney, and Creeser, 1990). These studies either present information coming from parents about their beliefs related to mathematics or present parents’ reported observations about children’s mathematics in out-of-school contexts. However, it seems that the methodologies employed in research with families
might be restricting what we can learn from parents in terms of their children’s mathematics and the way families engage in their children’s mathematical learning. When parents are asked directly about children’s learning, language and literacy practices of young children may be much more visible to detect compared to mathematics (Tudge & Doucet, 2004).

Focusing on how parents of young children can have influential roles on children’s mathematics, a growing body of research provides valuable insights. Not surprisingly, the more families provide cognitive support and home resources explicitly featuring mathematics (such as puzzles, shapes, and blocks) at home, and the more they actively engage in recognized efforts to explicitly teach mathematics at home, the more their children’s early mathematical ability is increased (Powell, Son, File and San Juan, 2010). Moreover, families’ positive dispositions toward mathematics also seemed to have positive effects on children’s mathematics (Skwachuk, 2009), Similarly, Blevins-Knabe and Musun-Miller (1996) found that families’ reported frequency and variety of mathematics-related activities at home have connections with their children’s mathematical ability measured by a standardized test, and also predicts their future mathematical abilities (Vukovic, Roberts, & Green-Wright, 2013). A very recent extensive literature review from the past decade also shows that engaging families in early mathematics has a positive link with children mathematical skills in preschool, kindergarten and the early elementary grades (Maier, 2014). These studies are enlightening in terms of showing the favorable effect of parental influence on children’s mathematical understandings, particularly in experimental research conditions or intervention-based research. Yet we still need more research to understand the nature of parental support in mathematics in children’s everyday lives and how to build bridges between parents and teachers to think about new ways of enhancing young children’s mathematics both in and out-of-school contexts.
Some of our important insights about socio-cultural influences in mathematics learning are rooted in research with diverse families and children that examine the wide range of influences on children’s mathematics including social class, ethnicity, race, and gender. This research has shown that regardless of their backgrounds, parents are involved in mathematical engagements with their children (Saxe, Guberman, and Gerhalt, 1987; Ginsburg & Russell, 1981; Starkey & Klein, 2000). However, there has been an increasing tendency (or assumption) in the current literature in terms of associating young children’s lack of readiness in mathematics with their families’ social class and racial backgrounds, although the research results on this issue are not conclusive (Parks, 2014). Another body of research with very young children and their families, employing ethnographic perspectives on the lives of young children, has critically questioned the gap between schools and home in terms of the expectation of what constitutes mathematics, and what are the legitimate ways of teachings mathematics to young children. These promising studies (Acar, 2010; Anderson & Gold, 2006; Baker, Street, and Tomlin, 2006; Parks & Bridges-Rhoads, 2009) demonstrate that more understanding of the value of familial resources is needed when shaping our mathematical expectations for young children. The researchers also argue that mathematical practices of families can be overlooked because of the methodologies employed to conceptualize and understand the families’ efforts to develop and enhance children’s mathematics.

To summarize, research literature to date provides some initial insights into the mathematical abilities of young children developed within the context of family, and families’ perspectives on young children’s mathematics. Drawing on this previous work, the starting point in this study was to position families as sources of knowledge and to generate dialogs with them about the idea of what is valuable is terms of mathematics in children’s daily lives. The present
study, employing multi-vocal video cued interviews, in which videos of children taking part in diverse mathematical engagements in their preschool settings, both explicit and not-so-obvious, were shared with their parents to be able to elicit rich conversations on mathematics. The video-cued interviews were used as an alternative to directly questioning parents about their children’s mathematical engagements, since that approach had been identified as problematic in earlier research. Grounded in Vygotskyian (1978) theoretical perspectives, and drawing on the notion of parents as intellectual resources (Civil & Andrade, 2003), the research I present in this article situates parental voices, elicited through multi-vocal video-cued interviews (Tobin, Wu, & Davidson, 1989), as sources of knowledge that have power to shed light on the diversity of young children’s mathematical engagements in both out-of-school and in-school contexts. Particular research questions, which guided this study, are: How can video-cued multivocal parental interviews assist us to engage in dialogs with parents about their children’s mathematical experiences? In the context of video-cued multivocal interviews, what do parents of young children tell us about diverse in- and out-of-school mathematical experiences of children?

**Theoretical Framework**

Of particular importance in thinking about young children’s mathematics are the social interactions in which they engage, starting from the very early months of their lives. Vygotsky (1978) wrote that, “Human learning presupposes a specific social nature and a process by which children grow into the intellectual life of those around them” (p.34). From a Vygotskyian perspective (1978), children’s cognitive constructions, in other words, not only their actual but particularly their potential developmental learnings, come to life through their social interactions that take place in a context in which socio-cultural values, historical factors, and language play
fundamental roles. Grounded in this Vygotskyian perspective, my research privileges the social interactions composed of interplays between mathematical dialogs and activities among parents and young children as valuable resources for their learning, and focuses on the nature of assistance reported by families during these social interactions.

Vygotsky (1987) proposes that children’s concept formation manifests itself on two different levels: everyday (or spontaneous) concepts and scientific (schooled) concepts. Everyday concepts are those a child acquires by himself/herself through interacting with the world and characterize the child’s actual development, whereas scientific concepts are those a child acquires only through the social interactions with more capable adults or peers and refer to a child’s potential development. Vygotsky (1978) conceptualizes the dynamic state between these actual and potential developmental learnings of children as the zone of proximal development, and emphasizes the importance of providing rich and stimulating experiences to children functioning in this zone.

The question of how and what kind of mathematical concepts children develop in these zones may generate different answers considering the nature of social interactions in the communities of practice in which the mathematics take place. Considering school and home as different communities of practice, for example, suggests that as these contexts change, the mathematics that is being produced in these communities of practice also changes because the practices and dialogs around the mathematics differ as different communities of practice possess differing daily cultural practices (Lave & Wenger, 1991). González, Andrade, Civil, and Moll (2001), for example, propose that “hegemony of a particular type of mathematics” (p.124) in school contexts may prevent educators from recognizing the rich mathematical experiences of children in out-of-school contexts.
Considering the Vygotskyian conceptualization of the everyday and scientific concept formation of children, González and colleagues (2001) remind us that children’s everyday mathematical concept development should not be ascribed solely to their household practices, with their scientific concept development ascribed solely to their in-school mathematical experiences. Put succinctly, as children experience different mathematical practices in- or out-of-school, their mathematical concept formation, either everyday or scientific, continues to develop regardless of the context. In line with this integrated and comprehensive perspective, rather than drawing a distinction between mathematical practices in these two contexts, my research aims to understand the multidimensionality of children’s mathematical experiences, residing in their social interactions in- and out-of-school as a whole, and situates parental voices as sources of knowledge that have power to shed light onto the diversity of young children’s mathematical engagements.

Civil and Andrade’s (2003) family engagement framework, which draws on socio-cultural theoretical perspective of Vygotsky (1978), provided strong foundations to my study in theorizing the potentials of “parents as intellectual resources” about young children’s mathematics. Civil & Andrade (2003) problematizes the traditional family engagement practices in schools and propose that parents hold valuable potential as intellectual resources for their children’s mathematical learnings. Therefore, family engagement frameworks in content areas such as mathematics should be conceptualized beyond restricted notions such as attending school-oriented math clubs or family math nights. In their longitudinal research titled MAPPS (Math and Parent Partnership in the Southwest), Civil and colleagues (2006) embraced a funds-of-knowledge perspective (Moll, Amanti, & Gonzales, 2005), and created a family engagement framework that centered around the notion of parents as intellectual resources by recognizing the
various effective roles of parents, such as parents as (a) parents, (b) learners, (c) teachers and (d) leaders. The findings in my study provide perspectives in line with this framework, which posits that families hold potentials to teach mathematics to children in diverse ways. Parents show eagerness to learn about the ways to support their children’s mathematics; they are eager to take leadership roles in their children’s mathematical learning; and as parents they bring their own close observations of the mathematical learning process of their children.

**Methodology**

In this study, my research design was guided by “video-cued multivocal ethnography,” a method developed by Tobin and his colleagues in the study *Preschool in Three Cultures: Japan, China and the United States* (1989) and also in the follow-up study *Preschool in Three Cultures Revisited: China, Japan and the United States* (Tobin, Hsueh, & Karasawa, 2009). In the original studies, researchers videotaped a typical day in a preschool in each culture, and then used these videos as cues to generate dialogs with early childhood educators across the countries with the aim of eliciting their own pedagogical practices embedded in their cultural beliefs. Drawing on this methodology, I recorded diverse mathematically rich engagements of four- and five-year-old children in a Pre-K classroom, and then, I shared these videos with families during the multivocal video-cued interviews. These interviews generated parental dialogs about children’s mathematical engagements both occurring in the preschool and also out-of-school contexts.

**Research Context**

I recorded the videos of the video-cued multivocal interviews in a university-affiliated childcare center because of the ethnically diverse profile of children in the classrooms and the convenience for video-based research at the site, which is located in the southeastern United States. This childcare center is open to infants, toddlers, and preschoolers; I conducted the study
with families of the Pre-K children between the ages of 4 and 5. Focusing on the classroom where I recorded the videos, the class had three teachers, one of whom was the lead teacher and the other two were assistant teachers. The mathematics center of the classroom was composed of a medium-sized rug and a wooden shelf holding mathematical materials such as items for sorting, board games, clock toys, measurement tapes, hourglasses, calendars, and small cubes. Although there was a specified center for mathematics, evidence of mathematics engagements could be observed everywhere in the classroom through the design of the environment, and in both teacher-directed activities and children’s self-directed engagements. Counting was largely embedded in teacher-directed math activities, and in daily classroom routines during gym, snack, and calendar time, such as, for example, counting the sunny, windy, or snowy days in the calendar where they kept record of this information. During the research process, the main teacher-directed mathematical activities were grounded in number operations and relations, particularly about counting up to 20, cardinality, adding, and estimation.

The teacher explained that she used state Pre-K content standards as a guide for mathematics activities; she also stated that the overarching curricular philosophy was a center-based curriculum that valued the free choice of children. The childcare center was accredited by the National Association for the Education of Young Children, and the center’s educational philosophy reflected the discourse of Developmentally Appropriate Practices (DAP) (Copple & Bredekamp, 2009). The individuality of each child, the uniqueness of his or her personality, and the importance of supporting children in terms of reaching their full potential in developmental areas such as the social, emotional, physical, and cognitive domains were emphasized both on the school web-site and in personal communications with the center director and teachers. In terms of families’ social class, generally speaking, they were middle class families.
Considering family engagement implementations in the childcare center, communications focused on the premise of informing parents about their children’s daily lives at the center. Bulletin boards located in front of the classrooms were updated regularly to inform parents about the daily, detailed schedules of the children. Monthly parent newsletters and a quarterly journal were shared with parents about the general announcements such as field trips, guests in the classroom, and general programs of the center. Parents were invited to have daily contacts with teachers. During the research period, a parent meeting about the transition to kindergarten, and individual conferences among teachers and the parents of a particular child about the child’s general well-being were held. Along with a number of parents who visited the classroom to read picture books, some parents accompanied field trips.

**Participants**

The Pre-K class served twenty students, eight females and twelve males. Ten of the children were White Americans, two were African Americans, four were Korean Americans, two were Chinese Americans, and one each was Greek-Cypriot and Turkish immigrants, characterizing this classroom as multicultural. For most of the children in the classroom, either English was their primary language or they were bilingual and fluent in speaking English. Along with examining the classroom as a whole, I focused particularly on the voices and actions of four children, namely Aeron, Amy, Clayton, and Octavia (pseudonyms), and their families. Since I had parental permission from twelve children’s parents out of twenty and was interested in the video-recording of the mathematical practices and then, interviewing families, at the beginning I did not limit observations to any child or group of children in particular. Because of children’s young age and social status, informed consent is always a process that requires attentiveness to the context and respect for each individual child (Freeman & Mathison, 2009). Therefore, once I
became known to the children through my repeated visits for classroom observations and video-recordings, certain children volunteered and seemed more comfortable to be video recorded, when I asked their verbal consent to participate. Then, I used “information-oriented selection” (Flyvbjerg, 2011, p. 307) with the expectation of selecting children who might generate rich-data in terms of including “maximum variation” (Flyvbjerg, 2011, p. 307), in this case, various mathematical engagements. Among the children who seemed comfortable to be recorded, I selected four children (two males and two females) based on their diverse engagements in mathematics. As also acknowledged by the classroom teacher, generally speaking, these four children’s levels and types of engagement in mathematics were different. These main observations about the particular children also appeared and were confirmed during the family interviews while families were sharing their children’s ways of engagements in mathematics both in the classroom and in their daily lives in general. Table 2.1 introduces the children and their families through information generated both in family interviews and my own observations in the classroom.

Table 2.1

*Information on the Participants*

<table>
<thead>
<tr>
<th>Focal Children</th>
<th>Family Members who volunteered for the interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aeron was a four-year-old white American child, who mostly preferred solitary play by himself at the math center, particularly during free play periods. He mostly remained silent but actively completed the mathematical tasks during small group and large group teacher-directed activities.</td>
<td>Aeron’s father was a single father in his late 20s. He explained his own previous mathematical engagements as unpleasant ones, and explained how he had difficulty in algebra during college. He stated that he supported Aeron’s mathematics, especially number sense and basic number operations, particularly because he did not want Aeron to have difficulty in kindergarten.</td>
</tr>
<tr>
<td>Amy was a Chinese-American child who was</td>
<td>Amy’s mother was in her late 30s and she</td>
</tr>
</tbody>
</table>
four-and-a-half-years-old. She generated mathematically rich conversations with teachers and peers, and showed enthusiasm in answering teachers’ mathematics-related questions.

| Clayton was a four-and-a-half-year-old, white American child who was physically very active in the classroom and took instrumental roles. He enjoyed engaging in group play, especially with his male peers, and explicitly engaged in mathematical tasks elicited in the classroom by the teacher. | Clayton’s mother and father were in their early 30s and they both participated in the interview. They described themselves as language persons rather than math persons. In many of the stories they told about Clayton’s mathematics, they emphasized how he was eager to work on mathematical tasks, especially word problems, and perceived them as challenges that he needed to overcome. |
| Octavia was a Chinese-American child who was four-and-a-half-years-old. She remained silent in teacher-directed mathematical activities, but took instrumental roles in her mathematically rich play with her peers, especially in the outdoor area. | Octavia’s mother and father were in their late 20s and they both participated in the interviews. They described themselves as art and language people, more than mathematics. They acknowledged the importance of mathematics in Octavia’s future life, and believed that Octavia was very interested in mathematical learning. |

Data Collection

Although the primary data collection method of this research was multivocal video-cued interviews, I started my research with participant observations to be familiar with classroom culture and establish a relationship both with teachers and children. After a month of participant observation, I made a transition to video-recordings in the classroom. During the whole research process, I kept field notes on a day-to-day basis, which included both descriptive accounts of participants’ practices and my personal experiences such as feelings, ideas, and reactions (Emerson, Fretz, & Shaw, 2001).
In this study, I recorded videos of Aeron, Amy, Clayton, and Octavia when they engaged in diverse mathematical practices in the classroom, three days in each week regularly over a semester. Relying on the notion that mathematical engagements are manifested at any time in a young child’s daily school life (Seo & Ginsburg, 2004), I sought evidences of mathematics engagements in the classroom- through the design of the environment, and through teacher and child talk, either in teacher-directed activities or children’s self-directed engagements. I recorded each of the four focal children on a day-long basis as they shifted from one context to another (e.g., small group - large group activities, structured teacher-directed mathematics activities- free play; indoor-outdoor; individual mathematical engagements-collective mathematical engagements). Then, at the end of the research process, I edited videos for each particular child down to a 10-minute video with the goal of making these short excerpts representative of the child’s mathematical engagements over the three months. The particular scenes in the 10 minute excerpts were composed of three main routines in the classroom such as (a) child engaging in a mathematically rich play activity or conversations with peers (such as during block play, board games, playing cards, or during snack time, or outdoor play), (b) child engaging in mathematically rich engagements by him/herself (such as completing puzzles, playing at math corners with small cubes, sorting materials, working on number sense cards prepared by teacher), and (c) child participating in mathematics activities brought by the teacher, mostly occurring in teacher-directed large group or small group activities.

Later on, I invited families of these four children for individual interviews and used the 10-minute excerpts to elicit conversations with them. At the beginning of the interview, families watched the videos of their own child, and they had the flexibility to re-watch some scenes, or stop and reflect on some scenes. Grounded in the idea of parents as intellectual resources (Civil
I structured interviews in a way that would allow a two-way communication between parents and me. In Spring 2012, I conducted the pilot study of this research with three parents to understand the effectiveness of the method in conducting mathematical dialogs with parents through video-cued interviews. After reviewing these previous three parental interviews, I revised and developed latest version of the interview questions with the supervisor of this research, who has experience in mathematics research with families.

During the interviews of the present study, I also shared my own ideas about the scenes from the Pre-K class and about children’ mathematics in general by sharing some resources with families (The book *Family Math with Young Children* by Grace Coates, Jean Kerr Stenmark, and Brian Gothberg; and mathematics family card sets about number recognition and basic operations). Families reflected on the scenes from the classroom and also shared their experiences in mathematics with their children in out-of-school contexts. I audio-recorded all four interviews which lasted around one-hour, and then, I transcribed them verbatim.

**Data Analysis**

I analyzed the data in an attempt to better understand the parental insights on young children’s mathematics education within the context of video-cued multivocal interviews. I approached the transcribed interview data inductively using both categorizing data analytic approaches and connecting ones (Maxwell & Miller, 2008). First, I identified codes and categories and then, developed them into three district but interrelated themes (see Figure 2.1). Notions of parents about early childhood mathematics expressed in their actual words assisted me to locate their voices and stories around the identified themes.
Findings

The analysis of video-cued multi-vocal interviews yielded rich insights about parents’ observations on their children’s mathematics in both out-of-school and in-school contexts along with their notions related to early childhood mathematics in general. The dynamics of the video-cued multi-vocal interviews allowed both parents and me to learn from and with each other about the potentials of young children’s mathematics as we engaged in conversations triggered both by interview questions and the visual data coming from children’s videos in addition to the families’
and my observations. The analysis highlighted three distinct but interrelated categories such as parental insights on (a) the content of early childhood mathematics (b) pedagogical ways of teaching early childhood mathematics and (c) the context of early childhood mathematics

**Parental Insights on the Content of Early Childhood Mathematics**

In the interviews, all parents shared various foundational aspects of mathematical content that they were drawing on when engaging in interactions that involve mathematics. These interactions are either initiated by children or by their parents when they mathematize children’s daily practices, with examples such as corresponding the number of family members with the food bought at the grocery store, or with the utensils on the dinner table. Not surprisingly, the major theme in mathematics content shared by parents is numeracy, which includes both number relations and number operations. It is well stated in the literature that parents report mostly numeracy activities as part of their children’s mathematics (Blevins-Knabe & Musun-Miller, 1996; Skwachuk, 2009). The type and the nature of these numeracy activities, however, have not been articulated clearly and in detail in previous research. Parental dialogs reported in this study manifested the ways these four-year-old children engaged in different dimensions of numeracy concepts. Parents, for example, reflected that their children show understanding of cardinality and engage in skip counting by 2 and 5, which are the practices that they engage in at the Pre-K classroom.

Besides these basic numeracy concepts, Octavia’s and Clayton’s fathers, both reflected that as their children count, they show interest in the ascending nature of numbers, and show excitement and curiosity when talking about big numbers. After watching the video of Octavia answering the teacher’s question about how many Easter eggs she collected by replying as “one trillion”, her father shared:
I think she has a good sense of numbers. She says one trillion, probably she has no idea how large the number is, but she knows that it’s a very large number. So, she expresses certain meanings in numbers. Yeah, she is trying to exaggerate [referring to the video scene]; sometimes at home she uses the word infinity. She knows that was not the correct answer, but just exaggerates like “infinity!” She made up the words like cazellion, bizillion, gazellion. So, I do not want to discourage her. I say, “Ok yes, it is a word, then.” She asks how large is a number. I say, “I do not know. Almost infinity…”

This experience shared by Octavia’s father shows how he scaffolds Octavia’s interest in big numbers, which is framed in imaginary words, through introducing the concept of infinity appropriately in response to her questions. Preschoolers’ intuitions about the concept of infinity is acknowledged in previous studies and these studies suggest a similar approach in responding to children’s questions related to the ascending nature of numbers by clarifying the fact that there is no greatest number (Lappan & Wheeler, 1987). Likewise, in her study, Evans (1983) exemplifies how the integration of infinity and zero concepts, perceived as impressive by kindergarteners and first graders, enhance their mathematical thought, which is evident in their problem solving skills. Although it may be developmentally early for four-year-old children to engage in thinking about these concepts rigorously, it seems to be effective to positively guide them and foster their curiosity when children initiate these conversations, as modeled by Octavia’s father. Similarly, focusing on the concept of zero, Clayton’s father shared that:

Recently he wanted us to quiz him in math… So we sit there, and he says “Give me a math problem”. Ok, so we do like what’s 2+3, what’s 4+3 and he has figured out connections (among numbers) so he says his sister is zero and he is five; that when he is six, sister will be one … He’ll say “daddy, daddy when I’m 20, how old my cousin be” and … he does these on his own.

In this example, based on his father’s sharing, Clayton shows an emerging understanding that zero has a numerical value, which is smaller than 1. In an imaginative mental number line, while he is moving to be six, his sister will move to 1. Clayton’s understanding of zero is in line with the research suggesting that toward the end of the preschool years, children pass through
steps related to the understanding of the zero concept, starting from recognizing zero as nothing and then, discovering its relationship with other numbers on the number continuum (Wellman & Miller, 1986). This ability of Pre-K children to recognize zero as an ordinal property in a numerical continuum sets the foundation of their future algebraic understanding (Meritt & Brannon, 2013). Clayton’s and Octavia’s fathers help us to see how these young children’s interests in the concepts such as zero and infinity hold potential for their further understandings in numeracy and algebraic concepts. These careful observations shared by parents suggest that preschool teachers could be encouraged to integrate meaningful conversations with children about these concepts in the curriculum through daily conversations (Lappan & Wheeler, 1987). Teachers could learn to guide children in a way that would not cause misconceptions when opportunities present themselves. Among the diverse ways to support children naturally can be counting backward until zero through songs, and rhymes, and including the written symbol of zero during mathematics activities (Wellman & Miller, 1986), associating “nothing” conceptually with the zero, and forming up creative questions that would lend themselves to considering the infinite nature of numbers.

Another theme on mathematical content shared by all parents is related to data analysis, a skill that requires other foundational mathematical knowledge such as number sense, comparison, categorization, and patterns. The dialogs around data analysis presented examples of children’s transference of some mathematical practices from school to home. Focusing on mathematical practices in the Pre-K class, in specific cases, they have a weather calendar in which they record the number of sunny, rainy, and windy days in a month. Similarly, as mentioned earlier, they do voting charts on two or more choices to make democratic decisions as a classroom community. Both Amy’s and Octavia’s mother touched upon how their children
reproduce similar charts at home, and explicitly reflect on what their children have been crafting mathematically through these charts. Amy’s mother, who has a solid background in statistics and mathematics, shares that:

The other day I saw the chart (a voting chart with two columns showing the friends who wanted and didn’t want to participate in physical education class. The columns have the names of the friends and the bottom line was showing the numbers of friends in two columns). You actually can see the frequency; it’s like a frequency chart, and I told her that and we analyzed the data, so Amy draws something like those…”? … “We play together, and she can show like the bar graphs. She can draw the pie chart, and she has not any problem to draw those.

The example provided by Amy’s mother shows how she is recognizing and supporting her child’s mathematical practice by using a language that has a rich mathematical value such as framing the choice of attending physical education class as a frequent choice, and the number of peers who voted as data. Drawing on the idea of parents as intellectual resources (Civil & Andrade, 2003), her recognition of Amy’s chart as a frequency table and how frequency tables can be represented through bar graphs and pie charts, which have a potential for data analysis, affirm that parents bring their own mathematical backgrounds to their interactions with children and also engage in interactions that have potential to move beyond the classroom practice regarding the mathematical content. Octavia’s mother (who described herself as an “arts and language person”) also reflected on a similar data analysis example. After seeing a video scene where children were engaging in completing the weather calendar, she stopped the video and shared a photo she took previously, showing Octavia producing a chart at home. The chart had four columns for each season, and several dots in each column under the season name.

Mother: She drew this (takes her phone and shows the photo to father and the researcher). We were not noticing that she would draw this. This is the fall, winter, spring, summer (points the columns photo). I asked what those dots meant and she said the person numbers that liked it (number of people, represented in dots, who liked the specific season). But, it’s not actually 12 dots.
Researcher: She is kind of imitating. You know, what they are doing in the class is very similar to this. She is reproducing in a very neat way. Actually, almost exactly how teacher is showing.…
Mother: Yeah, I’m sure. She also writes like less, and more. She compares which has the most number and which has the least number. 0 is corresponding less and 14 is more (points the chart).

This engagement of Octavia and the way Octavia’s mother talks about her observation highlight the rationale behind this mathematics activity, first conducted in the classroom and then reproduced by the child at home. The data analysis engagements at home are rich and linked to children’s understandings of number sense, representation, classification and categorization (Cross, Woods, & Schweingruber, 2009). Octavia shows understanding of number relations including the concept of zero; and symbolically represents the peers’ names in dots, and then, in numbers, which is an intricate skill for a Pre-K child. Octavia’s mother recognized, kept a record of this engagement, and shared this during our dialog. In other words, she assisted us to see how young children reinforce and practice their own particular mathematical learnings across different contexts.

Among the other types of mathematical content shared by parents were basic number problems, both in algorithm and story forms. Interestingly, basic geometry, considered as a core area in early childhood mathematics, did not manifest itself during the interviews, which is also an area the teacher was not focusing on during mathematical activities in the classroom. Overall, these dialogs with parents highlighted mathematical content knowledge their children are engaging with in out-of-school contexts as well as the way parents support the learning of this content knowledge. The diverse ways of parents supporting the mathematical learnings of children will be broadly analyzed subsequently under the category of pedagogical ways of teaching early childhood mathematics.
Pedagogical Ways of Teaching Early Childhood Mathematics

In looking into the stories told by parents we can witness the diverse methods of teaching that parents are drawing on in their mathematical engagements with their young children. Appropriate to the ages of their children, playfulness and pleasure is integrated as parents attempt to teach mathematics to their children, or as they responsively react to the mathematical opportunities brought by their children. Parents reported a playful response particularly in the child-initiated dialogs composed of formulating and answering mathematical questions.

In their dialogs, parents brought out the idea that their children are spontaneously engaging in mathematics in daily life (Ginsburg, Inoue, & Seo, 1999; Seo & Ginsburg, 2004). Parents’ recounting of their dialogs points out that they recognize natural learning moments, and they are building time and space to further enrich those experiences without directly explicating them as mathematics. Both Aeron’s and Clayton’s fathers, for example shared examples of these everyday moments. Aeron’s father, who plays guitar and studies music production, frames “the drums as the most mathematical instrument” and shares his observations in relation to use of the body, music, and mathematics:

Father: He [Aeron] likes drums, so he likes to play, kind of like along the beats, with me. He is actually a good singer too, but he won’t do it in front of everybody, only me [laughs]… Yeah, he is shy.. Umm, but his favorite is the drums, he loves the drums.

The researcher: So, I think there is some connections with mathematics and drums.

Father: Oh yeah, oh yeah, I mean you have, it’s like the main beat of every song, you have to count the beat while you’re playing. You know [father taps his feet]. It’s very, probably, the [drum], the most mathematical instrument. He like, I gotta couple of little drums for him, he really likes them a lot too, but you know, just, he can keep the rhythm, you know. And that amazes me, that a 4-year-old, he can keep the rhythm. Well, he uses his hands for that, and like it’s not like he’s counting the beat yet, like a musician would do, but he has, has the feel of it in his hands, like he can feel the rhythm and his hands just do it, you know.
Aeron’s father is exemplifying the research that has been informing us about the mathematical opportunities embedded in musical activities for young children. Through appropriate scaffolding, integration of music and mathematics can add playfulness, pleasure, and meaning to mathematical practices (Lim-Kim, 1999) and has potential to afford enhanced understandings in geometry, number sense, and measurement (Benes-Lafferty, 1995).

Interestingly, a very similar observation was shared by Clayton’s father at the very beginning of our video-cued interview, when he was introducing himself:

…Math has played a huge role in our extracurricular activities and she [Clayton’s mother] did dance. There is a lot of rhythm and counting and timing with that, knowing when things are coming, sequence. And that same thing, I did music and I think Clayton has a good portion of both of that… that he expresses himself with all parts of his feet, his hand, his arms and he’s very much in rhythm. It’s impressive, for even as far back [as when] he was 2 or 3 [years-old], he was nodding his head in time to the music and now, you know, he’ll kind of play the drums and drum my lap do some. And I do things [that] aren’t so much straightforward, you know, and he’ll keep up with that. And so he’s got a good internal clock, you know, and rhythm…

Later on, Clayton’s father continued with a similar theme, when he was giving an example from his own childhood related to mathematical engagements:

Father: I remember music class, like first learning time signatures, that a half note is two, and a quarter note is one. You know, they [teachers] pass all the wood blocks and triangles.
Mother: And he does that too, he is in choir. They have their rhythm sticks and they so yeah, he is doing that. Clayton is doing that too [in choir].
Father: I think it would be easier if you told him, you know, dance out, stamp seven times or hit a wood block or triangle seven times, than say count to seven. That would be easier for him to do that.

It is interesting to see how parents’ observations are parallel with the current literature on understanding the role of bodily movements in acquiring mathematics. From an embodied cognition perspective (Núñez, Edwards, & Matos, 1999), attention to children’s bodily experiences is recognized as important in their mathematics education. A growing body of research shows that particularly rich bodily experiences are central to children’s mathematical
Researchers are proposing that children learn mathematics not only through their bodily experiences but they are also thinking through their bodies.

In their dialogs, both Octavia’s and Amy’s mothers shared their observations about the way their children were creatively using their hands and toes for counting, and feet for estimation and measurement. Overall, although we do not know to what extent and in which ways these parents were explicitly mathematizing these moments and appropriately scaffolding for their children, we can see that they are aware of these teachable moments and recognize them as rich opportunities for their children’ mathematics. This is a promising awareness on parents’ part and shows the potential to collaborate with parents to draw on these integrated everyday moments as mathematically resourceful ones for children. The Family Math for Young Children (FYMC) program, for example, could be a resource for this collaboration, in which, families engage in combining movement and mathematical experiences to enhance children’s understudying of mathematical ideas (Dávila-Coates & Franco, 1999).

Another theme that came up under the theme of parents’ pedagogical ways of teaching mathematics, is questioning. During the video-cued interviews, all parents shared stories in which their children are initiating conversations full of formulating and answering mathematical questions. Parents were clearly articulating the phenomenon of their children’s asking mathematical questions at home, and also the way that they shape these questioning moments as appealing ones for their children by encouraging them to continue to do so. For example, Octavia’s mother and father shared that:

Mother: [Octavia says] “Mom, do you know what 200+200 is, do you know what 1 zillion + 1 zillion is?” Always those kind of questions she would ask, [then] she would, proudly [say], “I know the answer!” I would pretend, “Ohh, that’s too hard! Then, she will very proudly say, “That’s 400!, and do you know 8+8?” And, I, “Umm, let me
We’re writing numbers and we have an abacus, and she also solves the problem using the abacus. For simple ones, she uses her fingers, and if fingers are not enough, then, she uses toes, so 20 for fingers and toes. She can do like that. Then, umm, later, I ask and write problems and we can solve on the paper. And she can do it very quickly and she sometimes makes problems by herself. She just prepares the problem and she pretends as if she is the teacher and she solves the problem. She does that.
Amy’s mother allows us to see how she is participating in Amy’s imaginative play in which Amy is acting as a teacher, again with the similar aim to show her own understanding to her mother. Parental dialogs allow us to see how Pre-K children are aware of their mathematical learnings and enthusiastic about showing these understandings. Thoughtful questioning is a way to support children’s mathematical understanding. In the process of questioning, while inexplicit open questions allow children to think flexibility and come up with creative answers, explicit-focused questions, similar to the ones engaged in playfully by parents and children in this study, keep children focused and encouraged. These engagements of parents and the way they share their experiences hold potential for us as educators to communicate and collaborate with them deeply in terms of generating a wide repertoire of questions that would strengthen children’s mathematical thinking.

**Parental Insights on the Context of Early Childhood Mathematics**

Listening to parents’ voices through video-cued interviews allowed us to see that in their close observations parents are going beyond individual mathematical learning, content, and mathematical tasks; they are showing awareness of the children’s learning context broadly. Parents see the mathematics of their children, yet they also see the dynamics of the whole learning process. Grounded in the notion of parents as intellectuals (Civil and Andrade, 2003), and drawing particularly on the *parents-as-parents* conceptualization, we could see that along with the close observations, parents bring their own sensitivity as parents to the understanding of children’s mathematics. In other words, dialogs with parents yielded insights about the affective component of the mathematics learning process (Civil, Planas, & Quintos, 2005). The dialogs with parents illustrated how they are focusing an eye on their children’s social interactions with others during the learning process, including conflicts, negotiations, and in terms of showing
respect and caring for others. Moreover, parents of the bilingual children Octavia and Amy, were concerned with their children’s emotions resulting from their possible struggles, particularly because of the language issues they imagined their daughters might encounter in the context of mathematics. These diverse context-related sensitivities were evident in the stories told by parents. In Clayton’s mother’s words, “these are the side stories but math stories”.

Clayton’s Mother: …Last time, ok, this is a side story but it’s a math story… so we’re lying back last night and he said, “Can we do one math problem before I go to the sleep?” “Yeah, I said sure. What’s 6 plus 2?” And he said, “Ohh, that is easy Mom, that’s eight,” and I said, “Good, ok.” And I said, “By the way, what was your small group today?” He said, “umm, it was iPad … me and a friend, we’re doing dominos …. we had to match the number with the dots.” And I said, “Wow, was it easy? He said, “Yeah, it was easy for me, but it wasn’t so easy for my friend.” And, “Yeah,” I said, “Did you help him or did you boss him?” He said, “No, I helped him,” and I said, “Was [it] that he does not know numbers?” And he said, “Well, he knows the easy ones, he knows 1,2,3,4,5, but he doesn’t know the hard ones like, you know 7,8,9,10 and a hundred ” “Yeah,” and I said, “yeah, ok…..”

As introduced before, Clayton is a physically active child, who mostly engages in social interactions with both friends and teachers. He is clear and explicit when talking about his ideas, and he actively engages in classroom discourse in general. As his parents describe Clayton as having high self-confidence, they are sensitive about whether he is being assertive and interrupting both others’ and his own learning process. Later on, as we were watching the video in which Clayton was playing chess with a friend, this time his father made the same observation. In the video scene, Clayton was reminding his friend, with whom he was playing chess, that he should do his moves quicker as they were taking turns.

Clayton’s father: This is what Angelina was saying, did you boss them? Did you help them or did you boss them?

Clayton’s mother: A little bit bossy…? Umm, Onur, is like his brother. If it was [the] other kid, I would kinda feel bad…

As pointed out by Clayton’s parents, social interaction in mathematics learning is a constantly reciprocal and dynamic process between and among individuals. This dynamic nature
of interaction also results from the individuals’ uniqueness because “each person is a unique product of a range of socio-historical cultural communities and practices, of unconscious drives and desires, as well as propensities by virtue of genetic make-up and socio-cultural location” (Lerman, 2001, p.94). Focusing on Aeron, who is a more silent child, who mostly engages in solitary play, and prefers playing at the math corner during free play time, but mostly by himself, his father also shared concern about social interactions over a video scene focusing on mathematics. In the scene, after playing with a material that has mathematics value, Aeron attempts to join another friend’s puzzle game, and at first he is implicitly rejected.

Aeron’s father: That’s pretty cool…I like that (a play material for matching object pictures with the objects’ initials). Sometimes, he is not good at speaking about his feelings or telling someone that, you know, telling on someone, you know like, I was playing with that, nobody, he didn’t ask, you know, like, he just sometimes, he just would rather let it go than to speak up about it, you know…

These parents are highlighting the need of acknowledging individual needs of children, and creating an environment where their personality characteristics would not prevent them from engaging in classroom learning activities and resources. Conceptualizing learning as a process of participation in communities of practice (Lave & Wenger, 1991), each community such as a class, family, or specific culture has its own unique practices including language, values, identities, artifacts, norms, and rules. Lave and Wenger (1991) emphasize the importance of the critical issues learners face during this process. Power relationships and hegemony over the resources of the community affect how learners shape their identities in the community and how they are encouraged in, promoted in, or alienated from the community. Focusing specifically on language dimension, Octavia and Amy’s mothers shared their concern about the fact that their children’s home language is different than the academic language in schools, including in the area of mathematics:
Octavia’s mother: Right now, like my vision is that she will be struggling with her math education, especially…
Researcher: Because of the language?
Octavia’s mother: Yes, especially the terms (referring to mathematical terms)… So, I do plan to teach her in the future like that my understanding in some Chinese ways…
Researcher: This would be a really rich experience. Language and thinking, they have very strong connections, so if she can study mathematics both in Chinese and English, that would be really good for her cognitive thinking.
Octavia’s mother: Yes, yes.
Octavia’s father: …and math itself is a language, so it’s just the foreign language, it’s not a linguistic language but it’s a way of thinking…

Although Octavia is a child with intricate mathematical skills, as acknowledged by both her parents and the teacher, as a parent her mother is concerned with her mathematical development, and feels the need to support her child in her native language. Interestingly, both Octavia’s mother and father emphasize the relationship between language and mathematics by situating mathematics as a special language by itself with its special terms. In other words, these parents are showing awareness of how mathematical literacy is different from the daily language their bilingual children are engaging in, both in- and out-of-school contexts. The concern is reasonable as evidenced by previous studies pointing out the struggles of diverse children and families with mathematical literacy (Martin, 2006) and with their participation in mathematics. From a pedagogical perspective, Octavia’s mother is explicit about supporting her child’s mathematics in “Chinese ways.” When she is referring to “Chinese ways,” she is implying the Chinese language, but also certain ways of teaching mathematics in Chinese educational culture. Amy’s mother exemplifies these methods in detail:

Amy’s mother: I think she is talented, she’ll probably do mathematics better than me… But, (it) depends on… I’m not familiar with the American system, how they train those kids and so, I will try very hard at home, to make her interested in math. We have, for example, multiplication, I’m not sure how here they teach multiplication. In China, we have, like a table and so you can memorize very easily, and you can do like, from one times one to nine times very easily, and for me it works very well. But I’m not sure how that exactly is done in English, because if you translate in English it would have actually… If you speak Chinese, you can easily memorize it, but Amy is thinking
differently than me, because I’m familiar with Chinese and she is not, so she actually
didn’t get that part of… I can do it, but I try to teach her this, she is less interested in
[learning the Chinese way of mathematics] because of the language….. for me (referring
to her own childhood) it would be very hard to count in English, as well.

Amy’s mother is touching upon the idea that language and mathematical concepts have
strong connections, and language has power to shape the conceptualizations of mathematical
concepts. As pointed out by Amy’s mother, Chinese and English languages differ in terms of
naming the numbers words, which have implications in learning the base-ten system (Cross,
Woods & Schweingruber, 2009). Similar to Octavia’s mother, Amy’s mother is also planning to
support her daughter’s mathematics both in English and Chinese by drawing on the methods that
have been used in Chinese education, which has been shown to be effective in supporting young
children’s academic achievement, including the area of mathematics (Barnett, Yarosz, Thomas,
Jung, Blanco, 2007).

Conclusion

“Learning must be understood with respect to practice as a whole, with its multiplicity of
relations - both within community and with the world at large (Lave & Wenger, 1991, p.141).
It’s clear that it is the nature of social interaction that shapes and is being shaped by the multiple
identities of each unique individual in the learning process as a whole, including the
mathematically rich learning opportunities residing in these social interactions as the focus of
this research. Parents have a unique privilege in observing and interacting with their children;
their insights and experiences of the mathematical learning process have implications for both
educators and educational researchers in terms of what is valuable to teach children, what ways
are meaningful for creating learning opportunities, and what are the questions that we are
searching answers to in the hopes of a constructive change in early childhood mathematics
education.
The dialogs I engaged in with parents drew a broad picture of the landscape of early childhood mathematics, as we elaborated their notions and observations about content in early childhood mathematics, particularly parents’ observations of diverse number sense and data analysis engagements with their children. I also saw parents’ pedagogical ways of teaching mathematics, particularly in their use of questioning and the integration of play and movement. Finally, I heard parents’ reflections on the context of mathematics in which parents shared their deep concerns and sensitivities about the processes of their children engaging with mathematics.

In looking into the family engagement literature, there is consensus that parental engagement is necessary and ultimately good for children’s academic content areas including mathematics; however; the definition exactly what we intend for this engagement is vague and it is not commonly acknowledged that the phenomenon of parental engagement is not pleasurable for all parents (Dehli, 2003). We should be critical of the common assumptions that only expect families to support their children’s pedagogic practices in line with the school practices, which are for the most part disconnected from their home experiences. Research conducted from this frame of mind can lead us to the conclusions that would position parents as responsible for their children’s lack of mathematics knowledge while also positioning parents as being in need of learning mathematics to be able to support their children’s mathematics. This perspective lends itself to a promotion of general parental engagement practices with the expectation those will be fit for all parents and all children’s needs. However, “parents are not participating in their children’s education because they believe they ought to be or because some is telling them to, they do so because they believe they must in order the produce the effects they hope for” (Freeman, 2008, p. 472). When designing the research I reported here, this perspective allowed me to move away from concerns about whether or not parents are capable to support their
children’s mathematics; or concerns about whether or not they have enough means to stimulate their children’s mathematical interests at home or if they value language and literacy experiences over the mathematical ones during the early childhood education period. My aim is not to ignore these concerns, because they have emerged frequently in research contexts where understanding the process of children’s mathematics learning is a focus; instead, my goal is to move these concerns away from the center of the inquiry. The research I reported here based upon this insight made it possible for us to see that as long as we develop a methodology that allows us to draw on the strengths of parents, we could see that the notions coming from parents are powerful and very in line with the research exploring young children’s mathematics education broadly.

The National Research Council Early Childhood Education Committee (2009) acknowledges the effectiveness of programs that link families and schools in terms of enhancing children’s mathematics; however, their statement confirms our lack of knowledge about particular effective practices for educational programs to support parents and young children in mathematics. The results of this video-cued study with parents have potential to inform practice in terms of first acknowledging parental knowledge and experiences as a source of knowledge for early childhood mathematics as a starting point, and then, creating opportunities where teachers and parents might come together and engage in thinking and learning from each other in terms of children’s diverse mathematical engagements. Practices that already widely exist in schools, such as family math nights and school family math clubs, would be rich spaces for these engagements if designed from the parents-as-intellectual resources point of view. I imagine that the dialogues might take place in these spaces could expand our thinking on mathematics in the early years and could also provide us with an understanding of how we might make curricular connections with parents, as they share how children engage in and transform mathematical
practices as they move back and forth between home and school. Put succinctly, I envision that efforts to improve early childhood mathematics education can be developed as a way of thinking about how to support parents and how to be supported by them in these shared spaces.

Recommendations for enhancing early childhood mathematics education regarding content focus on number sense and geometry as core areas incorporating early number operations, spatial thinking, measurement and data analysis (Cross et al., 2009) along with the “habits of mind such as curiosity, imagination, inventiveness, persistence, wiling to experiment, and sensitivity to patterns” (Clements, Sarama & DiBiase, 2004, p.57). Parents in this study discussed how they draw on and observe their children’s engagements in some of these content-related areas, particularly in terms of number sense, number relations and basic number operations, and data analysis -which is rich in terms of patterning and knowledge organization. The content areas of geometry and measurement did not emerge in the research with parents, but this may have been due to the lack of these areas in the classroom video excerpts the parents observed and reflected upon, rather than being due to a lack of engagement with these areas with their children. When I take a more specific look at the areas of content parents explored with their children, I see some extensions beyond those outlined in recent literature about early childhood mathematics. Parents and children did not simply explore numbers 1-30 in the area of numbers sense, but were interested in contemplating “big numbers” such as a [gazillion]. Children did not restrict themselves to simple addition concepts such as considering how many pears and apples were in a basket-instead they wondered about how old their sister would be when they were two years older.

It is well stated in the literature that children engage in a great deal of mathematics as part of their everyday lives both in and out-of-school contexts (Seo & Gingsburg, 2004), therefore; it
has been recommended that early childhood educators recognize and mathematize these everyday situations with young children through elaborating on mathematical ideas along with appropriate math talk. As parents shared their observations, not only related to their children’s mathematics, but also about the very nature of mathematics itself, we could understand that they see how mathematics is embedded in their children’s daily lives; and they confirm that these everyday moments are rich for mathematical engagements, particularly when children bodily engage in physical play, music, and dance. On the other hand, it is not clear to what extent parents are mathematizing those moments, and in what ways they insert themselves into these teachable moments; but this could be a starting point for further research about observing these processes and generating insights for both parents and teachers in terms of turning teachable moments into mathematically meaningful ones for children.

In addition to these inadvertent everyday learning opportunities, intentional teaching moments (Cross, et al, 2009; Ginsburg, 2009) provide a context in which children engage in a foundational mathematics content under adult guidance with a particular goal related to the mathematical engagement itself. Parental dialogs in this study showed evidence that parents balance both intended and non-intended learning moments in the course of mathematical engagements. Parents do not only engage in mathematics that appear in their children’s daily lives spontaneously, but they also create intentional teaching moments or participate in mathematical practices brought by their children with a direct intention to teach mathematics such as engaging in imaginative play by taking the roles of teacher and student; or acting as if the answer of the mathematical question is not known themselves during the mathematical questioning moments.
The potential I see in these dialogues that take place between parents and researchers, and among parents and children, is that each actor, including the child, in the process will have mathematical insights to share with others. Specifically, in early childhood education, along with curricular knowledge, the idea of what is valuable in terms of mathematics would be a constructive topic in communication among teachers and parents and children. In relation to these dialogues, Walkerdine (1988) supports the notion that the discourse on mathematics changes as individuals and their discursive practices change. Therefore, when families, children, and teachers come together and engage in communication, they will produce and will be produced by a unique discourse on mathematics. Moreover, this dialogue could create a space for observing how children transform mathematical practices between home and school as parents and teachers share their own understandings of mathematics. These dialogues would expand the thinking on early childhood mathematics and also provide us with an understanding of diverse families’ perspectives on mathematics. How children transform the mathematical practices between home and school and the anxieties and pleasures of this process for teachers, parents, and children seems to be important and exciting foci for future research that would enrich our current knowledge about early childhood mathematics education.
References


CHAPTER 3

MANIFESTATIONS OF MATHEMATICS WITHIN THE DISCIPLINARY DYNAMICS OF A PRE-K CLASSROOM²

² Karsli, E. To be submitted to Educational Studies in Mathematics.
Abstract

This video-ethnography research with 4- and 5-year-old children in a Pre-K classroom elicited insights about how discipline is institutionalized within the contexts of schools, and how a school’s disciplinary mechanisms are infused in mathematical practices in a classroom of young children. As mathematics was enacted in multiple discourses, key scenes from the study showed verbal and bodily rules inserted in mathematical curriculum times, and demonstrated ways in which mathematics becomes a disciplinary tool itself during the course of the day, with its authoritative, and classificatory nature. Also evident were the ways in which all actors in a classroom draw on mathematics for problem solving in real life situations within a power/resistance dynamic. Along with unpacking the norms about appropriate ways of being when engaging in mathematics, this research has implications for considering how, when, and why children might be discouraged from engaging their bodies meaningfully in mathematics practices in a Pre-K classroom.
Introduction

Starting from their early years of childhood, young children are taught about their bodily dispositions in various settings. They encounter and become a part of the discourse of society’s taken-for-granted assumptions about the appropriate bodily acts for different settings. Some of these are institutional settings that require a strong compliance with the power relationships specifically inscribed on the bodies. The preschool classroom, in particular, is one of the first institutionalized spaces in which young children, as students, start to learn appropriate bodily acts. As in any other space, a preschool classroom has its own routines, explicit and implicit rules, and sanctioned bodily dispositions. It is the place in which children begin to experience the process of being a student and acting, talking, and thinking like a student.

Conceptualizing preschool classrooms as institutions that are meant to regulate children’s actions and interactions, this research focuses on mathematical practices in a preschool classroom and the distinct ways children’s bodies are engaging in these practices of mathematics. Although mathematics has been seen as a highly valued abstract discipline, for the most part associated with intellect and cognition, the central emphasis of this study was on children’s individual and collective bodies and their processes of becoming Pre-K students engaging in mathematics through particular verbal and bodily dispositions. In this research, I embrace a Foucauldian (1995) perspective, which conceptualizes school as an institution that has been developing its own primary techniques of control, creating its own disciplinary power with the aim of regulating and normalizing individuals. These bodily techniques of control are legitimized and usually considered to be normal in the institutionalized settings, such as schools, as being assumed social-cultural norms of socialization. Following this perspective, my research involves a consideration of how children’s bodies and minds are being engaged, or detached, within the
power dynamics of the preschool classroom in relation to learning mathematics. In other words, I am interested in exploring how and in what ways the mathematics produced in a Pre-K classroom intersects with the fluidity of the power dynamics produced by all of the actors in a Pre-K context.

Within this Foucauldian conceptual perspective, I particularly draw on Walkerdine’s (1988) conceptualization of mathematics in relation to the social practices of individuals. This view recognizes the body as part of individuals’ social practices. The child’s body, as a part of his/her social and daily practices, mediates his or her understanding of mathematical concepts, which is a notion that draws attention to the context in which and in what manner these experiences of children appear. Drawing on these conceptual and theoretical frameworks, the following questions guided the video-ethnography inquiry I conducted with 4 and 5 year-old-children in a Pre-K classroom during spring 2013: What are the bodily demands of engaging in mathematics in a Pre-K classroom and what are the discursive practices in a Pre-K classroom that regulate the mathematical engagements of young children?

**Bodily Engagements within the Power Dynamics of Early Childhood Classrooms: How Does it Relate to Mathematics?**

Looking at the theorization of the body in early childhood education, grand theories of young children’s development do not put explicit emphasis on the body, but some of them offer insights into how the physical bodies of children are important in their learning and their process of making sense of the world (Freud, 1905; Piaget, 1972). Focusing particularly on mathematical learning, in addition to the research proposing that physically active and playful learning environments support young children’s mathematical learning (Seo and Ginsburg, 2004; Clements & Sarama, 2007), recently an intriguing body of research, from an embodied cognition
perspective (Rosch, 1973), has been theorizing children’s physical bodies as central to their mathematical learning. The research supports the idea that children learn mathematics not only through their bodily experiences but also by thinking through their bodies (Alibali & Nathan, 2012; Valenzeno, Alibali, & Klatzky, 2003; Kim, Roth, & Thom, 2009). This research supports the notion that the child’s mind is largely governed by the experiences of his/her body because human cognition is itself biologically embedded in individuals (Lakoff & Núñez, 2000). This view conceptualizes the body as continuously available as a point of reference for mathematical thinking.

The starting point of the research I report here privileges children’s bodily experiences in the process of learning mathematics, and centers on the notion that rich bodily experience supports children’s mathematical understanding. This perspective enlarged my attention to the educational settings in which children’s bodily experiences are manifested and to the discursive practices that produce and are being produced by these experiences (Walkerdine, 1988). Therefore, beyond the body of a child engaging in mathematics at the individual level, I have sought other questions such as: which bodily experiences are welcomed or restricted during mathematical engagements; to what extent are children allowed to use their bodies; who is allowed to use his or her body more; and how and why do rules and routines shape all these processes in a classroom? In this sense, as the body becomes the object of study in many disciplines such as anthropology (Asch, Connor & Asch, 1983), sociology (Foucault, 1990; Mauss, 1973) and gender studies (Butler, 1993), critical insights have also been generated in the field of education (Leander & Boldt, 2013; Tobin, 2004), and have helped us to problematize the trends in today’s classrooms where the attention to bodies is almost exclusively taken up as ways of controlling and disciplining children’s bodies.
In early childhood, more specifically, the meanings attached to the cultural and social politics of the body have been changing as young children’s bodily engagements have been decreasing in the context of early childhood education classrooms (Tobin, 2004). Historical associations of the body of young children with running, jumping, screaming, and laughing are being replaced with descriptors such as silent, controlled, alert, and disciplined (Tobin, 2004). Drawing on Foucault’s notion of docile bodies, scholars such as Lee (2012) in her study with low-income families and children with special needs, show that when children fail to be “good” preschoolers by regulating their bodies, they are at risk of being labeled as having an attention deficit hyperactivity disorder. The discourse about “good” preschoolers may change slightly from context to context, but in many cases, the dominant discourse on the “good” preschooler refers to the normalization and acceptance of being controlled and obedient.

As the strong emphasis on cognitive skills development and the standardized assessment process exert pressure on children’s lives, even very young children are spending less time in physical play and more time in physically passive academic activities. Privileging the intellect over the body and valuing cognitive experiences over bodily ones lead teachers to overly control children’s bodies and place an emphasis on brain-rich rather than bodily- rich activities with an assumption that mind and body are different entities. Ross’s (2004) discussion points out this distinction between mind and body in American classrooms through a comparison of educating the body in the performance arts – specifically dance – and educating the mind in the academic context; these two cases, the body is disciplined through certain distinctive rules. While in dance, the child’s body is perceived as united with his/her mind and its presence is strongly recognized, in an academic context, the child’s mind and body are positioned as different entities and experiences of an “instructable body” (p.170) are diminishing because of the strong emphasis on
the intellect. Similarly, in her comparative study of Japanese and American early schooling, Walsh (2004) acknowledges that physicality in early childhood education, which was also highly emphasized by Froebel generations ago, has a profound importance in young children’s processes of making sense of the world. Nowadays, however, physical experiences are waning in early childhood classrooms. In American schooling, the focus has shifted to the education of the mind away from the education of the body as if mind and body were separate entities, whereas in Japanese culture children’s physical beings are supported with extended time for outdoor physical activities, free play, and integration of movement in the curriculum through drama and dance (Walsh, 2004). Tobin (2004) proposes that this trend toward the dichotomy of mind and body is transnational, and it has the potential to circulate worldwide soon because a variety of connected global trends creating this division. Trends such as rationalism, infant brain studies, the decline of psychoanalysis, and also the increase in moral panic concerning children’s bodies (Walkerdine, 1984) are all influencing this global tendency to separate children’s minds and bodies in educational settings.

Looking through the literature, there are conceptual writings that employ a critical perspective in analyzing bodily details of children’s school lives, but empirical studies, tracing the power dynamics inscribed on bodies in relation to the content-related practices, are scarce. My study aims to contribute to the literature through the means of an empirical study concerning video-taped mathematical practices from a Pre-K classroom. In my study, I make the assumption that in a Pre-K classroom, different forms of power could be observed in any instance of the children’s daily routines since children’s use of their bodies is situated in the power relationships and practices in particular settings. One can focus on mathematical practices, literacy practices,
teacher’s disciplining practices, or children’s play to observe how children are being made objects and also subjects of power relations.

A study exemplifying this assumption comes from Kamler, MacLean, Reid and Simpson (2001) in which they show how ritualized songs, rhymes, and routines in a kindergarten classroom become a source for disciplinary practices toward shaping children’s bodily dispositions. The movements called for in these songs and the rhymes used are related to sustaining control and order in the classroom such as “hands on shoulders, hands on hips, where’s your hips, hands on hips; legs crossed, hands to yourself, lips buttoned, hands in your laps.” These texts are having the “indirectness of hegemonic power” (p.221) because students follow these practices and produce order in the classroom in a joyful way while these texts produce their bodily dispositions in restricted ways, which shows that literary forms can be one of a number of systems operating as a means of power in children’s lives.

Focusing particularly on mathematics, in their study with children from a marginalized community, Parks and Schmeichel (2014) reflect on the power dynamics between researcher and children who differ in terms of their social class background and ethnicity. They show that by paying attention to the details of children’s bodily expressions, power dynamics between the researcher and the child can be reconciled and more meaningful interpretations can be obtained both to understand children’s comfort level and to evaluate their mathematical understandings evolving over time. In another ethnographic study of ten-to twelve year-old children’s understanding of the qualitative passage of time as they make the transition from primary to secondary school, Jenks (2011) claims that in the context of school we see “the child as being captured through time and captured by it and in a radical interpretation the body becomes the very instrument of time” (p.74). As evidenced by the children in Jenks’ study, the dominant
discourse situated around the notion of time was produced in a variety of ways such as following timetables, showing obedience to specified time limits for particular activities, managing time especially when working on standardized tests, grouping children according to their chronological ages, labeling them as being mature or not with respect to the passage of time in their lives, and imposing particular bodily movements on children accordingly to their developmental levels or stages.

To summarize, the literature provides insights about how educational processes, including mathematical ones, are under the constant influence of many discourses uniquely produced within the disciplinary dynamics of classrooms. Considering Pre-K classrooms as one of the first spaces where bodies are subjected to institutional regulations, my research traces the mathematical practices in a Pre-K context, in which I take into consideration the issues of power relations and control, along with sociocultural assumptions about how, when, and why children might be encouraged or discouraged from engaging their bodies in their mathematical learning activities.

**Theoretical Framework**

The theoretical perspective of this research aligns with the framework conceptualizing mathematical engagements from a discursive practices approach, which deals with issues of language and multiple forms of communication including bodily expressions in children’s mathematical thinking (Keiran, Forman, and Sfard, 2001; Lerman, 2001; Oers, 2001; Walkerdine, 1988). This approach points out that discursive practices which produce mathematics, and which are being produced by mathematics (Walkerdine, 1988), in multiple settings are central to children’s learning of mathematics because of their mediating role in learning. This framework positions mathematics as an activity of communication and
mathematics learning as becoming fluent in the classroom discourse and the process of the internalization of mathematical discourses in the classroom (Oers, 2001).

Every classroom has its own unique discursive practices that shape the organization and the production of knowledge, and that are influenced by the individuals’ culture and history, and the power relationships among them (Foucault, 1990; 1995). To this end, Foucault’s (1995) discussion of discipline and punishment provides a theoretical basis for analyzing discursive practices in a classroom as related to rules, use of space, and power relationships, which is a perspective that helps shift the focus from the expected outcomes of the classroom curriculum and management to a consideration of how children’s bodies and minds are being engaged, or detached, within the dynamic interactions of the preschool classroom and in relation to learning mathematics. Foucault (1995) introduced a perspective on the body by discussing the way disciplinary power operates on the human body both literally and symbolically. Individuals within their bodies are subjected to institutional regulations, and discipline enforced on the body manifests itself in consciousness. For this reason, bodies engaging in discursive practices can be observed and read to understand the discourses available to the mind (Foucault, 1995).

This research particularly draws on Walkerdine’s (1988) conceptualization of mathematical practices by placing emphasis on issues of power and the social construction of mathematical meanings from a Foucauldian perspective. In her studies, Walkerdine (1984; 1988) takes a critical stance on the domination of the Piagetian notion of children’s mathematical learning, and argues for the possibility of different theoretical perspectives on young children’s mathematical practices by juxtaposing the dichotomies related to mind and body, and the developmental stages found in grand learning theories.
According to her perspective, the conceptualization of mathematics cannot occur independently of the social practices of individuals, which are always at the intersections of power dynamics. The body of the child as a part of his or her social, cultural, and daily practices mediates the understanding of mathematical concepts. Early mathematical concepts, for example, big/small; heavy/light; tall/short, signify the characteristics of objects. Walkerdine (1988) suggests that these words not only communicate the functional relationships of objects but also carry meanings related to children’s social practices and how their bodies enter a relationship with the physical characteristics of the object. The concept of small, for example, may refer to a size, to the value of objects that are small in children’s daily lives, or to being the youngest member of the family who has the smallest body. Considering another example, the concept of weight communicates the functional and physical characteristics of the objects. However, one way that children give meaning to these concepts is to draw on their bodily experiences such as being or not being able to carry an object, and then conceptualizing the concept of heavy or light accordingly (Walkerdine, 1988).

**Methodology**

I collected the data for this research from a video-ethnography study in a Pre-K classroom located in the southeastern United States. The methodological approach I took in this research drew on multiple perspectives and insights I derived from the use of video as a research tool in educational settings (Erickson, 1992; Tobin, Hsueh, Karasawa, 2009; Flewitt, 2005). My research has an ethnographic-orientation because it involves being in the field, and participating in the ordinary life of a preschool classroom and engaging in a deliberate inquiry process to make the familiar strange (Erickson, 1984) by taking into consideration the historical and cultural contexts of schooling. In other words, my study was a search for “what is inside the
‘black boxes’ of ordinary life in educational settings” (Erickson, 1992, p.202) with respect to mathematical engagements. The integration of video as a research tool into this process provided a multitude of possibilities to closely and vividly attend to the daily complexities that are always present in preschool contexts where teaching and learning are the primary focus (Tobin et al., 2009). The integration of video methods and participant observation served the purpose of a close study of simultaneously occurring practices around the mathematical discourse in the Pre-K classroom and also allowed me to document the observed power dynamics in this classroom, which were both implicated through physical bodies and also manifested through the use of language by the teacher and the children. My view on using video as a source of data was enriched by using multimodal analysis approach that offered the possibility of capturing and systematically analyzing the multiple modes and affordances (e.g., culturally and socially shaped resources that we draw on to make sense of the world around us, such as gesture, gaze, speech, posture, image, writing and layout (Kress, 2009) available in a classroom and reflected on human bodies (Jewitt, 2009).

Through the aim of familiarizing myself with the preschool classroom community and establishing a relationship with the members of the community (Asch, Connor, & Asch, 1983), I started with participant observations in the classroom. The process of participant observation provided me a general picture about the routines of the classroom and helped me to make decisions, in line with my research questions, about where to position myself at the intersection of time and space during the daily routine of a preschool classroom. These participant observations allowed me to discover the physical and social spaces where most of the mathematical engagements (both formal and informal, explicit and implicit) were manifested in the classroom, and this process also helped to determine the four children who would be the
focus participants of my study (described later). After one month of participant observation and once I became confident and satisfied about making a transition to video, the process of video recordings started for the following three months, three days in each week, which resulted in overall 52 hours of video-recordings. Relying on the idea that mathematical engagements can be manifested at any time in a child’s school life (Seo & Gingsburg, 2004), my videotaped recordings captured a broad range of scenes from preschool life, such as teachers’ and children’s everyday practices and the classroom setting during daily routines (e.g., in sequence: morning calendar time; teacher-directed small group activities, free play, large group activities, outdoor play, lunch, nap time), with an eye on mathematics.

Starting from the first day of the research both during the participant observation and video-recordings period, I used extensive field-notes on a day-to-day basis, and included both descriptive accounts of participants’ practices and my personal perspectives such as my feelings, ideas, and reactions (Emerson, Fretz, & Shaw, 2001) to adopt a reflexive stance (Flewitt, 2006) and to aid my video recording process, which inherently has the threat of de-contextualization of recorded scenes from the rest of the research context (Erickson, 1992).

Research Context

This research took place in a university-affiliated childcare center particularly because of the convenience for video-based research at the site. This childcare center is open to infants, toddlers, and preschoolers. I conducted the study in the only Pre-K classroom of the center for children between the ages of 4 and 5. The teacher explained that they draw on state Pre-K content standards as a guide for mathematics activities; she also stated that the overarching curricular philosophy was a center-based curriculum that valued the free choice of children. The childcare center is accredited by the National Association for the Education of Young Children,
and the center’s educational philosophy reflected the discourse of Developmentally Appropriate Practices (Copple & Bredekamp, 2009) aiming to support young children’s optimal learning in each developmental area.

The Pre-K class was located on the ground floor of a large brick building and had a large outdoor play area. The classroom was separated into different spaces for art, book, block, drama, mathematics, and science centers. In terms of how children experienced the classroom space, the pre-established rules included specifics about time periods for the use of these spaces and the number of children who could use the spaces at the same time. There were also specific bodily ways of being in the classroom as individuals, and as collective human beings, evidenced in the excerpts from the classroom such as being a part of a perfect line, using an inside voice or normal Pre-K voice, using walking feet. Since it was already spring, I was able to observe how these rules were practiced but not how they were established as routines earlier in the school year. Overall, the classroom had an ordered and peaceful atmosphere. Children went about the activities purposefully and seemed comfortable with each other and the teachers. Occasionally fights or disagreements would occur and these were generally dealt with by reviewing the rules orally with the teacher individually. The classroom was generally calm; it was neat, but conflicts were arising from time to time. Children had smooth but loud transitions balanced with teachers’ rule reminders, and children’s disobedience, in this case, which refers to being loud, and acting contrary to the “hands to yourself, eyes looking straight” guideline while moving between the designated spaces such as the large carpet area, small group areas, restroom, and outdoors. The class had three teachers, one of whom was the lead teacher and the other two were assistant teachers, and several student-teachers who positioned themselves in different corners of the classroom during the day for added help and supervision. There were four cameras hanging on
the walls, and a big mirror that separated the classroom from the observation room for parents, researchers, and school staff to be able to watch the classroom. The classroom design and its enforced practices acknowledge Tobin’s (1995) description of American preschools as “panoptic mechanisms as self-scrutiny and psychological testing, but also of a literal panopticism obsessed with sight-lines and other techniques for making young children constantly visible” (p. 227).

The mathematics center of the classroom was composed of a medium-sized green rug that would allow about four children to play and a wooden shelf holding mathematical materials such as items for sorting, board games, clock toys, measurement tapes, hourglasses, calendars, and small cubes. Along with the specified center for mathematics, evidence of mathematical engagements could be observed everywhere in the classroom in the design of the environment, and in both teacher-directed activities and children’s self-directed engagements. Among other kinds of drawings and displays, for example, the walls of the classroom were full of class work related to mathematics, such as posters demonstrating the results of various estimations and number charts used for voting on two choices, such as deciding to have a physical education hour on that particular day or not. Counting was largely embedded in teacher-directed math activities, and in daily classroom routines during gym, snack, and calendar time, such as, for example, counting the sunny, windy, or snowy days on the calendar where they kept record of this information. During the research process, the main teacher-directed mathematical activities were grounded in number operations and relations, particularly about counting up to 20, cardinality, adding, and estimation.

Participants

In this Pre-K class there were twenty students, eight females and twelve males. Ten of the children were White Americans, two were African Americans, four were Korean Americans, two
were Chinese Americans, and one each were Greek-Cypriot and Turkish immigrants, characterizing this classroom as multicultural. For most of the children in the classroom, either English was their primary language or they were bilingual and fluent in speaking English. Along with examining the classroom as a whole, the study I report here focused particularly on the voices and actions of four children, namely Aeron, Amy, Clayton, and Octavia (pseudonyms) and their three teachers, namely Linda, Karen, and Jaelyn. Since I had parental permission from twelve children’s parents for the more individualized focus of the research, at the beginning I did not limit my observations to any child or group of children in particular. Once I became known to the children through my repeated visits for classroom observations, I identified those children who seemed more comfortable with being video recorded when I requested their verbal consent to participate. Then, I used an “information-oriented selection” (Flyvbjerg, 2011, p. 307) process to select children who might generate rich-data for “maximum variation” (Flyvbjerg, 2011, p. 307), in this case, various mathematical engagements along with bodily expressions. Among the children who seemed comfortable being recorded, I focused on four children (two males and two females) based on their diverse engagements in mathematics. This process was also supported by conversations with the classroom teacher, who stated, generally speaking, that these four children’s levels and types of engagement in mathematics and the way they expressed themselves both physically and verbally were different from each other.
Table 3.1 briefly introduces the focus children and their classroom teachers:

**Table 3.1**

*Information on Focus Children and Classroom Teachers*

**Focus Children**

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aeron</td>
<td>A four-year-old White-American child, who mostly preferred solitary play by himself at the math center, particularly during free play periods. He usually remained silent in the classroom but actively completed the mathematical tasks during small group and large group teacher-directed activities or during free play by himself. He always looked very engaged with the diverse classroom materials featuring mathematics. For example, he expressed this physically during teacher-directed math activities, by producing small movements, mainly jiggling. He sometimes, therefore, became the target of teachers’ reminders about appropriate bodily positioning when doing mathematics. During the other types of physically-rich activities directed by the teacher such as dancing, he was always showing resistance-staying still with his arms crossed.</td>
</tr>
<tr>
<td>Amy</td>
<td>A Chinese-American child who was four-and-a-half-years-old. She generated mathematically rich conversations with teachers and peers, and showed enthusiasm in answering teachers’ mathematics-related questions out loud during group times. She mostly played with other girls in the classroom, and often used mathematical language during her play. She was generally physically active, but at the same time usually followed the teacher’s rule reminders related to appropriate bodily dispositions.</td>
</tr>
<tr>
<td>Clayton</td>
<td>A four-and-a-half-year-old White-American child who was physically very active in the classroom and took instrumental roles such as being a leader in a play, requesting changes during an activity. Clayton also received many rule reminders about appropriate bodily acts during activities, but he seemed to ignore them. He enjoyed engaging in group play, especially with his male peers, and explicitly engaged in mathematical tasks elicited in the classroom by the teacher. He was eager to work on mathematical tasks both by himself and with other kids, and enjoyed being recognized by the teacher about the way he did well at a mathematics game, or mathematical task.</td>
</tr>
<tr>
<td>Octavia</td>
<td>A Chinese-American child who was four-and-a-half-years-old. She mainly remained silent in teacher-directed mathematical activities, but took instrumental roles in her mathematically rich play with her peers, especially in the outdoor area. Octavia generally stood still during teacher-directed small and large group mathematics activities, and seemed very focused on mathematical engagements.</td>
</tr>
</tbody>
</table>
**Classroom Teachers**

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linda</td>
<td>Linda was the lead teacher of the classroom and has an undergraduate degree from the Birth-to-Five program in the Child and Family Studies Department. She was responsible for the planning and particularly for the teaching of large group activities. In terms of classroom management and discipline, Linda was consistent throughout the semester in reminding the children about the same particular set of rules about the appropriate ways of being a Pre-K student.</td>
</tr>
<tr>
<td>Karen Jaelyn</td>
<td>Karen and Jaelyn were the assistant teachers and were responsible for leading small group activities, mainly art-related activities, and also for the general maintenance of the classroom such as preparing materials and snacks. In terms of classroom management and discipline, while Linda mostly used verbal instructions, Karen and Jaelyn, physically positioned themselves close to the children who needed rule reminders from the lead teacher in order to provide silent reminders through being physically actively present.</td>
</tr>
</tbody>
</table>

**Analysis**

Starting from the first day of my fieldwork, the analysis of the data was embedded in the entire research process followed by systematic analysis of the video data and field notes at the end of the data collection process. My data analysis was guided by strategies suggested by ethnographic micro-analysis of interaction (Erickson, 1992) and multimodal semiotics (Bezemer & Jewitt, 2010). While the ethnographic micro-analysis of interaction approach offered a general framework to examine the main corpus of video-data, the multimodal semiotics approach informed the systematic unit of analysis of the key microscenes I generated out of the entire data set.

Ethnographic micro-analysis of interaction offers an analytic induction method to analyze video data by assuming that video does not speak for itself, but requires construction and interpretation (Erickson, 2006). The basic premise of this approach is: portraying immediate human interaction as the collective activity of individuals in institutionalized relationships who, as they enact daily life locally in recurrent ways, are both
reproducing and transforming their own histories and that of the larger society within
which they live (Erickson, 1992, p.223).

A central tenet of this approach conceptualizes the “communicative action as a discursive
practice that manifests power relations among social actors” (Erickson, 1992, p.203). These basic
premises of ethnographic microanalysis intersect with the nature of my own inquiry in the
preschool classroom. The framework provided by Erickson (1992) offers a step-by-step approach
in which first the whole corpus of data are viewed, and then, major segments of the data relating
to the research questions are identified. Later on, in the third step, the context and individual
actions in these major segments of data are analyzed. This is the step in which the multimodal
analysis approach, which situates the bodily experiences at the center of attention and offers a
methodological application for observing these bodily engagements (Jewitt, 2009), assisted me
in engaging in a very detailed analysis of children’s and teachers’ actions and interactions in the
major segments, in other words in the key scenes. This analysis and the lens it brings provided a
careful observation of what resources and modes were available to whom, along with the
discourse that regulates how children and teachers used modes (Flewitt, 2003). At the end of the
process proposed by Erickson (1992), the relationship of the particular segment with the other
analogous instances in the whole corpus of data is discussed to show its representativeness or its
distinct dimensions. Similarly to this approach, I started with reviewing the entire corpus of
video data and field notes; and I documented the key scenes (major segments of data) that had
potential to inform my research question.

Erickson (1992) affirms that the last stage of the analysis process, which shows the
analogous instances in the whole corpus of data similar to the major segments analyzed, is the
most important step for data interpretation. In my analysis, rather than following a step-by-step
approach, when reviewing the whole corpus of data, I simultaneously noted the key scenes (major segments of data), but at the same time, I also recorded all the mathematical moments that had potential to answer the research questions. In this way, I could keep an eye on multiple appearances of mathematics in this preschool classroom, realize the patterns in the whole corpus of data, and better situate the key scenes and discuss their relationships with the general picture in this classroom. The process resulted in the identification of around two hundred mathematical moments in the entire video set, and around twenty key scenes. In other words, key scenes were a subset of mathematical moments. As a way to document different ways mathematics was appearing in this classroom, I organized and categorized all two hundred mathematical moments, ending up with three main categories (i.e., education-related mathematical manifestations; classroom management-related mathematical manifestations; problem solving-related mathematical manifestations). Then, I associated my twenty key scenes with these three categories. In my analysis, what distinguished key scenes from these mathematical moments was that key scenes were unique instances, whereas mathematical moments were repeated moments in the course of a daily routine. In addition, key scenes were longer time frames that included focus children clearly, and represented rich mathematical engagements with respect to power relationships in detail.

The Phenomenon of Interest: Constant Mathematization of Experience

As I observed the mathematical practices of children and teachers in the preschool classroom and revisited the field-notes and the video scenes I recorded daily, I started to realize that the two research questions I generated at the beginning of the process were not comprehensive enough to explain what I was witnessing in the classroom. What I was realizing was that in this preschool classroom, activities and routines always included issues of power
relations and control. Dynamics of domination and submission were presenting themselves in the preschool classroom context simultaneously to learning, playing, acting, and interacting. Furthermore, mathematical practices were not only manifesting themselves in the forms of bodily demands, but included many instances in which children were using their bodies creatively and freely and engaging in mathematics at the same time, for example, when Clayton was putting rocks in his pockets, and used his body as a scale to determine which pocket had the heavier rocks, or when Octavia and Amy were playing outside with hula-hoops as a way to experiment with notions of distance and speed. However, power dynamics could still be observed in these kinds of spontaneous play activities, for example, when Octavia was using her body to show off her hula-hoop knowledge and skill to Amy and other peers, she was also showing her proficiency to the peers who were not as proficient at performing certain bodily movements with the hula hoops.

As I revisited the videotaped scenes and re-read the field notes, diverse discursive practices in the classroom that produced mathematics and that were also being produced by mathematics (Walkerdine, 1988) started to become apparent. However, in relation to the second research question, these discursive practices were not confined to regulating children’s bodily experiences. There were many moments exemplifying this bodily regulation process, such as when the teacher was requiring children to have certain bodily dispositions before and during a mathematical activity, yet there were also many other moments in which mathematical discursive practices were not only used to regulate bodily experiences, but were also employed to regulate social relationships in the classroom. For instance, when Amy used mathematics as a language to negotiate how many turns she could take during a game, or when Cooper explained how long each of them could take to play with a material, or when Octavia clarified that when
they form partners in a competitive game, she should exclude herself from the calculation of partner numbers. Along with complex mathematical calculations, these moments included power struggles that were lending themselves to negotiations, conflicts, and resolutions of these conflicts again by drawing on the authoritative discourse of mathematics. In the light of these analyses, the research question guiding my analysis shifted from solely a search for the bodily demands of engaging in mathematics in a preschool classroom and the discursive practices that regulate bodily experiences of children engaging in mathematics to a search for the appearance of mathematics within the power dynamics of a Pre-K classroom. In this case, I would have access to the intersections of mathematical practices and power dynamics in general, and then better situate the intersections of mathematics and bodily manifestations in this classroom.

As shown in the Figure 3.1 below, in this preschool classroom when I was reviewing the entire corpus of data and field notes, all the diverse mathematics-related scenes were signaling the efforts of all the actors in this classroom to mathematize their experiences within a power/resistance dynamic. In this classroom, both children and teachers, either intentionally or unintentionally, were drawing on mathematics in verbal and bodily ways for different reasons. As I continued through the process of documenting the mathematical manifestations in the entire video set, certain mathematical moments started to repeat themselves dozens of times. To have a general picture of these diverse manifestations, when reviewing the whole corpus of data, I started to categorize each mathematical moment I had documented. As I went through the process, I generated umbrella categories based on the similarities between mathematical

3 In this study, I draw on Clement’s (2004a) definition of mathematization which refers to “….mathematical actions, such as counting or transforming shapes; and their structural relationships. Mathematizing involves reinventing, redescribing, reorganizing, quantifying, structuring, abstracting, and generalizing that which is understood on an intuitive and informal in the context of everyday activity (p.274).”
moments. These umbrella categories are (a) education-related mathematical manifestations (b) classroom management-related mathematical manifestations, and (c) problem solving-related mathematical manifestations. As shown in Figure 3.1, this categorization lent itself to three segments, which are interrelated and influence each other in the dynamics of the preschool classroom.

Figure 3.1. Appearances of mathematics in the Pre-K classroom within the power-resistance dynamics
**Education-Related Mathematical Manifestations**

There were manifold moments in this classroom in which children were engaging in mathematics guided by the teacher for educational reasons. Since this was a Pre-K classroom, along with specific mathematics activities, Linda was integrating mathematics into other types of classroom practices during art, science, or literacy related engagements, or during the course of the day by using mathematically rich language. Mathematical practices brought by Linda were enacted in diverse contexts such as large group, small group, and individual mathematical activities focusing on foundational mathematical content such as number sense, measurement and geometry (Cross, Woods, Schweingruber, 2009).

As I was observing these mathematical moments, it also became apparent that there were many rules embedded in these moments, and inserted in the physical space of this Pre-K classroom. Video-scenes from the classroom also showed the many embodiments of classroom rules in the use of space, and the power relationships and bodily rules enforced by the teacher especially during large group mathematics activities. In many cases these rules about bodily dispositions were enacted in explicit ways through teacher talk before or during mathematics activities such as “*show me with your body if you’re ready.*” Looking at the teacher’s explicit expectation, in this class, a body, which is ready for mathematics, could be pictured as a child sitting cross-legged, posture upright, and hands on his/her laps. Linda reinforced this verbal rule reminder with a colorful visual depicting a child with this particular posture. This was a dominant disciplinary discourse in the classroom where the teacher’s expectations for children were realized and were expected as a way of creating the desirable mathematical learning contexts. Another rule statement during mathematical moments was centered on the notion of comparing children’s bodily acts to others. For example, when the teacher began an activity by
stating: “I will start with a friend, who is listening, a friend whose body is ready. Octavia is sitting nicely, so I will pick her.” By creating a basis of comparison among the children, an internal drive to regulate their own bodily dispositions was being instilled in them to be the active participants of the ongoing learning process in the classroom and to get the chance to be heard by others.

The rules related to positioning of bodies as directed by the creation of small personal spaces during mathematical activities was also explicit in teacher talk such as “please stay in your space; don’t touch people’s bodies; this is my teacher space, please move to your own space.” During this process of individualization which sustains order and efficiency, most of the time, the physically more active child was forced to move out of the group area during large group mathematics activities, or put in another way, the child’s body was detached from the large group activity space and also detached from the community of learners since s/he was not able to regulate her bodily dispositions appropriately. Clayton was one of these children from time to time. These rules mainly manifested themselves during mathematics or language-related activities where the teacher formed large groups with a more structured way of teaching. Although all these rules were not specific to mathematical activities, I could observe that these disciplinary mechanisms were setting the context of mathematical practices, and carried with them the question of whether these disciplinary experiences were playing a role in shaping these young children’s notions of doing mathematics. This discourse in the classroom, as part of a disciplinary mechanism and classroom management strategy exemplifies the notion depicted by Foucault (1995) of “the crowd, a compact mass, a locus of multiple exchanges, individualities merging together, a collective effect is abolished and replaced by a collection of separated individualities” (p.201) The multimodal analysis of a scene involving Aeron and Linda during
morning calendar time exemplifies one of these mathematical moments in detail. When talking about the date, which was the 6\textsuperscript{th} of March, Linda was holding a cup with number cards and told children, “\textit{Make sure you are listening so I can tell you what we’re gonna do. When we see number six... When we see that number six come up, we are going to do a firework}” (She imitates a firework with her arms in the air).

Table 3.2

\textit{Multimodal Analysis of Aeron’s Engagement}

<table>
<thead>
<tr>
<th>Time (in seconds)</th>
<th>Teacher</th>
<th>Aeron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speech</td>
<td>Put your hands in your laps [1]\textsuperscript{4} If you are listening [2], you’re gonna know what we do, when we see the six. Our hands are in our laps [3]. OK. I’m gonna sit here, and I’m gonna wait until my friends show me they are ready [4]. If you’re ready, then your hands are sitting still, in your lap [5].</td>
<td>No speech</td>
</tr>
</tbody>
</table>

| Proximity | Sits on a small chair, at a higher position than children who are sitting on the carpet in rows. | Sits on the carpet right in front of the teacher. |

| Facial Expression | Serious | Smiling |


\textsuperscript{4} Numbers in the brackets are used to associate simultaneously occurring different modes.
This episode shows how rule statements targeting bodily dispositions function in this classroom within the context of mathematical engagements, and create tensions among the actors. Reading through the modes reflected on Aeron’s body, he was producing small but repetitive and continuous movements, which is generally typical for young children. This state of being, filled with small movements, could be a resistance shown to rules aiming to still bodies in the classroom or could be a self-regulation process in which the child produces a self-stimulation for himself to better engage in thinking.

In this particular scene, Aeron is confirming the fact that he had been listening to the teacher so that in the midst of wiggling he started to perform a firework movement right after he heard the direction about it. However, what the teacher referred to as listening was “hands in your laps” position. Since his timing was not correct in performing the movement, Aeron received a physical warning from the teacher, stopped for a second, but then continued the way he was wiggling without showing obedience. This was one of the multiple moments from the classroom, in which bodily dispositions outside of a predetermined frame, or manifested in an untimely way were pathologized; even the quiet child of the classroom becomes the object of the disciplinary discourse, and power struggles are mobilized between the child and the teacher.

Interestingly, this scene elicits two different but somewhat conflicting discourses related to the use of the body in the educational context. On the one hand, the teacher requested that
children respond to a number word by producing a bodily movement. This was a common practice in the classroom in which children were supposed to use their bodies to show their mathematical understandings such as “wiggle your shoulder when we find the number, put your finger on your nose, when you see number 6, clap 5 times, do a round of applause, we’re looking for number three, so raise your three fingers”. On the other hand, certain boundaries were drawn for the desirable bodily movements, and being still was represented as a norm in the classroom. In other words, the body could be used but only in the way proposed by the teacher. The integration of the body in the educational process of young children, similar to Linda’s efforts, is a common, well-stated practice in the current discussions in early childhood education suggesting children be active participants in the learning process. However, these kinds of moments exemplified in the key micro scenes allow us to unpack the norm of being engaged and to open up the discussion of what is really meant by creating physically active and free learning environments for children.

As mathematics was manifesting itself as an educational concern in this classroom, it is unclear whether this general disciplinary discourse was creating a desirable learning environment, in which children were not distracted by their own and others’ movements, or if these rule reminders were interfering with the learning process of children. What was apparent to me was that in this classroom, mathematical practice was becoming more than mathematical; it was becoming a disciplinary one, a regulative one, which intersected with other circulating discourses in the classroom in terms of acting like a student, and being an engaged student.

**Classroom Management-Related Mathematical Manifestations**

In this classroom, I witnessed the teachers’ mathematically rich language during the course of daily routines. When the context in which this language was produced was closely
examined, in most cases this mathematically rich discourse was accompanying teachers’ classroom management practices. This discourse comprised a body of statements organized in a regular way, and repeated every day in the classroom. For example, a teacher would say to children that “I’m gonna close my eyes, and count up to 5 to see if you are ready; I will count back to see how long it takes for you to get ready; Do your silent scream five times; You have 5 minutes left, [then] 3 minutes left to finish your task.” Different from the ongoing rule statements embedded in mathematical moments that I explained previously, in these cases the rule statements themselves were mathematical. In some cases, these rule statements were creating mathematical practices, for example, when the teacher set the alarm clock for five minutes and let children take turns in the context of play in which they worked with specific toys, or she positioned hourglasses near the children so that they knew when to finish their free play. Another interesting practice in this classroom was when the teacher made children count up or down to a certain number or made them think of some sort of estimation during times when she needed to be absent or busy herself and gather materials for the next activity. In other words, she was mathematizing children’s waiting time by engaging them in an activity, so that she could leave them alone without safety and security concerns.

Looking through these moments, it seemed to me that classroom management concerns were of primary importance rather than the mathematical potentials of these conversations. Overall, either intentionally or unintentionally, by drawing on mathematical language, the teacher was creating a context in which children, as part of their social practices in the classroom, were engaging in a discourse produced by the authoritative nature of mathematics. Moreover, this language was mediating their understandings of these foundational mathematical concepts (Walkerdine, 1988). Focusing on these manifestations of mathematics, I observed that
mathematics was becoming a discursive resource for other purposes in this Pre-K classroom. Because of its classificatory function, and the precision it brings, drawing on a mathematical language accentuated the hoped for effect of neat and regular routines, and certain bodily dispositions in the classroom.

The multimodal analysis of a scene from outdoor time exemplifies this mathematical discourse in the classroom. In this classroom, every day before outdoor time, children would exercise as a large group by following that day’s exercise leader child’s directions. In this episode, Clayton is the exercise leader and engaging in conversation with the teacher about which movements should be performed by the other children, and how many repetitions for the particular movements were sensible to perform. Then, the teacher takes the lead to remind the children of the rules for the upcoming outdoor playtime.

Table 3.3

*Multimodal Analysis of Clayton’s Engagement*

<table>
<thead>
<tr>
<th>Speech</th>
<th>Time (in seconds)</th>
<th>Teacher</th>
<th>Clayton</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>04.02</td>
<td>On our yellow slide, how many friends can be sliding? One friend! [1] Can you go up and down? [2], What can you use to make sure that it’s safe? Eyes! Maybe your nose! [3] Alright guys, how many finger touches? One finger touch, that’s how we keep our friends safe (referring to playing tag)[4] How many friends can play in the house? Four! How many friends can be on the tire swing? Three! [5] When we’re throwing balls, will we throw them at <em>(emphasizes)</em> them? No, we need to throw them to <em>(emphasizes)</em> them. [6] Guys, the last thing I’m gonna say, the last two things I’m gonna say before we move on, cause I’m having my friends having a hard…</td>
<td></td>
</tr>
</tbody>
</table>
time to listening. This is for your safety guys [7]…. Please sit on your bottom criss-cross, you are the exercise leader and you need to show them how we sit and listen [8]

<table>
<thead>
<tr>
<th>Proximity</th>
<th>Sits on the ground, facing children who are also sitting on the ground in rows.</th>
<th>Sits on the ground nearby the teacher, facing friends sitting in rows.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facial Expression</td>
<td>Serious</td>
<td>Smiling, Serious [6,7,8]</td>
</tr>
</tbody>
</table>
In this episode, Clayton’s bodily movements suggest that he was familiar with all these reminders targeting the use of the outdoor play area, and the positioning of bodies in the playground. Therefore, he was answering all the questions out loud, almost shouting and screaming. He was also maintaining a different kind of boundary such as lying on the floor, rolling, and jiggling. In the midst of this ritualized mathematical conversation, it could be inferred that he was bored; therefore, for the particular moment, he was creating different kinds of bodily engagements for himself. Looking at the interaction between the teacher and Clayton, he was ultimately reminded that, as the exercise leader, he had certain responsibilities that were supposed to be realized in his bodily orientation.

In this micro scene the language used by teacher is a mathematically rich one for young children in terms of early number concepts and spatial features and properties (Levine, 2014; Pruden, Levine, & Huttenlocher, 2011). Focusing on the intention behind this mathematical language, this type of clear reminders are also effective in terms of informing young children about the expectations for particular activities. Some of the reminders used by Linda, (e.g. “you have three minutes left”) are also effective to instill a sense of control in children over the classroom activities and when the end is coming for the tasks they are working on.

From another perspective, however, the rule statements in the micro scenes, such as stating the number of children who can stay in a particular space or informing children about the number of fingers used to touch other’s bodies when playing tag, are overly cautionary. The safety and security concerns in early childhood classrooms along with the disciplinary discourse targeting children’s bodies result in these types of preventative practices. The authoritative discourse of mathematics seems to have a supportive role during this process. Differently from
the disciplinary discourse circulating around mathematical practices as I described in the previous section, mathematics itself becomes the disciplinary tool in the present context.

Focusing on how children were reacting to these statements, I could not clearly observe if children were following these rules. These decisions were made naturally and spontaneously because children have an embodied sense of space and certain abilities for determining what is good for their bodies. Rather than the number of friends on the tire swing, they seemed more interested in finding an *extra* friend who would swing them; their turn taking time on the swing; and how and which direction of swinging would result in a faster and faster experience.

**Problem Solving-Related Mathematical Manifestations**

In this Pre-K classroom, another strand of mathematical moments was situated around problems arising in real life situations. As part of their spontaneous everyday activity, I could observe that while participants of this classroom were engaging in the elimination of unpleasant situations, they were producing a mathematical discourse. If we conceptualize teachers’ mathematical classroom management practices described above as problem solving efforts, these two categories at some point overlap. However, my observations about problem solving situations were mainly coming from children. As I was observing them, there were many moments in which children were also using mathematical language that reflected precision and employed classificatory functions. The goal for drawing on this mathematical knowledge was immersed in the process of power enactment in which children controlled their relationships with others, and the ownership of the materials. For example, they would firmly let each other know how many friends were allowed in a game; who was older in terms of the birth month and the day; how long each of them could take to play with the Ipad, and how this time allocation changed if they agreed to play with partners.
In the classroom, as the bodies of mathematical knowledge were produced, simultaneously functioning power dynamics could be observed both in the language they used and in the bodily dispositions they manifested. Drawing on the complex relationship between power/knowledge, Foucault states "there is no power relation without the correlative constitution of a field of knowledge, nor any knowledge that does not presuppose and constitute at the same time, power relations” (Foucault, 1995, p. 27). In one scene from the classroom, for example, Clayton was playing chess with a friend, but genuinely reminding him that he was supposed to make quicker moves, so that they could finish the game before the free play time ended. His reminders were accompanying bodily expressions, which could be interpreted as power poses, such as banging on the table, and leaning on his friend to make him to produce quicker moves. In this context, another ongoing dynamic was between the teacher and Clayton, in which he was arguing not to have snacks since they needed time to finish the game, and having snacks “would take at least their 5 minutes.”

Another pattern of interaction was involving Aeron who was mostly engaging in solitary play by himself. There were many moments in which Aeron positioned his body physically close to the other kids and offered his mathematical knowledge as an entry point to the group play. This mathematical knowledge could take the form of a puzzle piece, or an answer needed in the mathematics board game. His effort to gain social acceptance through the means of mathematical knowledge could be ignored, rejected, and sometimes welcomed by his peers, depending on other dynamics in the context.

In the daily routine of the classroom, it was possible to observe how children produced a genuinely mathematical discourse and how mathematical knowledge was created and appropriated in difficult situations. Multimodal analysis of a scene showing the interaction
between Amy and Octavia exemplifies one of these moments. In this scene, as requested by the teacher, children formed groups of two by themselves, and each group of two got one bubble bottle to play with on the playground. As they were supposed to take turns, Octavia was eager to take more time to play with the material:

Table 3.4

*Multimodal Analysis of Octavia and Amy’s Engagement*

<table>
<thead>
<tr>
<th>Time (in seconds)</th>
<th>Octavia</th>
<th>Amy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Proximity</strong></td>
<td>Close to Amy, they are in face-to-face position. [1,2,3,4,5,6,7,8]</td>
<td>Close to Octavia, in a face-to-face position. Moving around but in front of her.[1,2,3,4,5,6,7,8]</td>
</tr>
<tr>
<td><strong>Facial Expression</strong></td>
<td>Serious[1,2,3,4,5,6,7,8]</td>
<td>Little smile on her face. [1,2,3,4,5,6,7,8]</td>
</tr>
</tbody>
</table>
This interaction between Amy and Octavia over the bubble play can be read in detail by conceptualizing it as a mathematical practice. Oers (2001) says that an activity transforms itself into a mathematical practice when it is situated in certain moral values of the participants, and in the pre-set rules embedded in the context. Mathematical practice involves a performative action, in which a mathematical discourse is produced, and also has a conversational aspect, in which interlocutors communicate about this mathematical discourse (Oers, 2001). From this perspective, we can clearly see how particularly Amy is producing a mathematical discourse, when saying “how about I get o-ne...how about I get two turns, and you get three” to claim her right over the material. She is mathematizing the ongoing situation to make it explicit so that she would have fewer turns than her friend. This mathematization allows her to stress the situation’s unjust nature and allows her to attempt to re-organize a new turn taking structure so she would have at least two turns. Looking at this interaction, I could also speculate that Amy waives her turn to be able to compromise with her friend through avoiding a conflict or she is framing in this way so that she would at least a have a chance to play with the materials if Octavia becomes assertive.

| Gaze | Looks at bubble bottle, and bubbles flying away. | Looks at Octavia. Looks at bubble bottle. Looks at bubbles flying away. |
As Amy was putting effort to establish a common ground with Octavia by sacrificing her right to take turns, Octavia seemed to decline to be a part of this discourse, but she produces another one. She also mathematizes her act of producing bubbles by saying, “I’ve never seen so much bubbles! This was a gigantic one!” shifting Amy’s attention to the characteristics and the numbers of bubbles so that she would stay as the owner of the material. Their bodily dispositions in the whole process seemed to play a supportive role for both of their arguments. While Amy physically gets closer to Octavia while she was attempting to negotiate, Octavia puts effort to push Amy away by pointing out the bubbles flying away, and requesting that she catch them.

Apparently, as these two girls were legitimatizing their actions and producing justifications for the rationale behind them, they were utilizing their mathematical knowledge. In thinking about knowledge/power dynamic, Foucault (1980) states, “…one is able to capture the process by which knowledge functions as a form of power and disseminates the effects of power” (p. 69). The dynamic between Amy and Octavia illustrates how in a Pre-K classroom there are many moments in which children draw on mathematical knowledge as they engage in conflicts and negotiations constituted by power relations, which are operated and distributed through and among them.

**Conclusion**

This research was an attempt to observe and articulate how mathematics produced in a Pre-K classroom intersects with the fluidity of power relations and how children are becoming objects and subjects of these discourses through constructing particular bodily and verbal dispositions. Through the paper, I re-constructed my inquiry as a way to observe the appearances of mathematics across practices in a particular classroom. The research was not intended to provide a definitive discussion of what mathematics was, and what constituted all appearances of
mathematics in this particular classroom. However, this lens allowed me to identify multiple mathematical moments in a Pre-K classroom, and assisted me to analyze the context in which various mathematical engagements were manifested in a classroom within a power-resistance dynamic.

In this research, I elicited empirical evidence on how discipline is institutionalized within the contexts of a school, and how a school’s disciplinary mechanisms are infused in mathematical practices in a classroom of young children. As mathematics was enacted in multiple discourses, key scenes from the study showed verbal and bodily rules inserted in mathematical curriculum times, and demonstrated ways in which mathematics becomes a disciplinary tool itself during the course of the day with its authoritative and classificatory nature. Also evident were the ways in which all actors in a classroom draw on mathematics for problem solving in real life situations within a power/resistance dynamic.

This study, from a different perspective, connects to two different strands in the current literature; the ones that centralize the role of body in mathematical understandings (Alibali & Nathan, 2012; Valenzeno, Alibali, & Klatzky, 2003; Kim, Roth, & Thom, 2009), and the ones that situate the role of the body as supportive to mathematical understandings (Clements 2004a, Coates & Franco, 1999; Goodway, Rudisill, Hamilton, Hart, 1999). Studies focusing on embodied learning have been theorizing the role of body, and the body’s interaction with the physical world as central to mathematical thinking (Lakoff & Núñez, 2000). Focusing on early childhood education, the role of body, which is mainly referred to as physical experience or movement, is acknowledged in supporting children’s geometrical learning (Clements, 2004a), spatial skills (Clements, 2004b), and counting abilities (Dávila-Coates & Franco, 1999), particularly through the integration of play (Cross, Woods, Schweingruber, 2009) and music
(Lim-Kim, 1999). Overall, these studies, from different stances, focus more on the learner and content-related mathematical learning process, whereas, in my study I closely analyzed the disciplinary classroom discourses in relation to children as students and their general mathematical engagements. My research has implications for shifting attention to the context in which these bodily experiences are manifested, around the issues of power relations and control. Along with unpacking the norms about appropriate ways of being when engaging in mathematics, the research calls us to consider how, when, and why children might be discouraged from meaningfully engaging their bodies in mathematics practices in a Pre-K classroom.

The National Research Council’s Committee in Early Childhood Mathematics (2009) states that “infants’ and young children’s mathematical development takes place in the context of cognitive and behavioral regulation, which when stimulated and supported can promote mathematical learning” (p.82). In this statement, what is meant by cognitive and behavioral regulation is “the ability to stay on task and ignore distractions” (p.83), and “keeping information in mind while manipulating or changing it mentally” (p.85). Beyond such individual cognitive reasoning of young children assumed to take place in their minds, the analysis of the mathematical classroom discourses in this study suggests that the classroom context also includes constant influences of disciplinary dynamics, which could have a limiting and distracting effect on children’s engagement with mathematics by constraining their bodies. In other words, these regulatory cognitive processes of children are under the influence of institutionalized regulatory practices. Drawing on the insights of this study, further research can inquire about how children’s bodily engagements in a similar (or comparable) classroom context
influence the effectiveness of their mathematics learning process and young children’s interpretations of doing mathematics in schools.

References


Erickson, F. (2006) Definition and analysis of data from videotape: some research procedures and their rationales. In J. Green, G. Camilli & P. Elmore (Eds) *Handbook of*
complementary methods in education research (3rd edn) (Mahwah, NJ, Lawrence Erlbaum).


CHAPTER 4

RECOGNIZING YOUNG CHILDREN’S TECHNIQUES OF THE BODY:

MULTIMODAL OBSERVATIONS OF MATHEMATICS IN A PRE-K CLASSROOM

---

5 Karsli, E. To be submitted to *Teaching Children Mathematics.*
Abstract

Embracing a multimodal perspective, this paper introduces data from a video-ethnography study on young children’s mathematical practices in a Pre-K classroom. Multimodality offers a comprehensive perspective on research with young children by incorporating the physical body in the analysis and investigating the modes such as gesture, gaze, posture, facial expressions, sound, images, and speech, which are socially and culturally shaped in the contexts where they appear. Employing this lens in thinking about the way children engage in learning, the insights from the study reveal that recognizing children’s spontaneous bodily techniques have potential to reshape researchers and educators’ agendas on what it means to engage in mathematical learning in early childhood education classrooms.

---

6 In this article, I draw on Mauss’ (1973) concept of bodily techniques, which refers to physiological, psychological, and sociological assemblages all inscribed on human bodies. Embodied practices such as walking, running, sitting, eating are a few examples of the bodily techniques with diversifications and complexities they hold based on cultural and sociological influences.
Introduction

During a larger video-ethnography study, focusing on children’s mathematical practices in a Pre-K classroom, an interesting scene between 4-year-old Octavia and Amy in the playground was caught by my video camera. The original focus of the video-ethnography research was on children’s embodied mathematical engagements during the course of the day in a Pre-K classroom and, in what ways schools’ disciplinary discourses targeting children’s bodies intersect with these processes of children. In the midst of this critical research, multimodal analysis of a scene I captured opened up a new space to think about the possibilities manifesting themselves in Pre-K classrooms with respect to children’s mathematical engagements.

In this short video scene, four-year-old Octavia is picking up a hula-hoop, which was placed on the ground of the playground by the teacher before the outdoor play starts. During this spontaneous moment, Octavia is starting to twirl the big hula hoop smoothly and lightly around her waist for more than 10 seconds. The way she is using her body proficiently attracts the attention of her peers, especially Amy’s, which is noticeable in her bodily expressions such as positioning herself closer to Octavia, and watching carefully the harmony of her body with the hula-hoop. Later, as Amy also initiates hula hooping by imitating Octavia, Octavia starts to try different bodily techniques to advance her hula hooping. In other words, through the new techniques she had been developing, Octavia is using her body to show off her knowledge and skill to Amy and other peers, who are not as proficient at performing certain bodily movements with this material. Following a step-by-step approach, in particular, Octavia, with a serious face, first lifts the hula-hoop, so that it would take more time to fall down. Then, she tries different ways to twist her body to increase the speed of the turns, which is another way to decelerate the quick fall of the material. Lastly, she starts to stretch and open up her legs to prevent the drop of
the hula-hoop. As she engages in this practice with high motivation and concentration, more peers and the teacher recognize her, and their recognitions bring praise to Octavia. The video scene continues as Amy offers two more hula-hoops to see if Octavia could perform all these movements with more than one hula-hoop.

It was only later on when I saw the mathematically rich potential of this engagement during my analysis of the particular moment from a multimodal analysis perspective. Multimodal analysis refers to going beyond the language form of communication and systematically analyzing the simultaneously functioning occurrences both reflected on the human body, and that appeared during the body’s interaction with the material world around the body (Bezemer & Jewitt, 2010; Jewitt, 2009a). Jewitt (2009a) states, “to live in any culture is to live in a multimodal culture” (p.4) suggesting that we function in a complex multimodal landscapes within a particular time frame and in a particular space, for example, we move beyond language in our interactions through activating our other bodily affordances (such as gesture, gaze, speech, posture), and creating and utilizing materials, images, sounds, and representations in the environment. This kind of methodological application that draws on different modes of human interactions provides researchers with a comprehensive and detailed picture of the contexts of interest (Norris, 2004).

Looking back into the scene, embracing this multimodal lens made it visible to me as a researcher that four-year-old Octavia was responding to the dynamics of the social interaction among her peers, and at the same time drawing on multiple bodily techniques, such as experimenting with notions of distance, and speed; and making decisions in relation to the material form of the hula-hoop based on its radius, and circumference. Multimodal examination of this scene cannot reveal exactly if or what she was thinking in terms of mathematics, besides
simply adapting her body to the shape of the hula-hoop intuitively. However, it brought wonderings about how recognizing these spontaneous bodily techniques of children would contribute to our conceptualizations of engaging in mathematics in the early years, and how these kind of bodily recognitions would provide contexts for teachable moments in early childhood education classrooms.

Drawing on these insights, in this paper, I will analyze three scenes from a Pre-K classroom by utilizing multimodal analytic strategies in order to demonstrate the ways that detailed analysis of children’s bodily techniques can add a dimension to our interpretations of children’s mathematical practices in early years. In doing so, I will first provide research from different disciplines pointing the need of attending children’s bodies in thinking about their mathematics, and I will argue how multimodal analytic approaches can offer a methodological application in fulfilling this need. Drawing on Mauss’ (1973) concept of bodily techniques, I will particularly be focusing on scenes of four-year-olds Amy, Octavia and Clayton in their Pre-K classroom where I conducted a larger video-ethnography research in Spring 2013.

**Where does Early Childhood Mathematics Reside?**

**The Importance of Recognizing Body through Multimodal Lenses**

In my research, among many other content areas, my selection of mathematics as a context for observing bodily techniques was made for several purposes. In the literature, a growing number of studies focusing on the important role of children’s bodies in connection with mathematical practices exist. These studies, however, are grounded in diverse theoretical perspectives and assumptions. Looking back at the grand theories of young children’s development (Freud, 1905; Vygotsky, 1978) they do not include an explicit emphasis on the
body, but some of them offer insights into how the physical bodies of children are important in their learning.

As a starting point, it is important to delve into how the body is situated in Piaget’s theoretical ideas since many mathematical practices in early childhood classrooms are grounded in Piagetian constructivism. A Piagetian (1972) perspective conceptualizes children’s bodies in relation to objects in their environment, proposing that young children gain knowledge of the world from the physical actions they perform on objects such as sensing, hearing, seeing, and sucking. The most important cognitive milestone for a young child who is in the sensory-motor stage is seen as being able to form a mental representation of an absent object without sensing it. Piagetian theory proposes that the child does not depend on bodily experiences to grasp concepts as s/he proceeds through cognitive stages. In other words, Piaget situates the child’s bodily experiences only as a transitory step to reaching future abstract thought.

Researchers either from critical or from embodied cognition perspectives have criticized the views of Piaget. Walkerdine (1984; 1988), for example, in her studies takes a critical stance on the domination of the Piagetian notion of children’s mathematical learning, and draws a comprehensive picture of children’s mathematical understandings by juxtaposing the dichotomies related to mind and body, and the stages found in developmental learning theories. Looking into Walkerdine’s construct of how the body is positioned in mathematical learning, she situates the body as an important part of the social practices in mathematics. In Walkerdine’s view, the body of the child as a part of his/her social, cultural, and daily practices mediates the understanding of mathematical concepts. Early mathematical concepts, for example, big/small; heavy/light; tall/short, signify the characteristics of objects. Walkerdine (1988) suggests that these signifiers not only communicate the functional relationships of objects but also carry
meanings related to children’s social practices and how their bodies enter a relationship with the physical characteristics of the object. The concept of small may refer to a size, to the value of objects that are small in children’s daily lives, or to being the youngest member of the family who has the smallest body. Considering another example, the concept of weight communicates the functional and physical characteristics of the objects. However, one way that children give meaning to these concepts is to draw on their bodily experiences such as being or not being able to carry an object, and then conceptualizing the concept of heavy or light accordingly (Walkerdine, 1988). Walkerdine’s (1988) perspective points out the importance of children’s social practices situated around their bodies and shifts attention to the context in which and in what manner these experiences of children appear as they develop mathematical understandings.

From an embodied cognition perspective, Kim, Roth and Thom (2011), who conduct research about children’s geometrical understandings, also argue that “Children’s mental processes emerge not just as abstractions, as Jean Piaget thought, but they require the body as a point of reference and as a source of experiences to think, learn and develop” (p. 210). This perspective assists us in viewing the role of the body in a different way; and in Piagetian language, questioning the assumption that when children proceed through sensory motor to formal operational stages, they lose their bodily points of reference.

Continuing with the embodied cognition perspective, a growing area of research focuses on embodied cognition theory from a cognitive psychology stance and how it operates in mathematics learning from childhood to adulthood (Lakoff & Núnez, 2000). These studies have been theorizing the role of the body, and the body’s interaction with the physical world as central to mathematical thinking (Alibali & Nathan, 2012; Valenzeno, Alibali, & Klatzky, 2003; Kim, Roth, Tom, 2009; Lakoff & Núnez, 2000). The theory of embodied cognition proposes that
individuals’ fundamental bodily experiences affect their engagement in various mathematical understandings. Children learn mathematics not only through their bodily experiences but also by thinking through their bodies. In other words, this theory supports the notion that the child’s mind is largely governed by the experiences of his/her body because human cognition is itself embodied (Lakoff & Núnez, 2000).

My review of the literature investigating children’s mathematical understandings through paying attention to their bodies from the perspective of embodied cognition suggests that these studies focus primarily on children’s or teachers’ gestures at the individual level during mathematical engagements and suggest that these gestures have a functional role in mathematical thinking and the frequency, type, and strategies prompted by gestures change according to the abstractness of the mathematical tasks. In the literature, some of the main foci of these studies are the patterns of gestures and their favorable functional roles that are employed by teachers and students during mathematical engagements (Garber, Alibali, & Goldin-Meadow, 1998; Kelly, Singer, Hicks,& Goldin-Meadow, 2001; Hostetter, Alibali, 2008; Alibali, Spencer, Knowx, & Kita, 2011), the gestures and their supportive roles manifested during specifically abstract geometrical engagements (Roth & Thom, 2009; Kim, Roth, & Thom, 2009), and teachers’ gestures and their supportive roles in children’s understanding of mathematics (Goldin-Meadow, Kim, & Singer, 1999; Valenzeno, Alibali, & Klatzky, 2003; Alibali, & Nathan, 2007; Alibali, & Nathan, 2012). All in all, studies of embodied cognition position the body as continuously available as a point of reference for mathematical thinking, which is an argument with a strong theoretical basis in terms of legitimizing the need for shifting the focus to physical bodies in research on mathematics learning.
In addition to research from an embodied cognition perspective, in early childhood education, there is also growing set of research studies from diverse theoretical perspectives, proposing the role of the body as supportive to mathematical understandings (Clements 2004a, Dávila-Coates & Franco, 1999; Goodway, Rudisill, Hamilton, Hart, 1999) and arguing that physically active and playful learning environments support young children’s mathematics (Seo and Ginsburg, 2004; Clements & Sarama, 2007). In this strand of research, the role of the body is particularly acknowledged in supporting children’s geometrical learning (Clements, 2004a), spatial skills (Clements, 2004b), and counting abilities (Dávila-Coates & Franco, 1999), especially through the integration of play (Cross, Woods, Schweingruber, 2009) and music (Lim-Kim, 1999).

While attention to bodies has been increasing in conceptualizing children’s mathematical learning, discussions about methodological possibilities, which have the potential to assist in analyzing children’s bodily interactions in the context of mathematics, has also been generated. Multimodality, which I also embrace in this paper, appears as a method for systematically analyzing both bodies and bodies’ interaction with the environment in the context of mathematics. Only a few studies exist that draw on multimodal analysis in conjunction with early childhood mathematics. Parks and Schemichel (2014), in their study with children from a marginalized population, for example, provide a new line of inquiry through attending to children’s bodies by engaging a multimodal analysis and showing how this process adds value to interpreting children’s mathematical understandings that evolve over time. Within the context of early mathematics, there are also studies conceptualizing children’s mathematical meaning-making processes as multimodal, in which they analyze multiple representations in the learning environment, along with children’s embodied modes. In particular, these studies mainly argue
that a multimodal perspective assists us in seeing the deep mathematical value in children’s representations such as their drawings and writings (Worthington, 2007), and in their processes of understanding early math concepts (Jewitt, 2006) such as basic graphical representations (Ferrara, 2013).

Multimodal analysis, which centers researchers’ attention on bodily experiences, has power to bring a new lens to educational studies. Shifting attention away from linguistic communication to a variety of other rich communicational, interactional, and representational modes provides the researcher with an in-depth look into the classroom context. As I stated above when talking about Octavia’s hula hooping scenario, multimodal analysis cannot reveal exactly what children and teachers are thinking or feeling, or determine precisely how children construct knowledge in a classroom. However, it has the power to add a new dimension to our observations, and it helps us to recognize the classroom dynamics affecting how children are positioned in classroom contexts. From a socio-semiotic multimodal analysis perspective (Jewitt, 2009b), a variety of questions can be asked consistent with this kind of inquiry, such as the type of modes teachers use when teaching, the kind of modes children draw on when they engage in learning, the manner in which the design of the classroom affects bodily experiences, the ways that schools as institutional contexts restrict and reinforce certain types of modes, and the communicational and interactional modes that are available to which children in the classroom context. Embracing this perspective, in the present study I focus on children’s bodily techniques by drawing on the analytical lens multimodality offers as I generate discussions about mathematically rich potentials reflected in children’s bodies.
Theoretical Perspective

The body has been at the center of the theorizations in different disciplines such as developmental psychology (Freud, 1905), cognitive psychology with an emphasis on embodied cognition (Rosch, 1973), gender studies (Butler, 1993; Jones, 2010), anthropology (Asch, Connor, & Asch, 1983), and sociology (Elias, 1984; Foucault, 1990; 1995). The theoretical lens of this paper shares a certain alignment with those perspectives in privileging the body, either as a physical site for acquiring knowledge (Lakoff & Núñez, 2000; Rosh, 1973), or as having a symbolic value on which the larger society’s culture, history, and power dynamics are reflected (Elias, 1984; Foucault, 1990; 1995). In this paper, I particularly draw on Mauss’ (1973) conceptualization of bodily techniques, which refers to embodied practices carrying the imprints of physiological, psychological, and sociological assemblages, all inscribed on human bodies.

Mauss (1973) asserts that “in every society, everyone knows and has to know and learn what he has to do in all conditions (p.85), and “know how to use their bodies” (p.70). In terms of using bodies, Mauss refers to a multitude of bodily techniques such as running, eating, walking, sitting, swimming, resting, dancing, and even pushing and pulling. These bodily techniques are the product of our bodies’ physical mechanisms, which are structures and processes that can be investigated through anatomical and physiological theories. However, historically, socially, and cross-culturally, these techniques show variety across individuals and communities. Mauss further argues that there also exists a technique of education in particular bodily techniques; either acquired through instruction or spontaneous imitations of the powerful others. The specific way of educating people in terms of their bodily techniques relates to generations and dominant traditions.
Thinking back through Octavia’s vignette, for example, the bodily technique of hula-hooping is the reflection of her physiological capabilities, but observation of this technique as a whole also gives clues about some practices in today’s early childhood education classrooms because the availability of certain materials in a space reinforces the development of certain bodily techniques. The technique of her hula hooping was also a reflection of the psychological dynamic among peers, which pushed Octavia to develop more complex techniques that would keep her at the center of attention for a longer time period. Moreover, as Mauss (1973) mentioned about the “sexual division of techniques of the body” (p.76), in a stereotypical sense her technique of hula hooping could also be a reflection of a feminine technique. Her hula hooping, which attracted the attention of only girls and was being practiced only by the girls in the classroom, could be resulting from the fact that, as a girl she was gaining more experience with the material to develop complex techniques. Moreover, the way she was activating the bodily techniques seemed also related to her gender-related learnings such as embracing certain postures, gestures and poses like a girl.

Drawing on these insights generated out of Mauss’ theorization, in this paper, I situate children’s bodily techniques in relation to their mathematical practices at the center of my inquiry to observe what kind of bodily techniques of children hold high mathematical potentials, and to consider what kind of techniques of education can be shaped in a way to draw on these bodily techniques of children to engage them in mathematics in early childhood education classrooms.

**Methodology**

I generated the data for this paper from a larger video-ethnography study, in which I intensively participated in the ordinary life of a Pre-K classroom with the aim of capturing its
details and taken-for-granted assumptions (Erickson, 1992) with respect to children’s mathematical engagements. The methodological approach I am taking in the research draws on perspectives and insights I derived from the use of video as a research tool (Erickson, 1992; Tobin, Hsueh, Karasawa, 2009), and utilization of multimodal perspectives, particularly in ethnographic studies of educational settings (Flewitt, 2005). The integration of video as a research tool in conjunction with multimodal analytic approaches brought a reciprocal enrichment to the research process in which I could closely and vividly capture, and then, systematically analyze (Jewitt, 2009a) children’s simultaneously occurring bodily techniques in relation to mathematics.

In this classroom, I started my research with participant observations, which lasted around a month, to familiarize myself with the preschool classroom community and to establish a relationship with the members of the community (Asch, Connor, & Asch, 1983). The process of participant observation provided me a general picture of contexts and time periods in which a multitude of different bodily techniques manifested so that I could position my video camera and myself accordingly to be able to catch these moments. Later on, the process of video recordings started for the following three months, three days in each week, which resulted in overall 52 hours of video-recordings. Since mathematical engagements could be manifested at any time in a child’s school life (Seo & Gingsburg, 2004), and it is unpredictable when and how children would be drawing on their bodily techniques with respect to mathematical engagements, my videotaped recordings broadly captured scenes of children, both during free play and structured activity times, and appeared both indoors and outdoors, with an eye on mathematics.
Research Context

I conducted this research in a Pre-K classroom for the children between the ages of 4 and 5 in a university-affiliated childcare center located in southeastern United States, particularly because of the convenience for video-based research at the site. The childcare center is accredited by the National Association for the Education of Young Children, and the center’s educational philosophy reflected the discourse of Developmentally Appropriate Practices (Copple & Bredekamp, 2009), aiming to support young children’s optimal learning in each developmental area. Focusing on the place of mathematics in the curriculum, the teacher explained that she draws on state Pre-K content standards as a guide for mathematics activities, which mainly suggest preparing a mathematically rich environment balanced with purposeful mathematics instruction on numbers (particularly one-to-one correspondence), shapes, patterns, space-related understandings and measurement. In line with these standards, children were engaging in mathematics during both teacher-directed small and large group activity times mainly involving number operations and relations, in particular counting up to 20, cardinality, adding, and estimation.

As the overarching curricular philosophy of this preschool was a center-based curriculum that valued the free choice of children, the classroom was separated into different spaces for art, book, block, drama, mathematics, and science centers. The design of the classroom environment provided rich learning opportunities; the walls of the classroom were full of class work related to mathematics, such as number charts, posters demonstrating the results of various estimations. The mathematics center included materials such as items for sorting, board games, clock toys, measurement tapes, hourglasses, calendars, and small cubes.
In this classroom context, I observed various bodily techniques of children—both the ones they were bringing to the classroom probably in relation to their age, personal characteristics, upbringings, and culture, but also the ones they have been developing within the dynamics of the classroom context. Mauss (1973) claims that techniques of the body result from the body’s adaptation to the outside world, and occasionally this adaptation is “assembled by and for social authorities” (p.85). Looking through this lens, the institutionalized setting of the Pre-K classroom was demanding certain bodily techniques from the children, such as using a normal voice when talking, using fast walking feet rather than running in the classroom, dancing without touching their peer’s bodies, and sitting with legs and arms crossed when engaging in an activity, including mathematical during mathematical activities. As children were adapting their bodies to these rules in the classroom, overall, there was a clear difference between their bodily techniques inside of the classroom and outside at the playground. The teacher’s expectations for children’s bodily movements were less restrictive during outdoor free play time. As a result, and also because of their interactions with the playground materials requiring the use of large motor physical abilities, children were physically more active and loud outside. The two video scenes I will be sharing from Clayton, Octavia, and Amy in relation to their bodily techniques, holding high mathematical potentials, are all from the outdoor playground, which could offer an implication about how mathematically rich possibilities might manifest themselves more often in outdoor environments free from certain bodily restrictions.

Analysis

The analysis of the scenes in this paper was informed by multimodal analysis approaches (Jewitt, 2009a; Norris, 2004), in which the bodily techniques of children were situated at the center of the analysis. From an analytical perspective, Crossley (2007) argues that Mauss’
concept of bodily techniques gives the body a researchable and analyzable form because ‘the body’ and embodiment, despite their concrete connotation, are very vague, broad and abstract concepts that do not define a researchable object. ‘Body techniques’ by contrast does” (p.86). In the present study, I view the child’s body in its literal form, and assume that in addition to the physiological characteristics, human understandings, and knowledge are also reflected on the body. Therefore, looking at bodily techniques provides an entry point for further discussions and interpretations about human experience in general.

The concept of techniques foregrounds the observable dimension of the human body, which can be analyzed by diverse methodological approaches, either qualitative, quantitative, mixed-methods, or archival data, and the techniques of body could further be explored through new analytic lenses (Crossley, 2007). In this sense, multimodal analytic approaches, which incorporate the physical body in the analysis and attend to the investigation of modes reflected on the human body (Kress, 2009), provided fruitful possibilities in terms of looking closely and systematically at children’s bodily techniques manifested in the Pre-K classroom. Focusing on the data representation, multimodal analysis requires special types of transcription. For example, an analysis of an image, a drawing, an interaction between groups of people, or an interaction between a material and human, would be different from each other. If human interaction is videotaped, transcription can be written as a text and all different modes of the human body can be provided in parentheses (Flewitt, 2005), or alternatively, in the approach I will be following, simultaneously functioning modes can be written in tables by categorizing them into time, verbal interactions, bodily movements, and contexts (Parks & Schmeichel, 2014). In the next section, I will start my analysis as I share detailed information on my focus children Octavia, Clayton, and Amy.
Participants

In this paper, I am providing data from four-year-olds Octavia, Amy, and Clayton; in a multicultural Pre-K classroom where there were twenty students (eight females and twelve males). While the larger study was examining the classroom as a whole, the present study focuses on bodily techniques of these three children. During my participant observation period, as I became known to the children through my repeated visits, I was able to identify children who seemed more comfortable with being recorded when I requested their verbal consent to participate. Since my study was about young children’s embodied mathematical practices in general, I was drawing on an “information-oriented selection” (Flyvbjerg, 2011, p. 307) process to select children who might generate rich-data for “maximum variation” (Flyvbjerg, 2011, p. 307), in this case, various mathematical engagements along with different bodily techniques. Although the idea of incorporating children with different bodily techniques was a meaningful one, the actual process of selection was difficult. As I was focusing on around six children who seemed comfortable with being recorded, a scene I recorded toward the end of the first week of video recordings informed the final decision of my participant selection. After the analysis of this scene I captured during a mathematics activity, I decided to include Octavia, Clayton, and Amy as three of my participants.

In the scene, Octavia, Amy, and Clayton engage in a matching activity directed by the teacher during small group time. They have twenty memory cards in the shape of a clover reversed on the table. Numbers from 1 to 10 are written on ten of these cards, and the corresponding number of dots is placed on the rest of the 10 cards. Three children sit side by side as Clayton, Octavia, and Amy sit at a semi circle table, and the teacher is sitting right in front of them. The activity, in which they need to match the numbers with dots by keeping the place of
the matching cards in mind, lasted around 15 minutes. I will provide a detailed analysis of 10 seconds of this total scene to show how these children bodily engaged in this activity in different ways.

Table 4.1

**Multimodal Analysis of Clayton, Octavia and Amy’s Engagements**

<table>
<thead>
<tr>
<th>Time (in seconds)</th>
<th>Movement</th>
<th>Clayton</th>
<th>Octavia</th>
<th>Amy</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Proximity</th>
<th>Clayton</th>
<th>Octavia</th>
<th>Amy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standing on the right side of Octavia.</td>
<td>Sitting still on the chair</td>
<td>Sitting, and then, standing on the right side of Octavia</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Facial Expression</th>
<th>Clayton</th>
<th>Octavia</th>
<th>Amy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Serious [1,2,3]</td>
<td>Serious [1,2]</td>
<td>Little smile on her face.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Smiling [3]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Gaze</th>
<th>Clayton</th>
<th>Octavia</th>
<th>Amy</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Speech</th>
<th>Clayton</th>
<th>Octavia</th>
<th>Amy</th>
</tr>
</thead>
</table>

---

7 Numbers in the brackets are used to associate simultaneously occurring different modes.
The scene I provided above represents the pattern of interaction among these three children during the whole matching activity. As they picked two cards by taking turns, and checked to see if the dots match the number word, they were all showing different bodily presences. As shown in the analysis above, Clayton was physically very active. He was shifting between standing, leaning on the table, and leaning on his friends' and wiggling. On the contrary, Octavia was immobile, just sitting on her chair with a straight posture during the whole activity, and she was only keeping an eye on her own cards. Amy was somewhere in between Octavia and Clayton in terms of physical activity; she was standing and moving when picking her cards, and thinking about the number-dots matches, but sitting still during her friends’ turns.

Focusing on this interaction with the lenses of embodied cognition studies (Alibali, Spencer, Knox, and Kita 2011; Valenzo, Alibali, and Klatzky, 2003), overall, this scene exemplifies how these children manifest different bodily techniques to facilitate their engagement in mathematical thinking. For example, Clayton was thinking about the number word-dot match by counting out loud, pointing at dots with his fingers, and standing and jiggling, so maybe he was creating a self-stimulation in order to better engage in thinking. In contrast, Octavia was staring at the number words and dots for some time without producing any body movement during the whole activity, probably concentrating on the task. In the scene above, after Octavia had stated that she had the match of number word eight and dots, she looked a little bit unsure, and then, she is allowing Clayton to count the dots on her card out loud, and listening to him by staring away. Similar to what Kim, Roth, and Thom (2010) suggest in their study, children employ individual gestures to facilitate their mathematical thinking, and in such
interactive contexts, they produce shared gestures with their peers to support their thinking processes.

Overall, attention to Clayton, Octavia, and Amy’s bodies through the scene above was in line with my observations about them in general. However, this detailed multimodal analysis provided a concrete basis for my selection of three children who demonstrated a range of different bodily engagements in mathematics. In general, Clayton was always physically active and taking instrumental roles, and because of this, he was receiving many rule reminders from the teacher about appropriate bodily acts in the classroom. He enjoyed being recognized by the teacher about the way he did well at mathematics games, or tasks, so he was explicitly sharing these moments with the teacher. Octavia was mainly silent in teacher-directed mathematical activities, but she was taking instrumental roles in her mathematically rich play with her peers, especially with Amy, mostly in the outdoor area. Amy was generating mathematically rich conversations with teachers, and especially with peers during play, and was showing enthusiasm in answering teachers’ mathematics-related questions out loud during group times. In the next section, I will continue with the analysis of scenes from Clayton, Octavia and Amy in the playground.

**Mathematical Potentials Circulating around Bodies**

My analysis of children’s video scenes with a focus on mathematics and bodies shows two different but interrelated patterns. First, in some cases, Octavia, Amy and Clayton were manifesting bodily techniques, which appeared to hold mathematically rich potentials, such as Octavia’s hula hooping. However, these types of experiences should not be considered as mathematical practices by themselves. The mathematical value comes with the possibility that those bodily techniques of children could be turned into teachable moments for mathematics. In
other words, these moments could be mathematized by teachers integrating the content of these techniques into the curriculum in a developmentally appropriate way or initiating conversations drawing on these practices of children. Clement and Sarama (2009) define mathematization as “a critical learning process which involves redescribing, reorganizing, abstracting, generalizing, reflecting upon, and giving language to that which is first understood on an intuitive and informal level” (p.244). Therefore, the techniques that children were developing informally and intuitively have potential to be mathematized because they can be made salient and formalized.

In addition to these teachable moments, the second implication suggested by the data is that children were actively mathematizing their bodily experiences by themselves. For example, they were drawing on mathematical terms, or explaining out loud the mathematical relationships they discovered (Cross, Woods, Schweingruber, 2009). These were also important moments to recognize, so that by drawing on these kinds of mathematizations of children, further rich discussions might be generated with them.

Exemplifying the first part of data, Amy, during ball throwing competitions with Octavia, was perfectly twisting and stretching her body, and changing her distance and angle with respect to the target so that her ball could reach furthest. When playing ball, Clayton would change the position of his body so that he could have a good distance to be better able to throw the ball. When on the tire swing; Octavia would change the way she was sitting and using her legs to extend the time of swinging and create a faster swinging experience. All these experiences are examples of how human beings naturally adapt themselves to the physical world in which they function and play by the rules of physics and mathematics to meet their contextual goals. Mauss (1973) claims that “the body is man’s first and most natural instrument….or man’s first and most technical object, and at the same time technical means, is his body” (p.75). These bodily
techniques are naturally developed for efficiency in manipulating the environment. Through observing children’s actions and interactions, I could witness that the social dynamics of Pre-K classroom setting were pushing them to act in certain ways, and as a researcher I could see that some of the techniques they had been developing were rich in mathematical intuition and thus could potentially be used as teachable moments by the teacher.

An example of the other type of data is the conversation between Octavia and Amy about measuring certain spaces by using their feet. When standing near a friend, Clayton would check the height of his friend by looking at the top of his head, and try different postures in order to be able to stay on his toes so that, by using a comparative term, he could assert that he was taller. Another interesting example is as follows. Amy sneezes in one scene, and after that Octavia says “bless you” and claims that Amy sneezed twice the day before. Their conversation continues as they increase the numbers step by step until Amy asserts that she had sneezed 5 times before. At the end, in order to lead in numbers of sneezes, Octavia pretends to be sneezing. These moments exemplify that children generate mathematical conversations, based on their bodies, that could be further mathematized by their teacher by elaborating on their discussions, asking questions that would push them to explain their thinking, and creating contexts in which models of their everyday experiences were represented (Cross, Woods, Schweingruber, 2009).

In the next section, I will continue with the multimodal analysis of two scenes holding mathematical potential, and at the same time mathematized by children to some extent.

“My Heart Goes Super-Duper, Super-Duper, Super-Duper-Duper Fast!”

Octavia made this statement above during outdoor playtime while she was comparing her heart beat rate with Amy’s. This was one of the moments in which Amy and Octavia were eliciting mathematically rich conversations around their bodily experiences. This interaction
between them about their heartbeat rates took around eight minutes. I will describe their practices as a whole by providing multimodal analysis of two key moments showing the techniques Octavia and Amy were developing.

During outdoor free playtime, Amy and a friend were playing with a ball. Suddenly, Amy stopped and put her hand on her and then her friend’s chest. “My heart bumps fast,” she said. As these two children were checking their heartbeats, Octavia approached them. Amy put her hand this time on Octavia’s chest, and said “my heart beats fast.” Octavia’s reaction was as follows:

Table 4.2

Multimodal Analysis of Octavia and Amy’s Outdoor Engagements

<table>
<thead>
<tr>
<th>Time (in seconds)</th>
<th>Octavia</th>
<th>Amy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Movement</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.28</td>
<td>Stands still [1]. Puts her hand on her forehead [2]. Opens her mouth and starts to breathe fast by raising her shoulders [3]</td>
<td>Puts her hand on Octavia’s chest [1] Puts her hand on her own chest [2] Two seconds after Octavia, she also starts to breathe fast by raising her shoulders [3]</td>
</tr>
<tr>
<td>9.37</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Proximity</strong></td>
<td>In a face-to-face position with Amy</td>
<td>In a face-to-face position with Octavia</td>
</tr>
<tr>
<td><strong>Facial Expression</strong></td>
<td>Serious [1,2,3]</td>
<td>Serious [1,2,3]</td>
</tr>
<tr>
<td><strong>Gaze</strong></td>
<td>Looks at Amy [1,2,3]</td>
<td>Looks at Octavia [1,2,3]</td>
</tr>
</tbody>
</table>
This depiction of these two girls’ interactions with each other shows how they were engaging in mathematization through playing with their own bodies within a typical psychological dynamic in which children are generally interested in reaching the largest quantities or highest numbers. Octavia seemed to be motivated to get the faster heartbeat, which could be observed both in her language and in the bodily techniques she was developing. Amy’s statement “my heart bumps fast” pushed her to check her own heartbeat, after which she started to take short and quick breaths to increase her heartbeat rate. What Octavia was trying to achieve with this technique was to create a cause-effect relationship between the breathing and heartbeat rate. Interestingly, right after seeing Octavia, Amy started to try the same breathing technique, which again exemplifies how peer interaction provides a context in which children engage in gesture exchanges (Kim, Roth, and Thom, 2009) and how human beings have a natural tendency to imitate the bodily techniques of others for efficiency (Mauss, 1973).

Considering Octavia’s statements during this interaction, I also see a mathematical value in the language she was using. When creating a basis of comparison between their heartbeat rates, she was not using the comparative term “faster” or “fastest” but she was adding adjectives in front of the word fast, with an exaggerated fashion. This practice exemplifies how young children possess sophisticated skills featuring mathematical thinking, and how they manipulate the environment, and even their own bodies, towards certain contextual goals they set on their own.

Amy and Octavia continued to check their heartbeats, and other friends joined them. While a total of six children were constantly checking each other’s heart beats, Octavia suddenly
left the group and started to run. At the beginning, I was not sure why she suddenly started to run, but later with the multimodal analysis of a second scene; I realized that she was interested in another causal relationship. If she runs so fast, her heartbeat rate would increase again, maybe even faster than during the breathing condition. After a couple of tours around the playground, she stopped and approached Amy:

Table 4.3

*Multimodal Analysis of Octavia and Amy’s Second Outdoor Engagements*

<table>
<thead>
<tr>
<th>Movement</th>
<th>Time</th>
<th>Octavia</th>
<th>Amy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>seconds)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>17.28.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>17.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximity</td>
<td></td>
<td>Standing in front of Amy [1,2,3,4]</td>
<td>Sitting on the ground [1] Standing in front of Octavia [2,3,4,5]</td>
</tr>
<tr>
<td>Facial</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expression</td>
<td></td>
<td>Serious [1,2,3]</td>
<td>Serious [1,2,4,5]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Smiling [3]</td>
</tr>
<tr>
<td>Speech</td>
<td></td>
<td>No speech</td>
<td>Mine is faster [3]</td>
</tr>
</tbody>
</table>
In this second interaction, Octavia and Amy compare their heartbeats again, but as suggested by the way they used their bodies, this time they looked much more carefully. Octavia lifted her t-shirt, and then, placed her hand, so that she could feel her heartbeat more clearly. Then, Amy compared their heartbeats, said out loud “mine is faster” and pushed Octavia to run again.

While Octavia was running around the play garden, Amy and the other four kids kept checking their own and each other’s heartbeats, and continued talking about whose heartbeat was the fastest. The teacher of the classroom noticed the group of kids together, and approached them and asked:

Teacher: What are you guys doing?
Cansu: Our hearts bump fast!
Teacher: Why do you think your heart bumps so fast?
Amy: (smiles) Because we exercise.
Teacher: Because you exercise! Alright! (Smiles and then, teacher leaves.)

This dialog made apparent that Amy was aware of the fact that her fast heartbeat was resulting from a greater physical activity level. If this conversation among kids and teacher was sustained, Amy would probably continue to elaborate on the mathematical relationship they had been discovering between their heartbeat rates. Moreover, this also made me wonder if asked, how Octavia and Amy would respond to and formalize the bodily techniques (such as breathing and running) in relation to increasing heartbeats.

Overall, the eight-minute-long interaction from this classroom was one of the teachable moments my camera captured, in which children were mathematizing their bodily experiences, and engaging in highly interesting and sophisticated thinking that featured mathematics. Capitalizing on teachable moments is a central approach in early childhood education, referring to observing children’s informal and spontaneous practices closely, and putting in effort to turn
them into instructional moments (Charlesworth & Lind, 2013). Recognizing these teachable moments is important in mathematizing children’s daily experiences (Clements & Sarama, 2009). Creating teachable moments out of children’s own practices could motivate them to engage in mathematizations, and to see the value of mathematics in their real life practices (Ginsburg & Erdle, 2008). At this point, the scenes I captured and analyzed closely suggest that giving attention to children’s bodies adds value in recognizing teachable moments of mathematics in early childhood classrooms. In the next section, I will continue with a similar scene involving Clayton.

“**I Have Many Rocks in my Pockets. Twenty-Five… Fifty!**”

What distinguished Clayton from other children in the classroom was him being so explicit about his actions, particularly mathematical ones, and proudly telling his teacher the details of how he was doing better than his friends, especially during table games involving UNO cards, decks of cards, chess, and puzzles. In other words, he was initiating math talk, which could be capitalized upon and taken one step further in terms of the mathematical potentials they held.

The statement in the title above was made by Clayton during one of these moments after he put many small rocks in both of his pants pockets during an outdoor free play time. While he was squeezing the last couple of rocks in his right pocket, I noticed a bodily technique he was relying on to decide which rock should go into which pocket. The following analysis provides a detailed look at his body:
Table 4.4

Multimodal Analysis of Clayton’s Outdoor Engagement

<table>
<thead>
<tr>
<th></th>
<th>Time (in seconds)</th>
<th>Clayton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gesture</td>
<td>12.20</td>
<td>Picks up a stone [1] Puts in his right</td>
</tr>
<tr>
<td></td>
<td></td>
<td>in his right pocket again [4]</td>
</tr>
<tr>
<td>Posture</td>
<td></td>
<td>Leans on right and left [2] Leans on right</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and left [4]</td>
</tr>
<tr>
<td>Speech</td>
<td></td>
<td>No speech</td>
</tr>
</tbody>
</table>

Attending to Clayton’s body through multimodal analysis led me to infer that he was leaning on both sides of his body to check his body’s balance. Since he was interested in collecting as many rocks as possible, he needed to put them in both of his pockets. The most effective action would be distributing them almost equally between the two pockets. This technique of Clayton’s relates to our natural tendencies as human beings to maintain symmetry and balance. In this case, Clayton needed to keep the balance to be able to move and walk while carrying the greatest number of rocks possible. As children encounter such everyday situations involving quantities, they naturally make decisions and take actions regarding the relationships among these quantities (Carpenter, Fennema, Franke, Levi, Empson, 1999). As exemplified by
Clayton, even very young children show the skills to respond to the needs of the outside world by activating their body, which becomes the central tool to take mathematical actions.

Clayton’s technique demonstrated that the body itself could be used intuitively as a scale, which could allow experiencing the concepts of comparing and contrasting, and exploration of the concept of weight. When compared to the plastic pan scales in math corners of classrooms, the child’s body itself can provide a more realistic and naturalistic experience for young children to make sense of basic mathematical concepts.

After filling up his pockets with so many small rocks, Clayton slowly walked through the play garden to let his teacher know that he had many rocks in his pockets. The teacher saw him coming with rocks, and picked up a plastic bag to store them.

Teacher: How many rocks do you think you have?
Clayton: Twenty-Five.
Teacher: Twenty-Five!
Clayton: Fifty.
Teacher: Fifty!

Clayton’s talk strengthened my inference about his effort to keep balance, because probably he was implying that he had twenty-five rocks in each of his pockets, which would make a total of fifty. Drawing on my observations about Clayton’s mathematical abilities over one semester, I can say that he was able to make this calculation. When putting rocks in the plastic bag one-by-one, Clayton stated a couple of times that he had so many rocks, and the teacher replied back with approval.

There is no way to know the exact number of rocks, but based on my estimation, Clayton collected around 70. Rather than counting the total number of rocks or counting the rocks in each pocket separately for later comparison, the teacher only asked him to estimate the total number at
the beginning, which was a practice they were engaging in this classroom a lot, as well as being a state Pre-K content standard.

Observing Clayton’s body, and listening to the math talk he brought to the teacher, I could see that if he was given the opportunity, he would be able to build upon his matematizations and generate rich ideas about concepts such as comparison, equivalence, and the relationships among the sizes and weights of the objects. Ginsburg, Lee and Boyd (2008) state that although young children’s everyday mathematics entails sophisticated mathematical thinking skills drawing on a wide range of content areas, the general expectation for children is very limited. This limited expectation confines our conceptions of early mathematics to counting, and learning the name of shapes, which signals the need for a shift in our expectations for children. The close analysis of three children in this study demonstrates that our expectations should be shaped by the potentials of children indicated by their bodily techniques or the mathematically rich conversations that they generate. Only then, such missed opportunities could be turned into meaningful everyday learning experiences.

**Conclusion**

In this study, I shared scenarios of children’s bodily techniques appearing in the context of a Pre-k setting, in particular during outdoor free play time. As young children were responding to the dynamics of the social interactions among peers and with teachers, enacting certain contextual goals they set on their own, they were developing and manifesting spontaneous bodily techniques. I identified these bodily techniques as holding potential to be mathematized and turned into teachable moments for mathematics learning.

Multimodal analysis, holding the potential to reveal the privileged and backgrounded modes embedded in the daily lives of classrooms (Wohlwend, 2011), provided a foundation for
this study in terms of a general perspective, and also as a methodological application. In particular, the multimodal perspective guided my participant selection and data analysis. Kress (2011) states that shifting our attention to multimodal forms of analysis in educational research, by privileging certain modes over others in our observations, signals particular epistemological and ontological stances. The underlying notion of this study was that knowledge is generated through bodies, and represented on bodies, and these embodied forms of knowing and knowledge could be closely observed and analyzed. Therefore, multimodal analysis of scenes I captured in the Pre-k classroom provided a way to look into bodily techniques and opened up a space to think about the possibilities manifesting themselves in Pre-k classrooms with respect to children’s embodied mathematical engagements.

As with a growing number of research studies pointing the central role of the body in mathematical thinking (Alibali & Nathan, 2012; Valenzeno, Alibali, & Klatzky, 2003; Kim, Roth, Tom, 2009; Lakoff & Núñez, 2000), this study, by looking at children’s bodies closely, brought implications for what is to be learned, and how it is to be learned, with respect to early childhood mathematics. Focusing on what is to be learned, the mathematical potentials I envision linked to children’s bodily engagements are in line with traditional early childhood mathematics concepts such as number sense, basic geometry and measurement, but also with foundational algebraic thinking.

Focusing on how mathematics is to be learned, it has been suggested that along with the purposeful instruction of mathematics (Hachey 2013; Stipek, 2013), a teachable moments approach, focusing on children’s spontaneous mathematical engagements, should be a complementary practice in early childhood classrooms (Ginsburg, Lee, Boyd, 2008). It is well stated in the literature that children engage in a great deal of mathematics as part of their
everyday activities (Seo & Gingsburg, 2004), and these everyday mathematically rich moments for young children should be recognized and mathematized (Clements, 2004b; Cross, Woods, Schweingruber, 2009). However, the notion of recognizing children’s everyday mathematics is a vague one, which brings the question of how a teacher might recognize moments rich with possibility, particularly considering the fact that mathematics is not always easily observable.

Ginsburg and Ertle (2008) state that recognizing children’s spontaneous mathematical engagements depends on teachers’ own mathematical intuition and knowledge so that they could envisage the mathematical potentials underlying children’s actions, and it also depends on teacher’s high expectations for children’s mathematics. In relation to these perspectives, in this paper, I argued that recognizing everyday mathematics particularly requires valuing children’s bodies as holding mathematically rich potentials. Moreover, as we attempt to take up spontaneous learning moments, shifting our focus to children’s bodily techniques provides a concrete context for both researchers and teachers to realize mathematical potentials children show.
References


Standards for early childhood mathematics education (pp. 267-298), Mahwah, NJ: Lawrence Erlbaum.


CHAPTER 5

CONCLUSION

The three articles of this dissertation had a common underlying motivation, which was to emphasize the need for shaping formal mathematics education in early childhood education classrooms based on children’s embodied potentials that they bring to school and develop within the school. In addition, the value of considering families’ insights about children’s mathematics in and out of school was explored. In doing so, this dissertation also foregrounded the utility of video-ethnography as a research methodology for examining mathematics learning in prekindergarten classrooms. The video-ethnography methods used in the study allowed a meaningful interview experience for families in the context of video-cued multivocal dialogs, and offered me as a researcher a multimodal lens to closely attend to children’s bodies, in order both to observe the schools’ disciplinary discourse reflected on physical bodies, and children’s creative uses of their bodies in relation to mathematics.

The main implication of the first article is that efforts to improve early childhood mathematics education can be conceptualized as a way of thinking about how to support parents and how to be supported by them. Therefore, we need to create opportunities where teachers and parents might come together and engage in thinking and learning from each other about children’s diverse mathematical engagements. Practices that already widely exist in schools, such as family math nights and school family math clubs, would be rich spaces for these engagements but only if designed with an undergirding principle being the assumption of parents-as-intellectual resources. The dialogues in these settings could also provide us with an
understanding of how we might make curricular connections with parents, as they share how children engage in and transform mathematical practices as they move back and forth between home and school. Moreover, the video-cued dialogues could include children and then, create a space for observing how children transform mathematical practices between home and school as parents and teachers share their own understandings of mathematics. How children transform the mathematical practices between home and school and the anxieties and pleasures of this process for teachers, parents, and children seems to be an important focus for future research that would enrich our current knowledge about early childhood mathematics education.

The implications of the other two articles are complementary with each other. In particular, the implication of third article, which was about rich mathematical bodily techniques of children, stresses the importance of the arguments about disciplinary dynamics of prekindergarten classrooms that I raised in the second article. While the third article provided evidence about how young children develop and manifest bodily rich engagements in mathematics, particularly during free play in outdoor learning environments, the second article brought a critical lens to examine classroom discourses restricting and limiting children’s bodily engagements inside the classroom.

The second article highlighted empirical evidence of how discipline is institutionalized within the contexts of schools and how schools’ disciplinary mechanisms are infused in mathematical practices in a classroom of young children. These findings have implications for shifting researchers’ and educators’ attention to the disciplinary context in classrooms in which bodily experiences are manifested, especially around the issues of power relations and control. In particular, this article provided evidence on how mathematics, with its authoritative and classificatory nature, is embedded in the implementation of classroom management-related state
prekindergarten content standards, such as those that were followed closely by the teacher in this research study:

- Defining boundaries to promote body and spatial awareness, discussing and utilizing appropriate safety procedures (discussing safety rules for playground), and making classroom rules and expectations available in many different forms (pictures, words, and Braille) so all children can understand them.

The second article suggests that the classroom context is constantly influenced by disciplinary dynamics, which could have a limiting and distracting effect on children’s engagement with mathematics by constraining their bodies. Drawing on the insights of this study, further research can inquire how children’s bodily engagements in a similar (or comparable) classroom context influence the effectiveness of their mathematics learning process (or learning in other content areas) and young children’s interpretations of doing mathematics in schools. Along similarly lines, in future research, educators and researchers could co-design a learning environment purposefully to offer young children opportunities in and out of the classroom space to explore aspects of bodily engagement with mathematics. They could support teachers in this environment in searching for and taking advantage of teachable moments in which they might mathematize children’s bodily engagements, and could collaborate in documenting these teaching and learning moments.