YOVA, FREDERIQUE CECILE. Exploring Early Mathematics through Book Reading: An Inquiry Centering on Head Start Participants’ Experiences, Practices, and Sayings (Under the direction of Dr. Temple Walkowiak and Dr. Jonee Wilson).

The purpose of the dissertation was to better understand the phenomenon of exploring early mathematics through book reading, centering on Head Start. The inquiry comprised two sub-studies, both laying on Bronfenbrenner’s bioecological framework (Bronfenbrenner & Morris, 2006).

The first sub-study was a quantitative study, performed through multi-level models (Raudenbush & Bryk, 2002) using the Head Start Family and Child Experiences Survey (FACES, 2006) dataset. The sub-question guiding the quantitative study was: Are there relationships between the early mathematics experiences Head Start children are offered, their exposure to book reading, and the presence of Developmentally Appropriate Practices (DAP)? Findings showed that a large population of the children were exposed to both book reading and early mathematics experiences weekly, either in the school or in the home. In both contexts, some relationships were observed between book reading and early mathematics experiences. The study also focused on the alignment of the phenomenon with DAP, and its three core elements (i.e., attention to child development, contexts of learning and intentional teaching). In the home, the odds of playing counting games or reading books about numbers were significantly higher when parents encouraged children to be curious (i.e., attention to child development) and when parents reported that someone in the family taught the child letters, words, or numbers in the past week (i.e., intentional teaching). In the context of the school, results varied depending on the early mathematics content. In both the school and the home, attention to cultural contexts was associated with higher odds of playing counting games or reading books about numbers in the
home, and with being offered early mathematics experiences in the classroom.

The second sub-study was a qualitative single case study of six Head Start adult participants. The sub-questions guiding the qualitative study were: 1) What are Head Start participants’ experiences in exploring early mathematics through picturebooks? and 2) What do Head Start participants say about exploring early mathematics through picturebooks? Findings showed that participants expressed interest towards exploring early mathematics through picturebooks. Picturebooks were commonly used in the classroom but also accessible for families. In parallel, participants provided evidence of mathematics practices and discussions around mathematics in the school and in the home. The participants’ sayings and experiences in exploring early mathematics through picturebooks aligned with child development and social and cultural contexts of learning, two cornerstones of DAP. However, potential obstacles emerged that could restrain the endorsement of the phenomenon.

Implications for researchers and practitioners are discussed.
Exploring Early Mathematics through Book Reading:
An Inquiry Centering on Head Start Participants’ Experiences, Practices, and Sayings

by
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BIOGRAPHY

Frédérique Yova grew up in France, where most of her close family were elementary teachers. In college, a full scholarship to pursue a doctorate in Biology took her away from the familial tradition of teaching. She took a step even further away from a classroom when she became a European patent attorney and immersed heartily into the field of research. A few years after she moved to the U.S., she made the decision to switch careers and combine her skills, interests, and curiosity in research with her life-long beliefs in public education. She obtained her Birth-K teaching license from the University of North Carolina at Chapel Hill. She taught in both a Head Start program and a private daycare center prior to starting her graduate studies, first as a M.Ed. student at the University of North Carolina at Greensboro, then as a doctoral student at North Carolina State University. Over the years, she has developed a strong interest in early childhood education and mathematical thinking of young children; she has enjoyed volunteering in preschools, offering collections to count and story problems to explore during free-choice time. Her dissertation studies focused on understanding the phenomenon of exploring early mathematics through book reading, centering on Head Start participants’ experiences, practices, and sayings.
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TABLE OF CONTENTS

LIST OF TABLES ........................................................................................................................... viii
LIST OF FIGURES ........................................................................................................................... ix

CHAPTER 1. Introduction .................................................................................................................. 1
  1.1 Background of the study ........................................................................................................... 1
  1.2 Purpose statement ....................................................................................................................... 3
    1.2.1 Statement of the Problem ..................................................................................................... 3
    1.2.2 Purpose of the Study ............................................................................................................ 4
    1.2.3 Overview of Methodology ................................................................................................... 6
    1.2.4 Significance of the study ...................................................................................................... 6
  1.3 Definitions of terms ..................................................................................................................... 7
  1.4 Organization of the dissertation .................................................................................................. 8

CHAPTER 2. Background of the study .............................................................................................. 9
  2.1 Theoretical framework .............................................................................................................. 9
    2.1.1 Inquiry worldview ............................................................................................................... 9
    2.1.2 Subjectivity statement ....................................................................................................... 10
    2.1.3 Substantive content theories ............................................................................................. 11
  2.2 Review of Literature .................................................................................................................. 12
    2.2.1 Overview of Early Childhood Education ........................................................................... 12
    2.2.2 Early mathematics ............................................................................................................. 18
    2.2.3 Early mathematics in the context of Developmentally Appropriate Practices (DAP) ........... 24
    2.2.4 Endorsing early mathematics and DAP via book reading .................................................. 28
    2.2.5 Summary ............................................................................................................................ 34

  3.1 Introduction ............................................................................................................................... 35
  3.2 Early Childhood Education (ECE) and the framework of Developmentally Appropriate Practices (DAP) ........................................................................................................................................ 36
  3.3 The emergence of early mathematics ......................................................................................... 37
  3.4 Exploring early mathematics through literacy .......................................................................... 38
  3.5 The present study ...................................................................................................................... 39
  3.6 Material and methods ................................................................................................................. 40
    3.6.1 Data set and participants .................................................................................................. 40
    3.6.2 Selection of variables ....................................................................................................... 41
    3.6.3 Analysis plan ..................................................................................................................... 44
  3.7 Results ...................................................................................................................................... 46
    3.7.1 Descriptive statistics ........................................................................................................ 46
    3.7.2 Multi-level model results ................................................................................................ 48
    3.7.3 Summary ........................................................................................................................... 55
  3.8 Discussion .................................................................................................................................. 57
  3.9 Conclusion .................................................................................................................................. 61

CHAPTER 4. Exploring early mathematics through picturebooks: A case study in the context of Head Start ........................................................................................................................ 63
  4.1 Background ............................................................................................................................... 63
  4.2 Purpose of the study ................................................................................................................... 67
  4.3 Methodology ............................................................................................................................. 67
    4.3.1 Framework ....................................................................................................................... 67
4.3.2 Research design.................................................................................................................. 68
4.3.3 Study design......................................................................................................................... 69
4.3.4 Data collection...................................................................................................................... 70
4.3.5 Data analysis......................................................................................................................... 73
4.3.6 Validity and reliability of the study....................................................................................... 77
4.4 Findings .................................................................................................................................. 77
  4.4.1 What are Head Start participants’ experiences in exploring early mathematics through
       picturebooks?................................................................................................................................. 77
  4.4.2 What do Head Start participants say about exploring early mathematics through picturebooks?.... 82
4.5 Discussion................................................................................................................................. 88
4.6 Limitations & Implications....................................................................................................... 92
CHAPTER 5. Discussion and Conclusion...................................................................................... 94
  5.1 Summaries of my quantitative (Chapter 3) and qualitative (Chapter 4) studies ............94
  5.2 Cross-studies analysis............................................................................................................. 98
    5.2.1 Exposure to book reading and early mathematics content.............................................100
    5.2.2 Engaging with early mathematics through book reading: Intentional teaching in respect of child
         development and contexts of learning....................................................................................103
  5.3 Implications for Head Start programs ....................................................................................106
  5.4 Future research .....................................................................................................................110
  5.5 Concluding thoughts............................................................................................................112
References .................................................................................................................................113
APPENDICES ............................................................................................................................138
Appendix A ..................................................................................................................................139
Appendix B ..................................................................................................................................140
Appendix C ..................................................................................................................................141
Appendix D ..................................................................................................................................142
Appendix E ..................................................................................................................................144
Appendix F ..................................................................................................................................145
LIST OF TABLES

Table 3. 1. Selection of variables ........................................................................................................41
Table 3. 2. Descriptive statistics related to early mathematics experiences, the exposure to book reading and the presence of DAP..........................................................................................47
Table 3. 3. Odds of being offered mathematics experiences (classroom environment) ..........49
Table 3. 4. Odds of being offered mathematics experiences (home environment) ..............51
Table 4. 1. Selection of picturebooks ................................................................................................71
Table 4. 2. Sample of codebook around early mathematics ..............................................................74
Table 4. 3. Sample of codebook around DAP ....................................................................................75
Table 4. 4. Sample of codebook participants’ sayings and corresponding quotes ..................76
Table 4. 5. Early mathematics areas that emerged as participants read aloud or reviewed picturebooks ......................................................................................................................................78
Table 4. 6. DAP that emerged as participants read aloud or reviewed picturebooks .............80
LIST OF FIGURES

Figure 1.1. Bronfenbrenner’s biocological framework (from Brofenbrenner & Morris, 2006) ................................................................. 5

Figure 2.1. Early mathematics content .................................................................................................................. 19

Figure 3.1. Demographics .................................................................................................................................. 41

Figure 3.2. Overview of the relationships between variables observed through multi-level models .......................................................... 56

Figure 4.1. Overview of findings ......................................................................................................................... 89

Figure 5.1. Benefits and obstacles of exploring early mathematics through book reading ........................................ 100

Figure 5.2. Core elements to successfully endorse the phenomenon of exploring early mathematics through book reading ........................................ 107
CHAPTER 1. Introduction

As an early childhood educator, who offered early mathematics experiences daily in my classroom, I quickly endorsed, as a doctoral student, the push towards early mathematics that emerged from the literature in the past two decades. I remember enthusiastically highlighting a quote from Hachey (2013) during my first year of doctoral studies: “With increased recognition of the importance of early mathematics for later academic success, early childhood mathematics education is now a national priority” (p. 419). I could instantly see classes of preschoolers across the country, exploring mathematical relationships through play, both inside in activity centers and outside during recess. I could see families engaging in early mathematics as they cook or go grocery shopping. As time passed, though, I started thinking of the unintended consequences such endorsement across the nation may bring. In particular, I was especially saddened by a study reporting an increase in teacher-directed instruction and decrease in access to dramatic play areas or water or sand tables in schools serving primarily children from families with low incomes (Bassok, Latham, & Rorem, 2016). I wondered: will all children be part of such a national priority? Will all children have access to playful and engaging early mathematics experiences? Although I do value the necessary work of my peers investigating early mathematics practices in the classroom and in the home, and their effect on children’s achievement, I also see the need for the field to engage with reflective work. Throughout my dissertation journey, I have often wondered: what unintended consequences may be associated with early mathematics?

1.1 Background of the study

The promising outcomes of early childhood education (ECE) reporting in the literature in the early 2000s (National Research Council, 2009) has opened the door to extended research
studies on various areas, including early mathematics. In particular, a study based on the analysis of six longitudinal datasets and describing early mathematics as a strong predictor of later school achievement (Duncan, Dowsett, Claessens, Magnuson, Huston, Klebanov, et al., 2007) has brought much attention to the mathematical content to which young children should be exposed, that is, numbers and operations, geometry, measurement, algebraic thinking, and data analysis (Clements & Sarama, 2014; Copley, Jones, Dighe, Bickart, & Heroman, 2007; Erikson Institute, 2014). The exposure seems all the more critical to children living in poverty (Clements & Sarama, 2011; Duncan et al., 2007) such as children attending Head Start, a federally-funded program serving families with low incomes. Hence, significant efforts have emerged from both the research field as well as professional organizations to advance early mathematics. For instance, the Development and Research in Early Childhood Education network (DREME, 2021) has developed online modules that are accessible free of charge to teacher educators (https://prek-math-te.stanford.edu). The Erikson Institute (2021) and the Education Development Center (2021) also provide free research-based materials (https://earlymath.erikson.edu; https://youngmathematicians.edc.org). In parallel, the National Association for the Education of Young Children (NAEYC) issued a joint statement with the National Council of Teachers of Mathematics (NCTM) to provide guidance on promoting early mathematics while respecting Developmentally Appropriate Practices (DAP, NAEYC & NCTM, 2010), a widespread framework in U.S. preschool settings (Brown & Lan, 2013). These practices attend to child development, the contexts of learning, and the presence of intentional teaching to scaffold learning opportunities of young children (NAEYC, 2020). Despite initial concerns, there is now a consensus that early mathematics and DAP are not exclusive, and a balance can be found (Fowler 2017; Clements, Fuson, and Sarama 2017). A strategy recommended by the NAEYC
and the NCTM is integrating early mathematics with children’s literature (NAEYC & NCTM, 2010). Indeed, book reading could provide a reassuring starting point to families and preschool teachers, who are often more comfortable with literacy than mathematics (Cannon & Ginsburg, 2008; Copley et al., 2007). Also, books can empower young children and their identities when they present a reflection of children as well as a view to the world in which they live (Bishop, 1990). One can therefore envision, in the field of early mathematics, how a thoughtfully selected book could guide children, all children, in picturing themselves as mathematicians. However, little is known about how the phenomenon of exploring early mathematics through book reading, referred to as “the phenomenon” throughout my dissertation, positions with book reading and early mathematics practices already in place in the home and in the classroom. Also, to my knowledge, no studies have investigated how the phenomenon positions with the core elements of DAP (i.e., attention to child development, contexts of learning, and intentional teaching).

Throughout my dissertation, I use the verb “position” as a way to broadly refer to how the phenomenon may align, misalign, connect, or interact with early mathematics and book reading practices or DAP. Head Start, and its strong connection between families and schools, is an ideal setting to better understand the phenomenon.

1.2 Purpose statement

1.2.1 Statement of the Problem

Exploring early mathematics through book reading provides several advantages, such as providing an engaging context to scaffold early mathematics learning in both the home (Anderson, Anderson, & Shapiro, 2004) and preschools (Jacobi-Vessels, Brown, Molfese, & Do, 2016). However, the position of such phenomenon in view of DAP, a framework widely used in preschool settings (Brown & Lan, 2015), has not been described in the literature. A
misalignment between the phenomenon and DAP could result in unintended consequences that could prevent access for all children to early mathematics experiences.

1.2.2 Purpose of the Study

The purpose of the study was to better understand the phenomenon of exploring early mathematics through book reading via the lens of Head Start. The first goal was to investigate how the phenomenon positions with early mathematics and book practices in place in the home and in the classroom (i.e., how the position plays out in relation to home and classroom practices). A second goal was to investigate how the phenomenon positions with the core elements of DAP that are child development, contexts of learning, and intentional teaching (i.e., how the phenomenon plays out in relation to the core elements of DAP).

The study comprised two independent studies—a quantitative and a qualitative study—both laying on Bronfenbrenner’s bioecological framework (Bronfenbrenner & Morris, 2006), recognizing the personal characteristics of the individual, the reciprocal influences between individuals and their environmental context, and the effect of time on changes occurring among individuals and their environment (Figure 1.1.). The model sees the individual (i.e., the developing child) as nested in several environmental systems. In the context of the dissertation, the microsystem refers to activities and relationships experienced by the child either in the home or in the school, while the mesosystem refers to interrelations between the home and the school. The exosystem refers to additional settings in which the child is not an active participant (e.g., the neighborhood, a sibling’s classroom, a parent’s workplace). The macrosystem refers to a higher level of consistencies, due to policies, values, etc. For instance, access to health care and laws regarding Head Start teachers’ salaries or education requirements would be part of the
macrosystem. In other words, the child is nested into several “circles of influence” (Brendtro, 2006, p.163).

**Figure 1.1. Bronfenbrenner’s bioecological framework (from Brofenbrenner & Morris, 2006)**

The overall research question was: How does investigating Head Start participants’ experiences, practices, and overall sayings contribute to an enhanced understanding of the phenomenon of exploring early mathematics through book reading? I focused on two circles of influences, that were the microsystem and the mesosystem i.e. the influences of the home and the school.

The sub-question guiding the quantitative study was: Are there relationships between the early mathematics experiences Head Start children are offered, their exposure to book reading, and the presence of Developmentally Appropriate Practices?

The sub-questions guiding the qualitative study were: 1) What are Head Start participants’ experiences in exploring early mathematics through picturebooks?; and 2) What do
Head Start participants say about exploring early mathematics through picturebooks? By participants’ experiences, I sought evidence of specific experiences occurring as the participants read aloud or reviewed a picturebook. For instance, I looked for evidence of questions participants raised/would raise or interactions with children participants had/would have in view of a specific book they read or reviewed. By participants’ sayings, I sought for evidence of early mathematics and book reading practices they had in place as well as their perspectives on early mathematics, book reading, DAP, and the phenomenon in general. In other words, the first research question directly focused on the participants’ experiences with specific picturebooks, while the second research question opened the door to any additional evidence that would be relevant to better understand the phenomenon through the lens of Head Start.

1.2.3 Overview of Methodology

The first independent study was a quantitative study. The investigation was performed through multi-level models (Raudenbush & Bryk, 2002) using the dataset from the Head Start Family and Child Experiences Survey (FACES, 2006), a dataset with representative samples of Head Start programs, centers, classrooms, families, and children.

The second independent study was a qualitative single case study of six Head Start participants embedded in the context of using picturebooks to explore early mathematics. A single case study was relevant as the objective was to inquire into the connections affecting a common situation (Yin, 2017), that was exploring early mathematics through picturebooks.

1.2.4 Significance of the study

Understanding the phenomenon of exploring early mathematics through book reading and picturebooks seems even more critical with children from families with low incomes, such as children served by Head Start, as they would benefit the most from early mathematics
(Clements & Sarama, 2011; Duncan et al., 2007). However, the perspectives of Head Start participants are rarely disclosed in the literature. Relaying their voices will not only provide evidence to better understand benefits and obstacles of the phenomenon, but new pathways to investigate will emerge.

1.3 Definitions of terms

*Developmentally appropriate practices* (DAP) are practices that promote optimal development and learning of all children while considering three critical components of learning: (a) attention to child development (i.e., the recognition of patterns in child development as well as the uniqueness of each child through noticing child’s thinking or encouraging his/her/their curiosity); (b) the influence of contexts—social, cultural, and historical—on children’s learning (i.e., the context of the child, but also those of the family, the educator, the school setting, the community); and (c) intentional teaching the child must receive from adults to grow emotionally and cognitively that includes, in the context of the dissertation, scaffolding, questions stimulating and extending their thinking, and recall of prior knowledge (NAEYC, 2020).

*Early mathematics content* refers to mathematical content young children should encounter as deemed important by the research field. In particular, I refer to numbers & operations, geometry & spatial sense, measurement, patterns & algebraic thinking, and data analysis (Clements & Sarama, 2014; Copley et al., 2007; Erikson Institute, 2014).

*Multi-level models* refer to statistical models where units can be analyzed at more than one level (Hawkins, Guo, Hill, Battin-Person, & Abbott, 2001; Neupert, Almeida, & Charles, 2007; Raudenbush & Bryk, 2002). At Level 1, each participant’s variability over time is expressed as a set of parameters (i.e., the intercept and the slope). At Level 2, these parameters
become variables depending on participant-level characteristics. In the context of the present study, variation at Level 1 is within-children while variation at Level 2 is between-children.

*Phenomenon* refers to the phenomenon of exploring early mathematics through book reading, such as book reading in general (i.e., Chapter 3) or book reading of picturebooks (i.e., Chapter 4).

*Picturebooks* are books in which both visual and verbal components of the read-aloud are seen as essential to the understanding of the story (Moreillon, 2017; Strasser & Seplocha, 2007).

### 1.4 Organization of the dissertation

The dissertation is organized as follows. Chapter 2 includes an overview of the literature relevant to the study. Chapter 3 presents a manuscript laying on a quantitative study and aiming to investigate relationships between early mathematics experiences Head Start children are offered, their exposure to book reading, and the presence of DAP, in the context of both the classroom and the home. The target journal is *Contemporary Issues in Early Childhood*, a journal focusing on new and alternative perspectives in working with young children and their families. Chapter 4 presents another manuscript, a case study investigating the phenomenon of exploring early mathematics through picturebooks via the lens of a Head Start center. The target journal is *The Journal of Early Childhood Research*, welcoming qualitative studies in the field of early childhood education with a focus on equity. Finally, Chapter 5 discusses the overall findings and implications, as well as concluding thoughts. A section of Chapter 5 was written to be submitted to *Teaching Young Children*. 
CHAPTER 2. Background of the study

In Chapter 2, I first present the theoretical framework the dissertation builds upon. I then present an overview of the relevant literature. I begin with an overview of early childhood education (ECE) in the U.S. and the Head Start program, a federal program to support young children in poverty. Then, I extend to early mathematics and its implementation in the classroom and in the home in view of Developmentally Appropriate Practices (DAP). Finally, I review the use of book reading as a pathway to support early mathematics while maintaining DAP. Throughout I devote a particular focus on young children and families with low incomes, especially those served by Head Start.

2.1 Theoretical framework

My dissertation is based on theories, personal experiences, and conceptual frameworks presented hereafter.

2.1.1 Inquiry worldview

A social-cultural framework and its three major assumptions shaped the design of the study and the interpretation of the results (Crotty, 1998, as reviewed in Creswell & Creswell, 2017). A first assumption is that individuals construct meanings through their interactions with the world in which they live. Therefore, the dissertation deeply relied on participants’ perspectives and practices around the phenomenon of exploring early mathematics through book reading. For instance, the quantitative study rests on teachers’ and parents’ surveys reflecting on their school or home practices around early mathematics and book reading. Similarly, the qualitative study focused on experiences and sayings of Head Start participants around exploring early mathematics through picturebooks. A second assumption presumes that individuals make sense of their world via their own historical and social experiences. In other words, participants’
experiences and the interpretation of my results were influenced by our own lives and personal backgrounds. The third assumption adopts the generation of individual meanings as arising from social interactions. The research was inductive, based on quantitative and qualitative data collected in the field.

2.1.2 Subjectivity statement

I recognize that my European background, where universal early childhood education is widespread, may influence my dissertation. I also acknowledge my child-centered view of education. I am an advocate of providing young children with opportunities to freely explore mathematical concepts in conjunction with an age-appropriate and supportive learning environment. I believe such freedom in exploring mathematics emphasizes the uniqueness of every child. In the past three years, I have weekly visited state-funded and federally funded classrooms to explore early mathematics with preschoolers. These visits have given me the chance to not only reflect on young children’s mathematical thinking but also on preschool teachers’ and families’ perceptions of early mathematics. I have noticed the enjoyment teachers, parents, and children often have in engaging with book reading. These classroom experiences and the subsequent reflective process have deeply molded my dissertation. Finally, I have embraced a personal journey, reflecting on my position in our society as a white, able-bodied, cisgender, French American woman. I believe that, although education policies can contribute to reducing social inequities, they must be accompanied by social and economic policies. I taught in a Head Start center prior to pursuing my graduate studies and deeply value the essence of the program as well as the diverse representation of its participants.
2.1.3 Substantive content theories

The present dissertation lays on Bronfenbrenner’s bioecological framework (Bronfenbrenner & Morris, 2006). The theoretical model, as previously presented in Figure 1.1., recognizes the personal characteristics of the individual, the reciprocal influences between individuals and their environmental contexts, and the effect of time on changes occurring among individuals and their environment. The model sees the individual as nested in several environmental systems (i.e., microsystem, mesosystem, ecosystem, macrosystem, and chronosystem). By referring to such a framework, this dissertation focuses on the child level (microsystem) as well as the home and the school levels (mesosystem). Even though my data collection does not target higher levels, I also take into consideration social and economic policies and values (macrosystem, e.g., Head Start teachers’ salaries, their education requirement) and the effect of time (chronosystem, e.g., changes in Head Start policies throughout the years). Bronfenbrenner’s framework is especially relevant in the context of my dissertation, as Urie Bronfenbrenner was co-founder of Head Start (Brendtro, 2006), the federal program designed to support young children and their families living in poverty, that is at the core of my investigation.

Bronfenbrenner’s bioecological framework also aligns with other frameworks, relevant to the field of mathematics and the context of the dissertation. At the microsystem level, the framework aligns with previous work around Teaching mathematics for understanding. The theory is based on the assumption that children build a better understanding of mathematics when they are given time to develop their own strategies, reflect on their own thinking, and articulate their own ideas by sharing with adults and other children (Carpenter, Fennema, Franke, Levi, & Empson, 2015; Carpenter & Lehrer, 1999; Hiebert & Carpenter, 1992). In
particular, I was attentive to evidence of children being positioned and empowered as young mathematicians. At the macrosystem level, the framework aligns with *Teaching for social justice* and the “sociopolitical turn” (Gutiérrez, 2013, p.37) in mathematics education endorsed by researchers to address inequitable educational opportunities throughout the United States (Gay, 2001; Gutstein, 2003; Ladson-Billings, 1997; Gutiérrez, 2013; Rubel, 2017). My dissertation sought to highlight the voices of Head Start teachers and families, to contribute to a better understanding of the phenomenon and avoid unintended consequences that could reinforce inequitable educational opportunities among young children.

2.2  **Review of Literature**

2.2.1  **Overview of Early Childhood Education**

Early childhood is a decisive stage in the life of children, as they develop their physical, socio-emotional, and cognitive abilities at a fast pace. As mandatory public education starts once children are five years old in the United States, learning experiences and opportunities vary drastically among young children. Some may be enrolled prior to Kindergarten in part-time or full time, private-funded or public-funded programs, joining daycare centers at infancy or preschools at the age of three. Others may remain and learn at home until they start Kindergarten. In other words, access to early childhood education (ECE), and the quality of care, differs depending on families’ values and incomes. For instance, according to US Census Bureau, 66 percent of four-year-old children were enrolled in preschool; however, children from families with low incomes were less likely to be enrolled (Yoshikawa, Weiland, & Brooks-Gunn, 2016).
2.2.1.1 ECE in the U.S.

Access to universal ECE programs such as those often offered in Europe has historically been limited in the U.S., due for instance to a social value that mothers provide the best care at an early age and the subsequent ambivalence towards maternal employment (Cohen, 1996; Kamerman, 2006; Zigler, 2010). In other words, the endorsement of ECE does not only depend on its beneficial effect on children; much consideration is also taken in relation to its effect on our society (Nagasawa, 2019).

As the debate towards universal ECE still unfolds, consensus has been in the past half century to endorse ECE as an attempt to counter the effects of poverty. Indeed, children of families with low incomes have been described in the literature as growing up in a more stressful and hazardous environment due to uncertainties in parental employment, neighborhoods with higher crime rates, and low quality of childcare (e.g., Allee-Herndon & Roberts, 2019; Brooks-Gunn & Duncan, 1997; Engle & Black, 2008; Evans, 1997; Duncan, Magnuson, & Votruba-Drzal, 2014). The literature also highlights that parents facing poverty may have less time and resources to engage in educational activities (Duncan et al., 2014). Once mandatory school starts, additional factors such as historical segregation—both economic and racial—may extend the effect of poverty even further for children of color (Garcia & Weiss, 2014). The effects of poverty have been described as cumulative—the learning environments the child is exposed to first in the home, then in preschool, and later on during formal schooling all affect child development (Reimers, 2015).

While social and economic policies seem critical to restrain poverty, the literature suggests that access to high-quality ECE could, in the meantime, heighten educational opportunities for children from families with low incomes (e.g., Duncan, Ludwig, & Magnuson,
2007; Elango, Garcia, Heckman, & Hojman, 2015; Lamy, 2013) and better prepare them for school success and adulthood. For instance, evidence suggests that the gap of learning opportunities among children at the age of three due to families’ income could be eliminated by either universal ECE or programs based on income (Duncan & Sojourner, 2013). Two longitudinal studies spanning several decades, the Perry Preschool Project (PPP) and The Carolina Abecedarian Project are often cited in view of poverty. The Perry Preschool Project (PPP) was developed in the 1960s as an intervention offered to African American children living in poverty. A follow-up study reported, for instance, a higher level of schooling completed and higher monthly earnings for the PPP participants compared to the control group at age 27 (Schweinhart, Barnes, & Weikart, 1993). The Carolina Abecedarian Project (CAP) provides another example (Campbell, Ramey, Pungello, Sparling, & Miller-Johnson, 2002). Data from participants at age 21 showed a higher percentage of people enrolled in college/university among CAP participants compared to the control group. Although participants in these studies may not be fully representative of children living in poverty, as selection criteria included learning abilities as well (Zigler, 2010), it is worth noting that both PPP and CAP projects implemented a high-quality program in terms of emotional support, structure, and instruction, that appears critical in reducing the effect of poverty (Yoshikawa et al., 2016). In other words, access to ECE is not enough; children facing educational challenges due to poverty must have access to high-quality ECE.

Studying ECE in view of poverty is arduous as researchers must acknowledge the challenges of poverty without falling into a deficit model. On one hand, focusing on what people with low incomes may not have or may not do (Smit, 2012) may reinforce biases already in place in our society. Gorski (2012), for instance, warned against the “culture of poverty” that emerged
in the 70s, switching from attributing poverty from structural conditions to individual characteristics (i.e., blaming the victims). Strengths-based studies have been reported in the literature, such as recognizing “Funds of Knowledge” families may bring (e.g. Moll, Amanti, Neff, & Gonzalez, 1992). On the other hand, ignoring individual challenges and systemic inequities due to low incomes may attenuate the complexity of the phenomenon (Lubienski, 2003). For instance, the endorsement of Funds of Knowledge must be accompanied with the acknowledgment of social inequities (Rios-Aguilar, Kiyama, Gravitt, & Moll, 2011). Therefore, social responsibility towards the studied communities should be seen as an ethical principle for early childhood researchers (Bertram, Formosinho, Gray, Pascal, & Whalley, 2016). Head Start, a federal program with the potential to counter social inequities (Joshi, Geronimo, & Acevedo-Garcia, 2016; Sophian, 2004), provides a thoughtful strengths-based model to study ECE as it seeks to not only support young children living in poverty, but also empower their families (Bierman, Welsh, Heinrichs, Nix, & Mathis, 2015). Understanding the perspectives of Head Start participants and sharing their stories is therefore quite relevant to the field of ECE.

2.2.1.2 Early Childhood Education and the model of Head Start

Head Start was enacted as part of President Johnson’s “War on Poverty” legislation in 1962. Its creation was connected to the civil rights movement and a distrust in public schools to address racial and economic inequities (Nagasawa, 2019). Even though Head Start eventually stopped focusing on both promoting child development and societal change, the program was still developed as a partnership between the federal governments and families in poverty, with policy councils consisted of Head Start parents in order to empower families (Zigler, 2010). Built upon Bronfenbrenner’s framework (Brendtro, 2006; Zigler, 2010), Head Start focuses on the whole child and offers a wide range of services including early learning, medical and dental care,
social services, and family support (Barnett & Friedman-Krauss, 2016). As of today, Head Start serves around one million children across the U.S. and employs more than 40,000 teachers (Joshi et al., 2016; Kaplan & Mead, 2017). Nationally, 38.4% of children living in poverty are served by Head Start (Barnett & Friedman-Krauss, 2016). Around 75 percent of Head Start lead teachers have a bachelor’s degree or higher (Workman, Guernsey, & Mead, 2018). Initially focusing on the development of social competence, Head Start now focuses on school readiness (Barnett & Friedman-Krauss, 2016).

Head Start is a model of its kind. In one study, the interviews of 25 administrators and teachers from seven Head Start agencies provided insights from the field (Lubeck & Kezar, 2002). For instance, Head Start was perceived as an ecosystem that is “changing, adaptable and permeable” (p. 10), a team where “groups of people within the organization work collaboratively to make decisions and set policy” (p. 10), and a family with “individuals whose care and commitment make the program thrive” (p.11). Still, Head Start is not a homogenous entity, and variation can be found among programs and across states (Barnett & Friedman-Krauss, 2016). For instance, the percentage of eligible children who cannot be served due to a lack of funds varies across states (Joshi et al., 2016). Variation in funds also exists as each program are required to cover at least 20% of the approved program costs through non-federal funding, such as cash or services (Joshi et al., 2016). Finally, the quality of instruction, highlighted in the previous section as a critical element to reduce the effect of poverty, often differs among Head Start programs (Connors & Friedman-Krauss, 2017). For instance, Barnett and Friedman-Krauss (2016), using the Classroom Assessment Scoring System (CLASS®, Pianta, La Paro, & Hamre, 2008) to report quality of Head Start classroom instruction, identified only 10 states with an average score above the threshold recommended by research.
Mixed results have been reported regarding Head Start’s effectiveness towards children’s learning outcomes, and detractors have often emphasized the cost of Head Start in view of its short-term effects (Ludwig & Phillips, 2007). Although positive effects on cognitive domains such as vocabulary, letter-word identification, and spelling have been highlighted through the Head Start Impact Study led by the U.S. Department of Health and Human Services, most effects were reported to vanish by the end of first grade (Puma, 2010, 2012). A range of factors could explain these mixed results, including systemic inequities once children leave the program. For instance, the fade out effect was reported to be faster when children transitioned into schools identified as elementary schools with lower academic performance (Zhai, Raver, & Jones, 2012). The poverty of the neighborhood was also described as a mediator of the effect of Head Start on school readiness (Morrissey & Vinopal, 2018). Biases in methods have also been reported to counter argue the lack of effectiveness (Shager, Schindler, Magnuson, Duncan, Yoshikawa, & Hart, 2013). For instance, the study design should not involve a comparison with settings serving children from families with higher incomes, but rather a comparison with the educational setting Head Start children would otherwise experience (e.g., home care, low-quality childcare; Kline & Walters, 2016). Aligning with such study, Head Start children living in low-income neighborhoods have been shown to score higher on reading and mathematics assessments than their neighborhood peers who did not access Head Start (Pigott & Israel, 2005).

Results on mathematics assessments seem even more important to point out as early mathematics has been reported as a predictor of later school achievement (Duncan et al., 2007). As early mathematics research has strongly emerged in the past decades (Clements, Sarama, & DiBiase, 2004; Day-Hess & Clements, 2017; National Research Council, 2001), studying early mathematics through the lens of Head Start would provide relevant insights to the field, as the
model takes in consideration the child, but also his/her/their exposure to various “circles of influence” (p. 163, Brendtro, 2006) in the school and the home environments.

2.2.2 Early mathematics

The relevance of exposing young children to early mathematics has been well established in the literature. In fact, Linder and Simpson (2018) showed a yearly increase in articles related to early mathematics of over 200% between 2005-2015, compared to 2000-2005, with 70% of articles focusing on children’s achievement in mathematics. The literature provides evidence of early mathematics content young children should be exposed to, that will be reviewed hereafter. As receiving support from school and home would have a “catalytic effect” on children’s mathematical thinking (National Research Council, 2001, p. 411), I will discuss early mathematics in the contexts of the home and the classroom.

2.2.2.1 Early mathematics content

Multiple books have been published in the field of early mathematics outlining the mathematical content researchers have deemed meaningful for young children to explore and the activities in which students should engage to access and learn the content (e.g. Carpenter, Franke, Johnson, Turrou, & Wager, 2016; Clements & Sarama, 2014; Erikson Institute, 2014). As presented in Figure 2.1., early mathematics content includes several areas that are numbers & operations, but also geometry & spatial sense, measurement, patterns & algebraic thinking, and data analysis (e.g., Clements & Sarama, 2004; Copley et al., 2007; Erikson Institute, 2014).
These content areas are briefly described hereafter. To build up their number sense, children should have numerous opportunities to count objects to meaningfully learn the word sequence of counting numbers, practice one-to-one correspondence, and understand cardinality (Carpenter et al., 2016; Clements & Sarama, 2004). In geometry, children should not only recognize but also compose and decompose shapes and understand spatial relationships (e.g., Clements & Sarama, 2004; Erikson Institute, 2014). Young children can develop their understanding of measurement through exploring measurement attributes, comparing and ordering items by their size, weight, capacity, etc. and exploring the process of measuring (e.g., Clements & Sarama, 2004; Copley et al., 2007). Algebraic thinking can be strengthened through recognizing patterns, extending them, and making predictions (e.g., Carpenter, Franke, & Levi, 2003; Clements & Sarama, 2004; Erikson Institute, 2014). Finally, data analysis should be
explored through sorting and classifying by using objects and pictures (e.g., Clements & Sarama, 2004; Erikson Institute, 2014).

As school becomes mandatory once a child is five years old in the U.S., the exposure to the aforementioned early mathematics concepts, and the subsequent learning in mathematics, depends on the child’s preschool experiences and home environment.

2.2.2.2 Early mathematics in the classroom

Approaches to early mathematics in the classroom have been widely reported in the literature. As mathematics learning arises from the young children’s daily life, teachers should guide and scaffold children to support their interests in early mathematics (Early Childhood STEM Working Group, 2017). Adult-guided and child-centered activities should be balanced to fully nurture the child’s learning in mathematics (Bassok & Latham, 2017; Fowler, 2017; NAEYC & NCTM, 2010). Although no Standards or curriculum to support early learning in mathematics have been universally endorsed across the U.S., several research-based curricula have been studied since 2000, such as Building Blocks (Sarama & Clements, 2004) or Big Math for Little Kids (Greenes, Ginsburg, & Balfanz, 2004). Both curricula build upon the need to offer young children challenging mathematical activities while being playful and developmentally appropriate, and provide a guide for teachers to being intentional in supporting the children’s learning in mathematics. Both are rated as high-quality curricula by the Head Start office (The National Center on Quality Teaching and Learning, 2015). Mathematics learning should be promoted through various modes of communication (e.g., discussion) and representation (e.g., drawing, graphing) (Early Childhood STEM Working Group, 2017). For instance, teachers can nourish children’s classroom experiences with thoughtful questions as they play (Clements & Sarama, 2014; Copley et al., 2007); provide them with engaging materials (e.g., unit blocks,
Clements & Sarama, 2014); facilitate meaningful mathematics discussions daily (Donoahue, 2016); and stimulate the children’s mathematical thinking (Ginsburg, 2016).

Despite the emergence of early mathematics research, literacy is still predominant in preschool classrooms compared to mathematics (Blevins-Knabe, Austin, Musun, Eddy, & Jones, 2000; Day-Hess & Clements, 2017; Ginsburg & Golbeck, 2004). Overall, preschool teachers usually spend less time in teaching mathematics, or limit their instruction to simple skills (Yoshikawa et al., 2016). Such observation may be amplified in the context of Head Start. Although the rise in Standards in the 2000s resulted in an increase in literacy instruction in Head Start classrooms from 2000 to 2009, the frequency of mathematics experiences offered to Head Start students remained unchanged during that time (Walter & Lippard, 2017). Also, classroom observations of 335 Head Start teachers showed no evidence of mathematics instruction for 50% of the teachers observed (Hindman, 2013). The endorsement of early mathematics is still evolving, though. For instance, an increase in time spent on math content has been observed in Head Start classrooms between 2007 and 2015, depending on the content and the type of activity (Markowitz & Ansari, 2020). For instance, no increase was observed regarding the time spent on counting, but the frequency of using geometric manipulatives increased. Also, the frequency of teacher-directed, small group activities increased between 2007 and 2015. In other words, the implementation of research-based early mathematics experiences in classrooms does take time.

Several factors may influence the presence of early mathematics in the classroom. First, teachers’ attitudes towards early mathematics affects both the exposure of young children to early mathematics in the classroom (Çelik, 2017) as well as the children’s attitudes towards early mathematics (Early Childhood STEM Working Group, 2017). An open-ended survey of 31 Head Start teachers showed that teachers’ mathematics anxiety influenced their instruction planning,
and teachers who were more confident in their mathematics knowledge planned to teach more mathematics in their classrooms (Geist, 2015). In addition, a study of 67 Head Start teachers also showed a higher self-efficacy in teaching literacy compared to mathematics (Gerde, Pierce, Lee, & Van Egeren, 2018). The teachers’ beliefs in education, and how early mathematics should be taught, are also a factor of influence. The interviews of 60 preschool teachers showed their preference of embedding early mathematics in their teaching throughout the day (Lee & Ginsburg, 2007a). The population of children served may also influence these approaches to teaching early mathematics. For instance, teachers serving children from families with low incomes reported a more goal-oriented instruction and a higher focus on literacy, that could be linked to their perception of the teacher’s critical role in school readiness (Lee & Ginsburg, 2007a, 2007b). Additional factors influencing the implementation of mathematics activities included, among others, children’s abilities to stay still during table activities, attention span and readiness level (Güven & Çolak, 2019). As emphasized by the Early Childhood STEM Working Group (2017), families also play a critical role in young children’s learning in early mathematics.

2.2.2.3 Early mathematics in the home

Numerous studies suggest a relationship between home numeracy and young children’s performance in mathematics (Kleemans, Peeters, Segers, & Verhoeven, 2012; Lefevre et al., 2009; Niklas, Cohrssen, & Tayler, 2016) and significant effort from the field of early mathematics research is ongoing to encourage parents to nurture mathematics learning at home (Berkowitz, Schaeffer, & Maloney, 2015; Day-Hess & Clements, 2017). Parents can use everyday situations to connect mathematical ideas to the children’s world, building up knowledge from children’s natural curiosity toward mathematics (Baroody & Wilkins, 1999). Games, books, and puzzles also often provide opportunities for parents and children to engage in
mathematics (Fisher, 2016; Kleemans et al., 2012; Lefevre et al., 2009). Similar to classroom settings, mathematics talk should be encouraged daily (Elliott, Braham, & Libertus, 2017; Levine, Suriyakham, Rowe, Huttenlocher, & Gunderson, 2010), and books can provide a meaningful context to do so (Anderson, 1997; Skwarchuk, 2009). Indeed, parents seem to naturally engage in various concepts of mathematics when provided with purposeful children’s literature (Anderson, 1997). Although studies focusing on home early numeracy have emerged strongly in the past decades, the field of ECE still needs to know more about Home Learning Environment (HLE) indicators that foster early mathematics (Galindo & Sonnenschein, 2015). Indeed, programs to guide families in early mathematics should build from home practices already in place to increase the chance that parents follow the recommendations of the programs (Sonnenschein, Metzger, Dowling, Gay, & Simons, 2016). Surveying 38 Head Start parents about their beliefs in early mathematics, Sonnenschein et al. (2016) reported that 85% of parents believed that doing math at home was important. However, there is a lack of research on understanding families' perspectives on what practices are working best for them as they engage their children in early mathematics.

As with preschool teachers, parents’ mathematical knowledge and attitude towards early mathematics influence the presence of early mathematics practices in the home. Parents may do less mathematics than literacy at home (Blevins-Knabe et al., 2000) as they often consider they do not have the mathematics knowledge to do so (van Voorhis, Maier, Epstein, & Lloyd, 2013). However, once they know how to support their child, parents are more willing to endorse early mathematics in the home (Starkey & Klein, 2000). Culture also influences mathematics practices, as early mathematics is not culturally neutral (Early Childhood STEM Working Group, 2017). For instance, the method of counting with fingers used in India differs from the U.S.
method (Guha, 2006). Finally, poverty has been described as a limiting factor, due, in part, to the limited time and resources for parents to engage in educational activities (Duncan et al., 2014). For instance, families with low incomes have been reported in the literature as initiating fewer discussions around mathematics as they read to their child (Vandermaas-Peeler, Nelson, Bumpass, & Sassine, 2009). Also, children in poverty have been described to less often (a) play games involving mathematics, (b) have mathematics as part of their home routine, or (c) read books with mathematics content (DeFlorio & Beliakoff, 2015). However, further investigation of the relationships between home numeracy and mathematics performance for children living in poverty is still needed (Elliott & Bachman, 2018). Learning more from the perspectives of families facing poverty is critical as both the quantity and the quality of home experiences could contribute to the variability in numerical knowledge observed in children from families with low incomes (Ramani, Rowe, Eason, & Leech, 2015).

Whether early mathematics is explored in the home or in the classroom, Developmentally Appropriate Practices (DAP) should be maintained (Day-Hess & Clements, 2017; Fowler, 2017). Indeed, these practices currently constitute a widespread framework in preschool settings around the United States (Brown & Lan, 2015), and early mathematics should be experienced in the respect of these practices.

2.2.3 Early mathematics in the context of Developmentally Appropriate Practices (DAP)

2.2.3.1 Overview of DAP

In 1987, the National Association for the Education of Young Children (NAEYC), concerned by the rise in academics in early childhood settings, issued a statement to promote teaching practices that would be appropriate for a young child. Initially focusing on child development (Bredekamp, 1987), DAP have evolved over the years to endorse the influence of
the child’s cultural contexts (Bredekamp & Copple, 1997), and include the intentional decisions adults make to guide children’s learning (Copple & Bredekamp, 2009; Epstein, 2014; NAEYC, 2009). The latest version (NAEYC, 2020), emphasized the core consideration that development and learning are deeply influenced by social, cultural, and historical contexts. That is, all contexts should be considered—the context of the child, but also those of the family, the educator, the school setting, the community, etc. The updated version seeks to step away from a dominant cultural narrative contributing to sustaining inequities and to establish partnerships with families and communities. The practices must be “culturally, linguistically, and ability appropriate for each child” (NAEYC, 2020, p.5). Because of their focus on the individuality of the child and the influence of contexts, DAP are arduous to define. In the context of the present dissertation, I focus on three critical elements (NAEYC, 2020): (a) the endorsement of child development (i.e., the recognition of patterns in child development as well as the uniqueness of each child); (b) the influence of contexts—social and cultural—on children’s learning; and (c) the intentional teaching and scaffolding children receive from adults to grow emotionally and cognitively. These elements of DAP can be embedded into Bronfenbrenner’s framework. Indeed, child development can be related to the microsystem, through the activities experienced by the child either at home or at school; intentional teaching aligns with the microsystem as well as the mesosystem through the interrelations between the home and the school; while the contexts of learning unfold through all systems.

Widely implemented in preschool settings, DAP are often used as an indicator of a high-quality classroom environment. The Early Childhood Environment Rating Scale (ECERS, Revised edition, Harms, Clifford, & Cryer, 2014), commonly used in the field of early childhood education, are built upon these practices. Also, the Creative Curriculum® (Copley et al., 2007)
often adopted in childcare programs, also endorse DAP. Although DAP primarily target school settings, their implications should be extended to families, as evidence of scaffolding, positive relationships between adults and child, and social and cultural contexts—all aligning with the NAEYC statements—exist at home too. However, fewer studies have focused on DAP in the home, and ambiguous messages from parents seem to emerge from the literature. For instance, parents may support DAP in classrooms but also expect the use of didactic methods in literacy and mathematics (Holloway, Rambaud, Fuller, & Eggers-Pkirola, 1995). Also, a qualitative study involving Latinx families whose children attended a state-funded preschool program showed that participants endorsed, in addition to school readiness, critical elements of DAP such as the school’s focus on the socio-emotional development of their children and the incorporation of parents within the school (Ansari, Pivnick, Gershoff, Crosnoe, & Orozco-Lapray, 2020). Additional studies to understand families’ standpoints on DAP in the context of early mathematics are needed.

2.2.3.2 Endorsing early mathematics and DAP

Despite initial concerns in the field of ECE that a rise in academic content would be developmentally inappropriate for young children, early mathematics and DAP are now seen as not exclusive as long as a balance can be found (Day-Hess & Clements, 2017; Fowler, 2017; NAEYC & NCTM, 2010). However, several factors affect the balance in preschool classrooms and in the home.

On one hand, the field of ECE has historically endorsed a child-centered approach and shown resistance to academic learning, including early mathematics (Hachey, 2013; Sarama & Clements, 2017). For instance, the study of a professional development program to promote early mathematics in Head Start classrooms reported that mathematics concepts were more likely to be
included if they could be implemented in activity centers (Brendefur, Strother, Thiede, Lane, & Surges-Prokop, 2013), commonly available to young children throughout the day in child-centered classrooms. Even though DAP now include intentional teaching and teacher-directed activities, the switch has not been obvious in the field (Fowler, 2017). Finally, quality scales, such as the Early Childhood Environment Rating Scale (ECERS, Revised edition, Harms, Clifford, & Cryer, 2014) does not always recognize the use of teacher-directed instruction.

On another hand, the emergence of standards in mathematics in lower elementary grades has influenced teachers’ and parents’ beliefs about school readiness. For instance, counting to 20 was considered an essential component of kindergarten readiness for a higher proportion of both kindergarten teachers and parents in 2010 compared to 1998 (Bassok et al., 2016). The rise in standards, however, has been associated with an increase in school accountability and mandatory assessments, often considered developmentally inappropriate (Bassok et al., 2016; Stipek, 2006). In other words, early mathematics may be endorsed, but to the detriment of DAP.

Such conundrum seems all the more probable in the context of poverty. Indeed, children from families with low incomes would likely benefit the most from exposure to early mathematics content (Clements & Sarama, 2011; Duncan et al., 2007). But they also have a higher chance to experience developmentally inappropriate practices when school accountability increases (Bassok et al., 2016; Walter & Lippard, 2017). Some curricula targeting children in poverty have also been described as developmentally inappropriate in the context of early mathematics (Parks & Bridges-Rhoads, 2012), due to the limited time dedicated to early mathematics, and the focus on rote memorization rather than children’s thinking. Head Start, in particular, could experience the following problematic outcome: the program’s focus on school readiness (Pigott & Israel, 2005; Walter & Lippard, 2017) could lean the balance away from
DAP due to an increase in accountability while the teachers’ ambivalent attitudes towards mathematics (Sophian, 2004) and the lack of daily exposure to early mathematics content such as geometry or measurement (Markowitz & Ansari, 2020) could tilt the balance away from mathematics. Investigating balanced mathematics practices in the context of Head Start, especially those aligning with Head Start’s common emphasis on literacy (Walter & Lippard, 2017) is particularly relevant.

### 2.2.4 Endorsing early mathematics and DAP via book reading

A strategy to endorse both early mathematics and DAP consists of integrating mathematics with literacy (NAEYC & NCTM, 2010). Reading high-quality picturebooks, a critical practice to support young children in the development of their reading skills (International Reading Association & National Association for the Education of Young Children, 1998; National Early Literacy Panel, 2008), seems particularly promising as the practice could be endorsed in the context of both the school and the home. Book reading should go beyond reviewing math concepts to also support mathematics processes such as mathematics discourse and representation, connections among mathematical ideas, and problem solving (Flevares & Schiff, 2014).

Positive effects of exploring early mathematics through picturebooks have been described in the literature. For instance, reading two mathematics-related content picturebooks weekly for three months was found to have a positive effect on Kindergartners’ mathematics performance (van den Heuvel-Panhuizen & van den Boogaard, 2008). Also, a ten-week curriculum, *Booked on Math*, involving interactive read-alouds and follow up lessons around early mathematics was associated with higher score on students’ learning in quantities, spatial relationships and shapes, as measured by the Teaching Strategies GOLD assessment (McGuire, Himot, Clayton, Yoo, &
Logue, 2021). In the context of Head Start, a dialogic reading intervention focusing on mathematical language through picturebook reading increased the mathematical language and knowledge of the participants. The intervention consisted of 15–20-minute sessions, 2-3 times a week for 8 weeks, during which children were read one picturebook and asked mathematical language questions (Purpura, Napoli, Wehrspann, & Gold, 2017).

In addition to learning outcomes, several benefits in connecting mathematics with children’s literature have been suggested in the literature. First, books provide a meaningful context for young children to anchor their ideas in mathematics (Hong, 1996). Books also supply an emotional component and motivating context to learn mathematics (Flevares & Schiff, 2014; Hong, 1996) that can reduce mathematics anxiety (Furner, 2018). Books can also support mathematical thinking and discussions around mathematics (Dunphy 2020). Last, exploring early mathematics through book reading aligns with expert guidance around early mathematics, such as encouraging young children to communicate about mathematics ideas (National Council of Teachers of Mathematics, 2013) through scaffolding and various representations (Early Childhood STEM Working Group, 2017).

Finally, the literature provides guidance regarding picturebooks offering opportunities to support early mathematics. For instance, the National Council of Teachers of Mathematics published a critically annotated list of children’s books in mathematics (Thiessen & Matthias, 1998). The list provides a summary of each book, its usefulness in teaching mathematics, and the relevant grade level. More recently, the DREME network published a list of 40 children’s books to foster positive attitudes towards early mathematics (Development and Research in Early Math Education, 2019). Also, the Mathematics Sciences Research Institute distributes a Mathematical
Book Prize to recently published picturebooks fostering curiosity towards early mathematics (Mathematics Sciences Research Institute, 2021).

Development of frameworks and guides to select relevant picturebooks to support mathematics learning has also been reported in the literature, taking into account the presence of mathematics opportunities, but also the overall quality of the book (e.g. Halsey, 2005; Marston, 2010; van den Heuvel-Panhuizen & Elia, 2012). Indeed, mathematics picturebooks should be, first of all, high-quality picturebooks (Whitin, 2001), to avoid sending a negative image of mathematics and demotivating young learners (Nesmith & Cooper, 2010). In other words, general criteria to select high-quality picturebooks—an intriguing story plot, appealing illustrations, diverse representation of characters, etc., (Johnston, 2016)—should also be considered.

Numerous books have been written to guide practitioners in implementing mathematical activities following up a book reading. For instance, the *Math and Literature* book series provide samples of lessons based on children’s literature (Burns & Sheffield, 2004). Early mathematics can also be supported as picturebooks are read. Several studies have been pursued with preschool-age children, in both the classroom (Hojnoski, Polignano, & Columba, 2016; Jacobi-Vessels et al., 2016) and in the home (Barnes & Puccioni, 2017; Hojnoski, Columba, & Polignano, 2014). In the context of DAP, mixed results seem to emerge regarding the phenomenon of exploring early mathematics through book reading.

2.2.4.1 Benefits and obstacles associated with endorsing early mathematics and DAP via book reading

There are indeed several advantages to using picturebooks to explore mathematics with preschool-age children. First, the phenomenon aligns with the respect of child development at
the core of DAP. Indeed, reading picturebooks stimulate children’s engagement in mathematics (Hojnoski et al., 2014; Hojnoski et al., 2016; Jacobi-Vessels et al., 2016), aligning well with the child-centered philosophy of DAP. Second, DAP recognize various contexts of learning (i.e., social, cultural, historical) that can all be embraced through picturebooks. Derman-Sparks (2013) provides guidance to select anti-biased picturebooks that could be applicable to the field of early mathematics. Also, reading picturebooks is a practice commonly encouraged to be pursued in the classroom but also in the home, making the extension to early mathematics more likely to be endorsed by families (Sonnenschein et al., 2016). Finally, reading picturebooks provides a context to support mathematics learning through scaffolding and intentional teaching in both the home (Anderson et al., 2004) and preschool (Jacobi-Vessels et al., 2016). Read-alouds of picturebooks provide opportunities to informally engage in discussions around mathematics through the naturalistic context of the story for both families (Barnes & Puccioni, 2017; Hojnoski et al., 2014; Vandermaas-Peeler et al., 2009) and teachers (Hojnoski et al., 2016; Jacobi-Vessels et al., 2016).

However, several factors may interfere in maintaining a balance between early mathematics and DAP during book reading.

First, the content presented in mathematics picturebooks is often primarily reduced to counting, limiting the opportunities to embrace other early mathematics content areas. Indeed, a review of 52 picturebooks related to mathematics showed that 44.7 percent related to numbers & operations compared to 0.5 percent for Data Analysis (Yilmaz Genc, Akinci Cosgun, & Pala, 2017). Among counting books, mathematics concepts are often limited to numbers less than or equal to ten (Powell & Nurnberger-Haag, 2015). Also, mathematics picturebooks may lead to mathematical misconceptions. For instance, Nurnberger-Haag (2017) assessed 66 shape
picturebooks and reported that 76% of the picturebooks had at least one explicit inaccuracy. Similarly, Ward, Mazzocco, Bock and Prokes (2017) analyzed 120 counting books widely available; 48% of them had at least one inaccuracy between the number represented in the text compared to the pictures and 78% had at least one element that could distract the child from counting. Early mathematics can be found in general picturebooks as well. However, although guides to mathematize general picturebooks can be found in the literature (e.g. Hintz & Smith, 2013), the mathematics embedded in the story may be arduous to see and overlooked by the reader (Dunphy, 2020).

Second, the interactions between the reader and the child(ren) seem to play a critical role in the child’s exposure to early mathematics. Mathematical discourse may emerge more naturally with mathematics books (Anderson et al., 2004; Barnes & Puccioni, 2017; Hendrix, Hojnoski, & Missall, 2019), but even with a clear focus on mathematics, a picturebook may not be sufficient to stimulate young children’s mathematical thinking; prompts from the reader are necessary (Elia, van den Heuvel-Panhuizen, & Georgiou, 2010). However, high quality book reading, involving interactions between the reader and the child(ren) and questions of high-cognitive demand, should not be taken for granted. For instance, the coding of read-alouds from 96 preschool and Kindergarten teachers showed that, although 24% of the teachers utterances were questions, most of these questions were easy for children to answer (Deshmukh et al., 2019). Also, the analysis of teachers talks during read-alouds showed that 70% of the 98 preschool and Kindergarten teachers engaged children with low-cognitive demand topics (Zucker, Bowles, Pentimonti, & Tambyraja, 2021). These findings are worth noticing as child-adult interactions are critical to support learning (Wasik, Hindman, & Snell, 2016). Similar results have emerged from studies focusing on early mathematics. A study of 40 parents reading picturebooks revealed
that questions raised throughout read-alouds were often of low cognitive demand (Anderson, Anderson, Lynch, Shapiro, & Eun Kim, 2012). Also, videotape analysis of book reading from 700 randomly selected parent-child dyads showed an overall low quality of book reading (Barnes & Puccioni, 2017). Depending on the book and the reader-child dyad, the exposure to early mathematics will therefore differ (Anderson, Anderson, & Shapiro, 2005; Anderson et al., 2004; Hojnoski et al., 2016). For instance, the concept of size was discussed by the majority of 39 parents as they read *Mr. McMouse and Swimmy* to their 4-year-old child, while the concept of shape was discussed by only a few (Anderson et al., 2005).

Finally, the selection of the book seems critical to embrace both early mathematics and diverse social and cultural contexts of learning. When thoughtfully selected, picturebooks can act for young children as a reflection of themselves as well as a view to the world in which they live (Bishop, 1990), thereby empowering them and their identities. However, the overrepresentation of white, middle class, cisgender, and able-bodied characters in children’s literature (Koss, 2015) could reinforce the stereotype that mathematics is not for all. For instance, a review of 13 picturebooks about getting ready for the first day of kindergarten showed that only 50% included Latinx characters. Native Americans were not portrayed at all. Such lack of representation is even more stunning in the context of Head Start, which often serves populations who have been historically marginalized: 35% of children served by Head Start in North Dakota are Native American; 29% in North Carolina are Latinx (Barnett & Friedman-Krauss, 2016). In addition, making sure that all children are represented is not enough; one must also ensure that the diverse representation of characters does not reinforce stereotypes (Mendoza & Reese, 2001). Although these articles involved children’s literature of general content, one can expect a similar lack of representation in mathematics picturebooks.
2.2.5 Summary

In summary, book reading has the potential to support early mathematics in the context of DAP but reading practices and book selection can affect the exposure to early mathematics and the respect of the child’s uniqueness and own identities. The purpose of this dissertation is to fill a gap in the literature and better understand the phenomenon of exploring early mathematics through book reading in view of DAP. By focusing on the context of Head Start, this dissertation aims to quantitatively investigate the alignment of early mathematics and literacy practices with DAP in classrooms and homes of Head Start participants (Chapter 3) and to qualitatively report Head Start participants’ practices and standpoints regarding exploring early mathematics through picturebooks (Chapter 4). The perspectives of Head Start participants is rarely reported in the literature. Reporting their practices, experiences, and standpoints will not only provide evidence to better understand benefits and obstacles that families, teachers, and children may face as they explore early mathematics, but also new practices will emerge from the participants that will be important to investigate.

3.1 Introduction

Early childhood is a critical phase for human development. However, since formal school starts in the U.S. once the child is five years old, nurturing experiences supporting young children’s development vary depending on their surroundings and their home and school environments. Understanding these “circles of influence” (Brendtro 2006, p. 163) is critical to assure equitable opportunities to all children. The latest version of Developmentally Appropriate Practices (DAP, National Association for the Education of Young Children, 2020), a framework widely used in early childhood settings (Brown & Lan, 2015), recognizes these circles of influence and highlights especially the importance of cultural contexts on the child’s learning.

Although early childhood studies have often focused on early literacy, early mathematics (EM), reported as a strong predictor of later school achievement (Duncan et al., 2007), has brought a lot of attention in the past two decades (Hachey, 2013). However, a number of questions remain regarding factors that may affect young children’s exposure to EM, especially in view of DAP. In the present study, I investigated the phenomenon of exploring early mathematics through book reading, a strategy encouraged in the literature (NAEYC & NCTM, 2010) in view of the presence of DAP. This study builds upon Bronfenbrenner’s framework—a theoretical model recognizing the personal characteristics of the individual and the reciprocal influences between individuals and their environmental contexts (Bronfenbrenner & Morris, 2006)—and focuses on Head Start. The program and its strong connection between families and
schools make it an utmost model to investigate the phenomenon of interest, through various circles of influence.

3.2 Early Childhood Education (ECE) and the framework of Developmentally Appropriate Practices (DAP)

Early childhood is a fast-paced phase of development, highly influenced by learning experiences and nurturing environments. However, because access to universal Early Childhood Education (ECE) has been historically limited in the U.S. (Kamerman, 2006; Zigler, 2010), young children’s daily experiences varied drastically depending on various circles of influence. A first circle of influence would be the context of the home, and the interactions between the child and close family members, rooted in the family’s background and culture; another circle of influence would be the context of the school, and the exchanges the child engages with his/her/their teacher(s) and peers; and additional circles include higher levels of the society (e.g., values and laws) (Bronfenbrenner & Morris, 2006). The endorsement of these circles of influence is gaining momentum in ECE, as stated in the latest version of Developmentally Appropriate Practices (DAP, NAEYC 2020). Initially focusing on child development (Bredekamp, 1987), DAP have evolved over the years to endorse the influence of the child’s cultural context (Bredekamp & Copple, 1997) and intentional teaching (Copple & Bredekamp, 2009). The latest version (NAEYC, 2020) took a step further, emphasizing that all social, cultural, and historical contexts should be considered—the context of the child, but also those of the family, the educator, the school setting, the community, etc. When investigating DAP, it is therefore critical to consider its three core components: child development, contexts of learning, and intentional teaching. The DAP framework has been widely spread in U.S. settings and beyond (Brown & Lan, 2015), and has evolved with the rise in academics in early childhood
education. For instance, a consensus has been found to support early mathematics while maintaining DAP (Clements et al., 2017; Fowler, 2017).

3.3 The emergence of early mathematics

Research around early mathematics has strongly emerged in the past couple of decades (Day-Hess & Clements, 2017; National Research Council, 2001). Young children should have access to various early mathematics content areas, including numbers & operations, but also geometry, measurement, patterns & algebraic thinking, and data analysis (e.g., Clements & Sarama, 2004; Copley et al., 2007; Erikson Institute, 2014). These experiences should be offered in the classroom and in the home. In the classroom, teachers’ practices should support children’s interests in early mathematics through scaffolding (Early Childhood STEM Working Group, 2017), providing a balance of adult-guided and child-centered activities (Bassok & Latham, 2017; Fowler, 2017; NAEYC & NCTM, 2010). Practices should also include mathematical questions, raised as children play (Clements & Sarama, 2014; Copley et al., 2007). Although no universal curriculum to support early learning in mathematics has emerged across the U.S., curricula describing early mathematics practices exist. For instance, the Creative Curriculum® offers goals and objectives of mathematics learning and guidance to integrate mathematics throughout the day through child-initiated learning and teacher-guided instruction (Copley et al., 2007). Home practices should nourish young children’s natural curiosity towards mathematics (Baroody & Wilkins, 1999). Practices for young children to engage in mathematics with their family include games, books, and puzzles (Fisher, 2016; Kleemans, Peeters, Segers, & Verhoeven, 2012; Lefevre, Kwarchuk, Smith-Chant, Fast, Kamawar & Bisanz, 2009). Finally, practices include discussions around mathematics that should be encouraged daily (Elliott et al., 2017; Levine et al., 2010).
3.4 Exploring early mathematics through literacy.

A strategy to explore early mathematics involves literacy (NAEYC & NCTM, 2010). Book reading could indeed provide a reassuring starting point for adults to engage with young children around early mathematics (Furner, 2018), as adults’ negative attitudes towards mathematics have been described in the literature as a limiting factor for young children to engage with early mathematics in the home (Blevins-Knabe et al., 2000; van Voorhis et al., 2013) and in the school (Geist, 2015). Such strategy also ties well with literacy still being predominant compared to mathematics in preschool classrooms (Day-Hess and Clements 2017) and in the home (Blevins-Knabe et al., 2000). Finally, building up literacy and numeracy skills has been recommended to be pursued simultaneously (Munn, 1994) and relationships between literacy and numeracy activities have been reported in the literature. For instance, a study of 183 rising kindergartens in Canada showed a correlation (.46) between informal literacy activities (book exposure) and informal numeracy activities (game exposure) (Skwarchuk, Sowinski, and LeFevre 2014). A correlation was also found between parent-child literacy activity and parent-child numeracy activities among 60 kindergartners in the Netherlands (Segers, Kleemans, & Verhoeven, 2015). In other words, one can envision children who are exposed to early literacy in the home being exposed to early mathematics as well. In addition, books provide meaningful contexts for young children to anchor their learning in mathematics (Hong, 1996) through discussions around mathematics (Dunphy 2020). Several studies have described early mathematics learning that has occurred as books are read to preschool-age children, in both the classroom (e.g. Hojnoski et al., 2016; Jacobi-Vessels et al., 2016) and in the home (Barnes & Puccioni, 2017; Hojnoski et al., 2014).
However, little is known about how the phenomenon of exploring early mathematics through book reading could be leveraged from practices already in place in the home and in the classroom. In addition, in the context of DAP, mixed results seem to emerge as the phenomenon could be associated with both benefits and obstacles. Book reading aligns well with the child-centered philosophy of DAP, and their attention to child development, as books can stimulate children’s engagement in mathematics (Hojnoski et al., 2014; Hojnoski et al., 2016; Jacobi-Vessels et al., 2016) and children’s natural curiosity towards early mathematics (Baroody & Wilkins, 1999). Also, book reading aligns with the notion of intentional teaching promoted with DAP as books provide a context to scaffold and support mathematics learning in both the home (Anderson et al., 2004) and the school (Jacobi-Vessels et al., 2016). Nevertheless, the evolution of the DAP framework has often been unrecognized in the field (Fowler, 2017), making the literature unclear about how the phenomenon of exploring early mathematics through book reading would align with all current elements of the DAP framework—child development, contexts of learning, and intentional teaching. In particular, to my knowledge, no studies position the phenomenon in view of cultural contexts of learning, a critical component highlighted in the latest DAP statement. The current study fills that void by providing the field of ECE with a better understanding of the pros and cons of exploring early mathematics though book reading, in view of home and school practices in place, and the presence of DAP.

3.5 The present study

The goal of the present study is to examine the phenomenon of exploring early mathematics through book reading in view of home and school practices, and all components of DAP (i.e., child development, intentional teaching, and cultural contexts). The study lays on Bronfenbrenner’s bioecological framework (Bronfenbrenner & Morris, 2006), a model
recognizing the personal characteristics of the individual, the reciprocal influences between individuals and their environmental context, and the effect of time on changes occurring among individuals and their environment. The study focused on Head Start participants, as the program’s strong connection between families and schools makes it an ideal model to investigate a phenomenon through various circles of influence. The research question that guided my exploratory study was: Are there relationships between the early mathematics experiences Head Start children are offered, their exposure to book reading, and the presence of DAP?

3.6 Material and methods

3.6.1 Data set and participants

The investigation was performed using the Head Start Family and Child Experiences Survey (FACES, 2006) dataset, a measurement tool using representative samples of Head Start programs, centers, classrooms, families, and children. Its nested design allowed for data analyses of various levels of Bronfenbrenner’s framework (2006), through multi-level model analyses (Raudenbush & Bryk, 2002). Data included surveys of parents, teachers, and administrators, classroom observations, and child assessments. I created a subset of the FACES 2006 dataset to include children who attended a school-based Head Start for two years, their families, and their Head Start teachers. The subset included 40 programs, 62 centers, 325 classrooms, and 1,179 children and their families. Data were collected in the fall 2006, spring 2007 and spring 2008, and comprised 3,537 observations. Demographics reported 49.1% of the children as female and 50.9% as male; 18.8% as white, 35.8% as African American, 37% as Latinx, 1.1% as American Indian or Alaska Native, 1.6% as Asian or Pacific Islander, 4.6% as Multi-racial/Bi-racial, and 1% as other race.
3.6.2 Selection of variables

Several variables were selected from the FACES (2006) dataset to investigate early mathematics experiences Head Start children were offered, their exposure to book reading, and the presence of DAP in the context of the home and the classroom. The variables, presented in Table 3.1., came from either the teachers’ (classroom context) or parents’ (home context) surveys. These variables are presented in further details hereafter.

Table 3.1. Selection of variables

<table>
<thead>
<tr>
<th>Early mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numbers &amp; operations</td>
</tr>
<tr>
<td>In the classroom, children work with counting manipulatives weekly</td>
</tr>
<tr>
<td>In the home, children play counting games or read a book about numbers weekly.</td>
</tr>
<tr>
<td>Geometry</td>
</tr>
<tr>
<td>In the classroom, children work with geometric manipulatives weekly.</td>
</tr>
<tr>
<td>Measurement</td>
</tr>
<tr>
<td>In the classroom, children work with measuring instruments weekly.</td>
</tr>
<tr>
<td>Book reading</td>
</tr>
<tr>
<td>In the classroom, children were read to daily.</td>
</tr>
<tr>
<td>In the home, children were read to daily.</td>
</tr>
<tr>
<td>In the classroom, children were read to weekly.</td>
</tr>
<tr>
<td>In the home, children were read to weekly.</td>
</tr>
</tbody>
</table>
Table 3.1.  Continued

<table>
<thead>
<tr>
<th>DAP</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Child development</td>
<td>In the classroom, one strength of the curriculum was being developmentally appropriate.</td>
</tr>
<tr>
<td></td>
<td>In the home, parents stated “I encourage my child to be curious, to explore, and to question things.”</td>
</tr>
<tr>
<td>Cultural contexts of learning</td>
<td>In the classroom, one strength of the curriculum was being culturally sensitive.</td>
</tr>
<tr>
<td></td>
<td>Someone in the family talked with the child about his/her/their family history or ethnic heritage in the past month.</td>
</tr>
<tr>
<td>Intentional teaching</td>
<td>In the classroom, one strength of the curriculum was addressing early literacy and/or early mathematics.</td>
</tr>
<tr>
<td></td>
<td>Someone in the family taught the child letters, words, or numbers in the past week.</td>
</tr>
</tbody>
</table>

3.6.2.1 Early mathematics experiences children were offered

I focused on weekly early mathematics experiences offered in both contexts of the home and the school. I selected 4 variables: two related to numbers & operations (Children worked with counting manipulatives weekly in the classroom; Children played counting games or read books about numbers weekly in the home), one related to geometry (Children worked with geometric manipulatives weekly in the classroom), and one related to measurement (Children worked with measuring instruments weekly in the classroom). To represent a weekly frequency of exposure to early mathematics content, I created 4 binomial variables (0: no; 1: yes), from the original Likert-scale variables (Never [0]; Once a month or less [0]; Once or twice a week [1]; Two or Three times a week [1]; Three or four times a week [1]; Every day [1]).

3.6.2.2 Exposure to book reading

I also selected variables to assess the frequency children were read to in the classroom and in the home. For both contexts, I investigated two frequencies of being read to, that were either daily or at least weekly.
I first created a binomial variable to investigate a frequency of being read to at least weekly in the classroom (0: no; 1: yes) from the original Likert-scale variables (Never [0]; Once a month or less [0]; Once or twice a week [1]; Two or Three times a week [1]; Three or four times a week [1]; Every day [1]). I also created another binomial variable to investigate a frequency of being read to daily in the classroom (0: no; 1: yes) from the original Likert-scale variables (Never [0]; Once a month or less [0]; Once or twice a week [0]; Two or Three times a week [0]; Three or four times a week [0]; Every day [1]).

Similarly, I created a binomial variable to investigate a frequency of being read to in the home at least once in the past week (0: no; 1: yes) from the original Likert-scale variables (Not at all [0]; Once or twice [1]; Three or more times, but not every day [1]; Every day [1]). I also created a binomial variable to investigate a frequency of being read to in the home daily in the past week (0: no; 1: yes) from the original Likert-scale variables (Not at all [0]; Once or twice [0]; Three or more times, but not every day [0]; Every day [1]).

3.6.2.3 Presence of DAP

Although the dataset did not include variables that explicitly focused on the presence of DAP, I selected several variables (see Table 3.1.) providing evidence of potential attention to (a) child development, (b) cultural contexts of learning, and (c) intentional teaching.

The attention to child development in the classroom was assessed through a variable stating that, according to the teachers’ surveys, one strength of the curriculum was being developmentally appropriate (i.e., aligned with child development; 0: no; 1: yes). In the context of the home, parents reported their agreement to the following statement in their surveys “I encourage my child to be curious, to explore, and to question things.” This statement was considered to align with child development as it acknowledges the child as an individual (Copple

Attention to the cultural context of learning in the classroom was assessed through the creation of a new variable, based on the teacher’s indication that one strength of the curriculum was being culturally sensitive (0: no; 1: yes). Another variable was selected to assess the cultural context of learning in the home. Parents indicated whether someone in the family talked with the child about their family history or ethnic heritage in the past month (0: no; 1: yes).

Finally, a new variable was created to assess the attention to intentional teaching in the classroom, based on the teacher’s report that one strength of the curriculum was addressing early literacy and/or early mathematics (0: no; 1: yes), with the assumption that a curriculum addressing early literacy and/or early mathematics would provide support for teachers to being intentional throughout the day in their teaching i.e. providing samples of activities and examples of questions to raise to support children’s learning. In the context of the home, parents reported whether someone in the family taught the child letters, words, or numbers in the past week (0: no; 1: yes), as an indicator of intentional teaching of academic concepts for the child in their home.

3.6.3 Analysis plan

The research question was investigated through multi-level models (i.e., statistical models where units can be analyzed at more than one level, Hawkins et al., 2001; Neupert et al., 2007; Raudenbush & Bryk, 2002). To provide a wide overview of relationships between early mathematics experiences Head Start children were offered, their exposure to book reading, and the presence of DAP, several models were run, but a generic explanation is provided hereafter.
A preliminary analysis (null model, Nezlek, 2012) was performed to describe the total variance in the odds of being offered mathematics experiences at level 1 (within children; i.e., across the two years they attended the Head Start program) and level 2 (between children). Because of the dichotomous element of the outcome variable, a transformation (logit function) was applied to achieve normality and reduce heteroscedasticity (Maas & Hox, 2005).

\[
\text{Logit } EM_{it} = \beta_{0it} + r_{it} \quad \text{(Null model)}
\]

\[
\beta_{0i} = \gamma_{00} + u_{0i}
\]

The outcome EM represents the odds of a child being offered mathematics experiences, that involved: (a) working with counting manipulatives weekly in the classroom, (b) playing counting games or reading a book about numbers in the past week in the home, (c) working with geometric manipulatives weekly in the classroom, and (d) working with measuring instruments weekly in the classroom. Also, \(t\) represents timepoints of data collection (i.e., Fall 2006, Spring 2007, Fall 2009); \(i\) represents individual children; \(\beta_{0i}\) represents the mean odds of being offered mathematics experiences for child \(i\); \(r_{it}\) represents a unique effect associated with child \(i\) (i.e., the deviation from the child means); \(\gamma_{00}\) is the mean odds of being offered mathematics experiences for all children; and \(u_{oi}\) is the deviation from the sample mean.

One-way ANCOVA with random effects models were performed to investigate the relationships between the odds of being offered mathematics experiences and the exposure to book reading.

\[
\text{Logit } EM_{it} = \beta_{0it} + \beta_{1it} \text{(Reading)} + r_{it}
\]

\[
\beta_{0it} = \gamma_{00} + u_{0i}
\]

\[
\beta_{1i} = \gamma_{10}
\]
\(\beta_{0i}, r_{it}, \gamma_{00}\) and \(u_{oi}\) are described above; \(\beta_{1it}\) represents the expected change in the odds of being offered early mathematics experiences associated with the exposure to book reading (daily or weekly); \(\gamma_{10}\) represents the within-children relationship between the odds of being offered mathematics experiences and the exposure to book reading (i.e., the odds ratio of being offered mathematics experiences when children are read to, either daily or weekly).

The presence of DAP was then added to the model to investigate the relationships between the odds of being offered mathematics experiences and the presence of DAP.

Logit \(EM_{it} = \beta_{0it} + \beta_{1it} \text{(Reading)} + \beta_{2it} \text{(DAP)} + r_{it}\)

\(\beta_{0it} = \gamma_{00} + u_{0i}\)

\(\beta_{1i} = \gamma_{10}\)

\(\beta_{2i} = \gamma_{20}\)

\(\beta_{0i}, r_{it}, \gamma_{00}, \beta_{1it}, \gamma_{10}\) and \(u_{oi}\) are described above; \(\beta_{2it}\) represents the expected change in the odds of being offered early mathematics experiences associated with the presence of DAP; \(\gamma_{20}\) represents the within-children relationship between the odds of being offered mathematics experiences and the presence of DAP (i.e., the odds ratio of being offered mathematics experiences in the presence of DAP).

3.7 Results

3.7.1 Descriptive statistics

Descriptive statistics related to the early mathematics experiences that Head Start children were offered, their exposure to book reading, and the presence of DAP are presented in Table 3.2.
Table 3.2. Descriptive statistics related to early mathematics experiences, the exposure to book reading and the presence of DAP (n = 1,179).

<table>
<thead>
<tr>
<th>Early mathematics experiences</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Counting</strong></td>
<td></td>
</tr>
</tbody>
</table>
| In the classroom, children work with counting manipulatives weekly. | Yes 85.7%  
|                             | No 14.3%   |
| In the home, children play counting games or read a book about numbers weekly. | Yes 87.4%  
|                             | No 12.6%   |
| **Geometry**                 |   |
| In the classroom, children work with geometric manipulatives weekly. | Yes 96.8%  
|                             | No 3.1%    |
| **Measurement**              |   |
| In the classroom, children work with measuring instruments weekly. | Yes 82.1%  
|                             | No 17.9%   |

<table>
<thead>
<tr>
<th>Exposure to book reading</th>
<th>%</th>
</tr>
</thead>
</table>
| In the classroom, children were read to daily. | Yes 87.6%  
|                             | No 12.4%   |
| In the home, children were read to daily. | Yes 32.1%  
|                             | No 67.9%   |
| In the classroom, children were read to at least weekly. | Yes 96.3%  
|                             | No 3.6%    |
| In the home, children were read to at least weekly. | Yes 91.7%  
|                             | No 8.3%    |

<table>
<thead>
<tr>
<th>DAP</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Child development</strong></td>
<td></td>
</tr>
</tbody>
</table>
| In the classroom, one strength of the curriculum was being developmentally appropriate. | Yes 49.7%  
|                             | No 50.3%   |
| I encourage my child to be curious, to explore, and to question things. | Exactly 46.1%  
|                             | Very much 38.7%  
|                             | Somewhat 15.2%  
|                             | Not much -   |
|                             | Not at all - |
| **Cultural contexts of learning** |   |
| In the classroom, one strength of the curriculum was being culturally sensitive. | Yes 30.8%  
|                             | No 69.2%   |
| Someone in the family talked with the child about his/her/their family history or ethnic heritage in the past month. | Yes 45.1%  
|                             | No 49.4%   |
| **Intentional teaching**     | % |
| In the classroom, one strength of the curriculum was addressing early literacy and/or early mathematics. | Yes 52.2%  
|                             | No 47.8%   |
| Someone in the family taught the child letters, words, or numbers in the past week. | Yes 95.7%  
|                             | No 4.3%    |

At least 80% of the children were offered early mathematics experiences weekly, either in the classroom (counting manipulatives: 85.7%; geometry manipulatives: 96.8%; measuring instruments: 82.1%) or in the home (87.4%). Almost 90% of the children were read to daily in
the classroom while 32 % of the children were read to daily in the home. Over 90% of the children were read to weekly, either in the classroom or in the home.

The variable selected for attention to child development in the classroom showed that 49.7% of the teachers identified their curriculum as being developmentally appropriate. In the context of the home, about 50% of the parents strongly agreed with the statement “I encourage my child to be curious, to explore and to question things”. Regarding cultural contexts of learning, 30.8% of the teachers identified their curriculum as being culturally relevant. In the home, 45.1% of the parents reported that someone in the family talked with the child about his/her/their family history or ethnic heritage in the past month. Finally, regarding intentional teaching, 52.2% of the teachers identified their curriculum as addressing early literacy and/or early mathematics. In the home, 90.4% of the parents reported that someone in the family taught the child letters, words, or numbers in the past week.

3.7.2 Multi-level model results

The odds of being offered early mathematics experiences in the classroom or in the home, and the odds ratio of being offered early mathematics experiences when book reading occurred, or DAP were present are presented in Table 3.3. (classroom) and Table 3.4. (home).
Table 3.3.  *Odds of being offered mathematics experiences (classroom environment, each model included 3,537 observations).*

<table>
<thead>
<tr>
<th></th>
<th>Experiences in working with counting manipulatives weekly</th>
<th>Experiences in working with geometric manipulatives weekly</th>
<th>Experiences in working with measurement tools weekly</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Null models</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed effects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\gamma_{00}$</td>
<td>9.43 (.10) **</td>
<td>45.74 (11.63) **</td>
<td>7.57 (.69) **</td>
</tr>
<tr>
<td>Random effect</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\tau_{00}$</td>
<td>1.47 (.27)</td>
<td>.89 (.53)</td>
<td>1.93 (.30)</td>
</tr>
<tr>
<td><strong>ICC</strong></td>
<td>30.9%</td>
<td>21.3%</td>
<td>37.0%</td>
</tr>
<tr>
<td><strong>One-way ANCOVA with random effects models</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Experiences in working with counting manipulatives weekly</td>
<td>Experiences in working with geometric manipulatives weekly</td>
<td>Experiences in working with measurement tools weekly</td>
</tr>
<tr>
<td></td>
<td>At least weekly book reading</td>
<td>At least weekly book reading</td>
<td>At least weekly book reading</td>
</tr>
<tr>
<td><strong>Book reading (BR)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed effects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\gamma_{00}$</td>
<td>7.25 (1.35) **</td>
<td>2.55 (1.15) *</td>
<td>47.50 (12.36) **</td>
</tr>
<tr>
<td>$\gamma_{10}$</td>
<td>1.34 (.24)</td>
<td>1.39 (.42)</td>
<td>3.39 (.40) **</td>
</tr>
<tr>
<td>Random effect</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\tau_{00}$</td>
<td>1.46 (.28)</td>
<td>.89 (.53)</td>
<td>1.82 (.29)</td>
</tr>
<tr>
<td><strong>Attention to child development. One strength of the curriculum was being developmentally appropriate</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed effects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\gamma_{00}$</td>
<td>7.71 (1.86) **</td>
<td>441.67 (501.1) **</td>
<td>67.06 (33.77) **</td>
</tr>
<tr>
<td>$\gamma_{20}$</td>
<td>.81 (.11)</td>
<td>.84 (.27)</td>
<td>3.38 (.59) **</td>
</tr>
<tr>
<td>$\gamma_{10}$</td>
<td>1.13 (.23)</td>
<td>.13 (.13) **</td>
<td>2.74 (1.41) **</td>
</tr>
<tr>
<td>Random effect</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\tau_{00}$</td>
<td>.48 (.30)</td>
<td>.44 (.30)</td>
<td>.63 (.29)</td>
</tr>
<tr>
<td><strong>Attention to cultural context of learning. One strength of the curriculum was being culturally sensitive</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed effects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\gamma_{00}$</td>
<td>6.28 (1.39) **</td>
<td>269.53 (297.99) **</td>
<td>38.56 (17.14) **</td>
</tr>
<tr>
<td>$\gamma_{20}$</td>
<td>1.35 (.20) *</td>
<td>7.44 (3.90) **</td>
<td>1.98 (.29) **</td>
</tr>
<tr>
<td>$\gamma_{10}$</td>
<td>1.35 (.20) *</td>
<td>7.16 (3.76) **</td>
<td>2.08 (.31) **</td>
</tr>
</tbody>
</table>
Table 3.3. (continued)

<table>
<thead>
<tr>
<th></th>
<th>BR $\gamma_{10}$</th>
<th>1.13 (.23)</th>
<th>1.64 (.91)</th>
<th>.12 (.12) *</th>
<th>1 (omitted)</th>
<th>3.09 (.54) **</th>
<th>2.88 (1.49) *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random effect</td>
<td>$\tau_{00}$</td>
<td>.48 (.30)</td>
<td>.45 (2.42)</td>
<td>.76 (.93)</td>
<td>.94 (.99)</td>
<td>.60 (.29)</td>
<td>73 (.30)</td>
</tr>
</tbody>
</table>

Attention to intentional teaching. One strength of the curriculum was addressing early literacy and/or early mathematics

<table>
<thead>
<tr>
<th></th>
<th>Fixed effects</th>
<th>$\gamma_{00}$</th>
<th>5.75 (1.30) **</th>
<th>4.05 (2.34) *</th>
<th>355.34 (398.52) **</th>
<th>55.88 (26.77) **</th>
<th>1.63 (.29) **</th>
<th>1.74 (.95)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DAP $\gamma_{20}$</td>
<td>1.52 (.21) **</td>
<td>1.52 (.21) **</td>
<td>1.35 (.37)</td>
<td>1.33 (.37)</td>
<td>2.24 (.31) **</td>
<td>2.29 (.32) **</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BR $\gamma_{10}$</td>
<td>1.14 (.24)</td>
<td>1.58 (.89)</td>
<td>.13 (.13) *</td>
<td>1 (omitted)</td>
<td>3.27 (.59) **</td>
<td>2.73 (1.47)</td>
<td></td>
</tr>
</tbody>
</table>

Random effect

| $\tau_{00}$ | .54 (.31) | .51 (.31) | 1.14 (1.02) | 1.34 (1.08) | .81 (.32) | .97 (.34) |

* $p < .05$, ** $p < .01$. $\gamma_{00}$: mean odds of being offered mathematics experiences for all children; $\gamma_{10}$: within-children relationship between the odd of being offered mathematics experiences and the exposure to book reading; $\gamma_{20}$: within-children relationship between the odd of being offered mathematics experiences and the presence of DAP; $\tau_{00}$: between group variance. ICC: Intraclass Correlation Coefficient. The label “1 (omitted)” indicated the omission of the variable due to a dependency among the independent variables in the proposed model.
Table 3.4. Odds of being offered mathematics experiences (home environment, each model included 3,537 observations)

<table>
<thead>
<tr>
<th>Experiences in playing counting games or reading a book about numbers weekly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null models</td>
</tr>
<tr>
<td>Fixed effects</td>
</tr>
<tr>
<td>( \gamma_{00} )</td>
</tr>
<tr>
<td>Random effect</td>
</tr>
<tr>
<td>( \tau_{00} )</td>
</tr>
<tr>
<td>ICC</td>
</tr>
</tbody>
</table>

One-way ANCOVA with random effects models

<table>
<thead>
<tr>
<th>Daily book reading</th>
<th>At least weekly book reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Book reading</td>
<td></td>
</tr>
<tr>
<td>Fixed effects</td>
<td></td>
</tr>
<tr>
<td>( \gamma_{00} )</td>
<td>11.52 (1.59) **</td>
</tr>
<tr>
<td>BR ( \gamma_{10} )</td>
<td>2.96 (.51) **</td>
</tr>
<tr>
<td>Random effect</td>
<td></td>
</tr>
<tr>
<td>( \tau_{00} )</td>
<td>2.60 (.45)</td>
</tr>
<tr>
<td>Attention to child development. “I encourage my child to be curious, to explore, and to question things.”</td>
<td></td>
</tr>
<tr>
<td>Fixed effects</td>
<td></td>
</tr>
<tr>
<td>( \gamma_{00} )</td>
<td>2.80 (1.50)</td>
</tr>
<tr>
<td>BR ( \gamma_{10} )</td>
<td>2.75 (.61) **</td>
</tr>
<tr>
<td>DAP ( \gamma_{20} )</td>
<td>1.45 (.17) **</td>
</tr>
<tr>
<td>Random effect</td>
<td></td>
</tr>
<tr>
<td>( \tau_{00} )</td>
<td>2.58 (.70)</td>
</tr>
<tr>
<td>Attention to cultural context of learning. “Someone in the family talked with the child about his/her/their family history or ethnic heritage in the past month.”</td>
<td></td>
</tr>
<tr>
<td>Fixed effects</td>
<td></td>
</tr>
<tr>
<td>( \gamma_{00} )</td>
<td>8.10 (1.15) **</td>
</tr>
<tr>
<td>BR ( \gamma_{10} )</td>
<td>2.82 (.49) **</td>
</tr>
<tr>
<td>DAP ( \gamma_{20} )</td>
<td>2.15 (.32) **</td>
</tr>
<tr>
<td>Random effect</td>
<td></td>
</tr>
<tr>
<td>( \tau_{00} )</td>
<td>2.40 (.42)</td>
</tr>
<tr>
<td>Attention to intentional teaching. Someone in the family taught the child letters, words, or numbers in the past week.</td>
<td></td>
</tr>
<tr>
<td>Fixed effects</td>
<td></td>
</tr>
<tr>
<td>( \gamma_{00} )</td>
<td>2.20 (.57) **</td>
</tr>
<tr>
<td>BR ( \gamma_{10} )</td>
<td>2.75 (.47) **</td>
</tr>
<tr>
<td>DAP ( \gamma_{20} )</td>
<td>5.43 (1.34) **</td>
</tr>
<tr>
<td>Random effect</td>
<td></td>
</tr>
<tr>
<td>( \tau_{00} )</td>
<td>2.19 (.40)</td>
</tr>
</tbody>
</table>

* \( p < .05, ** p < .01 \). \( \gamma_{00} \): mean odds of being offered mathematics experiences for all children; \( \gamma_{10} \): within-children relationship between the odd of being offered mathematics experiences and the exposure to book reading; \( \gamma_{20} \): within-children relationship between the odd of being offered mathematics experiences and the presence of DAP; \( \tau_{00} \): between group variance. ICC: Intraclass Correlation Coefficient.
As presented in Tables 3.3. (classroom environment) and 3.4. (home environment), the null models showed the following between-children variation: the odds of working with counting manipulatives in the classroom weekly (30.9%); the odds of playing a counting game or reading a book about numbers in the home weekly (49.6%); the odds of working with geometric manipulatives in the classroom weekly (21.3%); and the odds of working with a measuring instrument in the classroom weekly (37.0%). Therefore, the between-children variation warranted analyses beyond the null models.

3.7.2.1 Early mathematics experiences and exposure to book reading

Relationships were found regarding the odds of being offered early mathematics experiences and exposure to book reading in the classroom and in the home.

In the classroom, a significant relationship was observed between daily exposure to book reading and the odds of working with measuring instruments ($\gamma_{10} = 3.39; z = 7.60, p < 0.01$). In other words, the odds of working with measuring instruments when book reading occurred daily were 3.39 times the odds of working with measuring instruments weekly when book reading did not occur daily. No relationships were observed between daily exposure to book reading and the odds of working with counting manipulatives or with geometric manipulatives. Weekly exposure to book reading increased the odds of working with counting manipulatives weekly ($\gamma_{10} = 3.69; z = 2.93, p < .01$), and working with measuring tools weekly ($\gamma_{10} = 5.41; z = 3.67, p < .01$).

In the home, a significant relationship was observed between daily exposure to book reading and the odds of playing a counting game or reading a book about numbers ($\gamma_{10} = 2.96; z = 6.26, p < .01$). In other words, the odds of playing a counting game or reading a book about numbers when book reading occurred daily were 2.96 times the odds of playing a counting game or reading a book about numbers when book reading did not occur daily. Weekly exposure to
book reading also increased the odds of playing counting games or reading a book about numbers by 6.73 ($\gamma_{10} = 6.73; z = 6.01, p < .01$).

### 3.7.2.2 Early mathematics experiences and presence of DAP

Several relationships were found regarding the odds of being offered early mathematics experiences and the presence of DAP, and similar patterns were observed whether the models related to children being read to daily or at least weekly. However, these relationships depended on the focus of the DAP (i.e., attention to child development, the cultural context of learning, or intentional teaching). These relationships also depended on the early mathematics experiences (i.e., working with counting manipulatives, geometric manipulatives, or measuring tools), and therefore the early mathematics content areas (i.e., numbers & operations, geometry, or measurement).

#### 3.7.2.2.1 Attention to child development

In the classroom, significant relationships were found between the curriculum being developmentally appropriate and the odds of being offered mathematics experiences, depending on the mathematics content strand. For instance, a positive relationship was found between working with measuring tools weekly and the curriculum being developmentally appropriate ($\gamma_{20} = 1.35, z = 2.41, p < .05; \gamma_{20} = 1.23, z = 1.67, p < .05$). That is, the odds of working with measuring tools when the curriculum was developmentally appropriate were 1.23-1.35 times the odds of working with measuring tools when the curriculum was not developmentally appropriate, according to the teachers’ surveys. No relationship was found for the other two mathematics content strands (i.e., working with counting manipulatives or geometric manipulatives.)
In the home, a positive relationship was found between parents encouraging children to be curious and the odds of playing a counting game or reading a book about numbers ($\gamma_{20} = 1.45$, $z = 3.16$, $p < .01$; $\gamma_{20} = 1.49$, $z = 3.32 p < .01$). The odds of playing counting games or reading books about numbers when parents encouraged their children to be curious were about 1.5 times the odds of playing counting games or reading books about numbers when parents did not encourage their children to be curious.

### 3.7.2.2 Attention to cultural contexts of learning

In the classroom, significant relationships were found between the curriculum being culturally relevant and the odds of being offered mathematics experiences weekly. A positive relationship was found between the strength of the curriculum being culturally relevant and the odds of working with counting manipulatives ($\gamma_{20} = 1.35; z = 2.11, p < .05$; $\gamma_{20} = 1.36; z = 2.11, p < .05$), the odds of working with geometric manipulatives ($\gamma_{20} = 7.44; z = 3.82, p < .01$; $\gamma_{20} = 7.16; z = 3.74, p < .05$), and the odds of working with measuring tools ($\gamma_{20} = 1.98, z = 4.61, p < .01$; $\gamma_{20} = 2.08; z = 4.92, p < .05$). In other words, the odds of being offered early mathematics experiences when the curriculum was viewed as culturally sensitive were 1.35 to 7.44 times the odds of being offered early mathematics experiences when the curriculum was not viewed as culturally sensitive, from the teacher’s perspective.

In the home, a positive relationship was found between the odds of playing a counting game or reading a book about numbers and families talking about family history / ethnic background ($\gamma_{20} = 2.15, z = 5.24, p < .01$; $\gamma_{20} = 2.24, z = 5.39, p < .01$). The odds of playing a counting game or reading a book about numbers when families talked about family history / ethnic background were a little more than twice the odds of playing a counting games or reading a book about numbers when families did not talk about family history / ethnic background.
3.7.2.2.3 Attention to intentional teaching

In the classroom, significant relationships were found between the curriculum addressing early mathematics and/or early literacy and the odds of being offered mathematics experiences, depending on the mathematics content. A positive relationship was found between the curriculum addressing early mathematics and/or early literacy and the odds of working with counting manipulatives weekly ($\gamma_{20} = 1.52, z = 3.12, p < .01; \gamma_{20} = 1.52, z = 3.13, p < .01$), and with measuring instruments weekly ($\gamma_{20} = 2.24, z = 5.88, p < .01; \gamma_{20} = 2.29, z = 5.98, p < .01$). No relationship was found between the curriculum addressing early mathematics and/or early literacy and the odds of working with geometry manipulatives weekly.

In the home, a positive relationship was found between the odds of playing a counting game or reading a book about numbers and families teaching letters and numbers ($\gamma_{20} = 5.43, z = 6.83, p < .01; \gamma_{20} = 5.42, z = 6.61, p < .01$). The odds of playing a counting game or reading a book about numbers when families taught the child letters and numbers were about 5.4 times the odds of playing a counting game or reading a book about numbers when families did not teach the child letters and numbers.

3.7.3 Summary

Before discussing the results in view of the literature, I present a brief summary, highlighting the relationships between variables – early mathematics content, book reading and DAP – in Figure 3.2.
As presented in Figure 3.2., the present exploratory study suggests that relationships between book reading, DAP and early mathematics depend on the content. For instance, working with geometric manipulatives weekly was independent from the exposure to book reading or the presence of DAP, except the attention to cultural context. By contrast, working with measurement tools in the classroom or playing games or reading books about numbers were related to both the exposure of book reading (daily or weekly) and the presence of all components of DAP. In other words, the exploratory study highlights that exploring early mathematics through book reading could be leveraged from practices such as playing games or reading books about numbers in the home or working with measurement tools in the classroom.
These practices would be relevant practices to investigate further, as they were both associated with a daily exposure to book reading.

3.8 Discussion

The goal of the present study was to investigate relationships between early mathematics and book reading experiences in the home and in the school, to better understand the phenomenon of exploring early mathematics through book reading from the perspective of Head Start. Evidence emerged from the results suggesting the relevance of exploring early mathematics through book reading, but additional steps should be considered to ensure all children will benefit from the phenomenon.

First, over 90% of the children were exposed to book reading weekly, either in the home or in the school. These findings are consistent with a frequency of literacy practices of three to four times a week in Head Start in 2009 (Walter & Lippard, 2017). Encouraging teachers and parents to explore early mathematics through book reading would therefore build up from practices already in place, increasing the chance of the endorsement of the phenomenon. One must point out, though, that although a similar percentage of children were exposed to weekly book reading in the home or in the school, daily exposure to book reading varied between contexts, as only 32% of parents surveyed reported reading daily. In other words, home and school practices align with exploring early mathematics through book reading weekly, but endorsing the phenomenon daily could lean towards inequitable access to early mathematics in the home. Indeed, because not every child is read to daily in the home, not all children would be exposed daily to early mathematics. I would therefore encourage researchers to first investigate the effect of exploring early mathematics through book reading weekly versus daily. If the
phenomenon must occur daily, then home-school partnerships should be developed to ensure that every child has daily access.

Second, a large population of children also had access to early mathematics experiences weekly either in the school through working with counting manipulatives (85.7%), geometric manipulatives (96.8%), or measuring tools (82.1%), and in the home, through playing games or reading a book about numbers (87.4%). This result is worth noticing in both contexts. In the classroom, children had access to early mathematics experiences that go beyond counting in the classroom. This finding aligns with recommendations from the literature (e.g., Clements & Sarama, 2004; Copley et al., 2007; Erikson Institute, 2014), but contrasts with prior studies suggesting a lack of early mathematics exposure in Head Start (Hindman, 2013). Such discrepancy could be explained by the use of different methodologies (e.g., surveys vs classroom observations), as well as differences across Head Start programs and centers regarding funding, the population of children served, etc. In the home, the finding is substantial as even a little exposure to mathematics helps in terms of mathematics achievement (Berkowitz et al., 2015). Future research should investigate how exploring early mathematics through book reading with preschoolers contributes to later mathematics achievement.

Third, in both contexts, some relationships were observed between book reading and early mathematics experiences. In the school, the odds of being offered early mathematics experiences depended on the mathematics content areas and the frequency of book reading. In the home, the odds of being offered early mathematics experiences when book reading occurred daily or weekly were 3 to 6 times the odds of being offered early mathematics experiences when book reading did not occur. These results align with previous studies that found relationships between literacy and numeracy activities in the home and in the school (Segers et al., 2015;
Such findings are worth noticing because the phenomenon of exploring early mathematics through book reading provides an opportunity to support both simultaneously. The findings also provide evidence regarding the alignment of the phenomenon with DAP. Regarding the attention to child development, the odds of playing counting games or reading books about numbers were significantly higher when parents encouraged children to be curious. Further investigation is necessary to better understand such relationship, such as studying parents’ discourse as they encourage their child to be curious and as they play counting games or reading books about numbers. Indeed, this finding is worth noticing as parent-child active discussion has been reported as a predictor for school readiness (Hill 2001). In the school, the attention to child development was associated with an increase in the odds of working with measurement tools. This result would align with the fact that measurement tools are often recommended in child-centered curricula such as the Creative Curriculum® (Copley et al., 2007). Measurement tools also appear in scales used to assess the quality of the classroom like The Early Childhood Environment Rating Scale Curricular Extension (ECERS®, Harms et al., 2014). Regarding the attention to intentional teaching, 90.4% of the parents reported that someone in the family taught the child letters, words, or numbers, significantly increasing the odds of playing a counting game or reading a book about numbers. Even if social desirability may have biased the parents’ survey responses (Groves et al., 2009), such a high percentage provides a clear indication that parents wanted to support their child’s learning. In the school, attention to intentional teaching from the teacher was associated with an increase in the odds of working with counting manipulatives or measurement tools, but no effects were observed on the odds of working with geometric manipulatives. Such discrepancies between early mathematics content areas could be explained, at least partially, by the curriculum, and the early mathematics
areas it emphasizes. For instance, the Creative Curriculum® provides various mathematics activities to be implemented in interest areas, such as the discovery area or the sand and water area (Copley et al., 2007), often involving the use of measurement tools.

A critical finding relates to the relationship observed between the attention to cultural contexts and early mathematics practices. In the home, 45.1% of the parents reported that someone in the family talked with the child about his/her/their family history or ethnic heritage in the past month, which significantly increased the odds of playing a counting games or reading a book about numbers. In other words, families talking about history or ethnic heritage to their child seem more likely to engage with playing a counting game or reading a book about numbers. In the school, the odds of being offered early mathematics experiences when the curriculum was culturally relevant, as perceived by the teachers, were 1.35 to 7.44 times the odds of being offered early mathematics experiences when the curriculum was not culturally relevant. The relationships between early mathematics and the cultural context of learning are noteworthy, as few studies relate early mathematics to race/ethnicity (National Research Council, 2009), and overall, studies on race/equity are rare in early childhood education. Indeed, among 403 articles focusing on mathematics and race/equity between 1999 and 2012, only 13 (3%) were published in early childhood journals (Parks & Schmeichel, 2012). My findings align well with the new DAP framework and its focus on cultural contexts of learning as well as the Early Childhood STEM Working Group (2017) highlighting that early mathematics is not culture free. Capitalizing on children and families’ culture would increase the chance that all families endorse the phenomenon.
3.9 Conclusion

Although the study provided insights on the phenomenon of early mathematics through book reading in view of home and school practices in the context of Head Start, it is important to recognize some limitations. First, data were collected between 2006 and 2009. Since then, there has been a push towards endorsing early mathematics in both the classroom and the home. For instance, an increase in time spent on mathematics content has been observed in Head Start classrooms between 2007 and 2015, depending on the content and the type of mathematics activity (Markowitz & Ansari, 2020). This exploratory study should be extended to further study the classroom and the home, to better assess current practices in place. Second, the study rests on a dataset that was not initially designed to investigate the phenomenon. In particular, the FACES 2006 did not include data to investigate DAP. Although variables were carefully selected to address the attention to child development, cultural contexts of learning, and intentional teaching, follow-up studies should be designed to further investigate these areas of DAP. For instance, the variable selected to inquire intentional teaching should be supplemented with data measuring intentional teaching actually occurring in the classroom. In addition, findings related to cultural contexts should be extended to better understand the potential role of discourse in the cultural context-early mathematics relationship observed in the present study.

Despite these limitations, evidence from the study align with endorsing early mathematics through book reading. For instance, weekly practices are in place in both the home and the classroom offering experiences to young children in both early mathematics and book reading, that could be used to endorse the phenomenon. However, the endorsement of the phenomenon of exploring early mathematics through book reading should be pursued with care. In particular, attention should be given to cultural contexts to fully support the child and nurture
a life-long commitment to learning (Erickson, 2018). Then, exploring early mathematics through book reading could become a meaningful practice that supports more equitable opportunities for young children.
CHAPTER 4. **Exploring early mathematics through picturebooks: A case study in the context of Head Start**

*“Why did you like this book?”*

*“Because Mommy reads it to me.”*

Picturebooks can act for young children as a reflection of themselves as well as a view of the world in which they live (Bishop, 1990), thereby empowering them and their identities. In the context of early mathematics, one can envision how a thoughtfully selected picturebook could guide children, all children, in picturing themselves as mathematicians. *More than One*, written by Miriam Schlein and illustrated by Donald Crews, for instance, combines a playful concept that one can be more than one— one pair of shoes is two shoes, one dozen eggs is twelve eggs, etc.— with an inclusive selection of human characters— various genders, ages, disabilities, and races/ethnicities. But how representative is this book of those read in homes and preschools? What are practices commonly in place to explore early mathematics through picturebooks? Such questions seem all the more relevant with children living in poverty, whose identities are often underrepresented in children’s literature (Koss, 2015). However, their perspectives, as well as those of their teachers and families, are rarely disclosed in the literature. What would they say about exploring early mathematics through picturebooks?

### 4.1 Background

Early childhood is a critical phase of development. From birth to 8, young children develop at a fast pace, highly influenced by their learning experiences and nurturing environments. However, as formal school starts once the child is five years old in the U.S., young children’s daily experiences vary drastically depending on their home and school environments. For instance, Brento (2006) calls these environments “circles of influences” (p.
163). In the present study, a first circle of influence would be the context of the home while a second circle of influence would be the context of the school. The society as a whole would constitute another circle of influence through its values, practices, laws, and policies (Bronfenbrenner & Morris, 2006). Although universal early childhood education (ECE) has been historically limited in the U.S. (Kamerman, 2006; Zigler, 2010), programs such as Head Start, a federally-funded program serving families in poverty, have been built to take into account these circles of influence (Zigler, 2010). Head Start focuses on the whole child and offers a wide range of services including early learning, medical and dental care, social services, and family support (Barnett & Friedman-Krauss, 2016).

Accounting for these circles of influence is critical to assure equitable opportunities to all children. The latest version of Developmentally Appropriate Practices (DAP, National Association for the Education of Young Children, 2020), a framework widely used in early childhood settings (Brown & Lan, 2015), recognizes their importance. Initially focusing on child development (Bredekamp, 1987), DAP has expanded to also consider children’s social and cultural contexts of learning (Bredekamp & Copple, 1997) and the intentional decisions adults make to guide children’s learning (Copple & Bredekamp, 2009). Indeed, learning will be supported through scaffolding between the child and a more knowledgeable person, implying children’s thinking and stimulation of prior knowledge. The latest version (NAEYC, 2020) took a step further, emphasizing that all social, cultural, and historical contexts should be considered in view of the child’s learning—the context of the child, but also those of the family, the educator, the school setting, the community, etc. The current DAP therefore lays out three core components (i.e., child development, contexts of learning, and intentional teaching). The DAP framework has also evolved to respond to the increasing focus on academics, including early
mathematics. For instance, the National Association for the Education of Young Children (NAEYC) issued a joint statement with the National Council of Teachers of Mathematics (NCTM) to promote early mathematics while maintaining DAP (NAEYC & NCTM, 2010). Despite initial concerns, there is now a consensus that early mathematics and DAP are not exclusive as long as a balance is found (Clements et al., 2017; Fowler, 2017). Young children should have access to various areas of early mathematics, including numbers and operations, geometry, measurement, early algebra/patterns, and data representation (e.g., Clements & Sarama, 2004; Copley et al., 2007; Erikson Institute, 2014). It has also been well established that these experiences should be offered in the classrooms and in the home. In the classroom, teachers should provide a balance of adult-guided and child-centered activities to fully nurture children’s interests in early mathematics and scaffold their learning in mathematics (Bassok & Latham, 2017; Fowler, 2017; NAEYC & NCTM, 2010; Early Childhood STEM Working Group, 2017). In the home, young children’s natural curiosity towards mathematics (Baroody & Wilkins, 1999) can be nourished through everyday situations, as well as games, books, and puzzles (Fisher, 2016; Kleemans et al., 2012; Lefevre et al., 2009).

A strategy to balance early mathematics and DAP consists of integrating mathematics with literacy (NAEYC & NCTM, 2010). Such recommendation seems all the more meaningful with picturebooks as they are commonly used in both classrooms and homes. Also, picturebooks could provide a reassuring starting point towards early mathematics as parents and teachers are often more comfortable with literacy (Cannon & Ginsburg, 2008; Copley et al., 2007). Several studies have investigated the use of picturebooks with preschool-age children, in both classrooms (Hojnoski et al., 2016; Jacobi-Vessels et al., 2016) and the home (Barnes & Puccioni, 2017; Hojnoski et al., 2014). However, in the context of DAP, both advantages and obstacles seem to
emerge. For instance, the phenomenon aligns well with the child-centered philosophy of DAP as picturebooks can stimulate children’s engagement with mathematics (Hojnoski et al., 2014; Hojnoski et al., 2016; Jacobi-Vessels et al., 2016). The phenomenon also positions well with intentional teaching, as picturebooks provide a context to scaffold and support mathematics learning in both the home (Anderson et al., 2004) and the school (Jacobi-Vessels et al., 2016).

However, several obstacles may interfere with maintaining a balance between early mathematics and DAP as picturebooks are read. For instance, a book, even with a clear focus on mathematics, is not sufficient to stimulate young children’s mathematical thinking; prompts from the reader are necessary (Elia et al., 2010). Depending on the questions raised during the read-aloud, the exposure to early mathematics will therefore differ (Anderson et al., 2005, 2004; Hojnoski et al., 2016). Overall, high quality book reading, involving interactions between the reader and the child(ren) and questions of high-cognitive demand, may be arduous to achieve in both the school (Hojnoski et al., 2016; Wasik et al., 2016; Zucker et al., 2021) and the home (Anderson et al., 2004; Barnes & Puccioni, 2017; Hojnoski et al., 2014). Also, the contexts of learning—social but also cultural—are a key element of the DAP framework. However, the overrepresentation of white, middle class, cisgender, and able-bodied characters in children’s literature that have been reported in research (Koss, 2015) could reinforce the stereotype that mathematics is not for all.

This conundrum is all the more relevant in the context of Head Start, serving primarily children of color (Office of Head Start, 2018).

To ensure that all children would benefit from exploring early mathematics through picturebooks, one must better understand the phenomenon to avoid any unintended consequences. The perspectives of Head Start participants, rarely reported in the literature, are especially relevant, pointing to the significance of this study.
4.2 Purpose of the study

The purpose of the study was to better understand the phenomenon of exploring early mathematics through picturebooks from the perspectives of Head Start adult participants. My first layer of analysis focused on the participants’ experiences in exploring early mathematics through picturebooks. My second layer of analysis focused on the participants’ overall sayings regarding the phenomenon. Hence, I sought to answer the following research questions (RQs):

RQ1. What are Head Start participants’ experiences in exploring early mathematics through picturebooks?

- What early mathematics areas emerge throughout these experiences?
- How do those experiences align with DAP?

RQ2. What do Head Start participants say about exploring early mathematics through picturebooks?

In other words, I sought evidence of specific experiences participants had as they read or reviewed picturebooks (RQ1) and opened the door to any additional evidence, besides experiences on specific picturebooks, that would be relevant to better understand the phenomenon through the lens of Head Start (RQ2).

4.3 Methodology

4.3.1 Framework

My study lays on Bronfenbrenner’s bioecological framework (Bronfenbrenner & Morris, 2006), recognizing the personal characteristics of the individual, the reciprocal influences between individuals and their environmental context, and the effect of time on changes occurring among individuals and their environment. By referring to such a model, I positioned the child as nested in several systems, or “circles of influence” (Brendtro 2006, p. 163). In my study, a first
circle of influence was the context of the home; another circle of influence was the context of the school.

4.3.2 Research design

4.3.2.1 Positionality

I recognized that my European background, where universal ECE is widespread, may influence the study. I also acknowledge my child-centered view of education. I taught in a Head Start center prior to pursuing my graduate studies and deeply value the essence of the program as well as the diverse representation of its participants. Since I stepped away from the classroom, I have continued to weekly visit state-funded and federally-funded preschool classrooms. These visits have given me the chance to not only reflect on young children’s mathematical thinking but also on preschool teachers’ and families’ perceptions of early mathematics. These classroom experiences and the subsequent reflective process have molded the present study.

4.3.2.2 Theoretical assumptions

I shaped the design of the study and the interpretation of the results through a social-cultural framework (Crotty, 1998, as cited in Creswell & Creswell, 2017). A first assumption is that individuals construct meanings through their interactions with the world in which they live. Therefore, my study deeply relied on the participants’ perspectives. A second assumption presumes that individuals make sense of their world via their own historical and social experiences. In other words, the participants’ experiences and the interpretation of my results were influenced by our experiences and background. The third assumption adopts the generation of individual meanings as arising from social interactions. The study was inductive, based on the data collected in the field.
4.3.3 Study design

My study was a qualitative single case study of a Head Start center. A single case study was relevant as the objective was to inquire into the connections affecting a common situation (Yin, 2017), exploring early mathematics through picturebooks. Also, I chose a holistic approach to better reflect overall experiences a child may be offered while attending the Head Start center, whether the child is in the home or in the classroom (Yin, 2017). Indeed, I was interested in the overall sayings emerging from the center that could contribute to a better understanding of the phenomenon of exploring early mathematics through picturebooks.

4.3.3.1 Context & participants

The study was implemented in the center of a Head Start program in the southeastern region of the United States. The center was chosen due to an ongoing professional relationship. The center comprised one classroom serving three- to five-year old children. The case included six participants involved with the center: two administrators, two teachers, and two parents. All participants were invited to provide background information that they would consider relevant, regarding their gender, age, race/ethnicity, ability/disability, interests, jobs, etc. (Appendix A). The sample provided a wide range of rich and various experiences. For instance, three participants had been involved in Head Start as both parents and teachers. To respect the confidentiality of my participants and avoid the disclosure of personal information that may breach their anonymity, I decided to include these pieces of information with parsimony when discussing findings. For example, I disclosed the gender of a participant who valued the presence of a male figure in a picturebook.
4.3.4 Data collection

4.3.4.1 Procedures

I collected data between February and October 2020. I invited participants to experience the phenomenon of exploring early mathematics through picturebooks (read-aloud or review of a variety of picturebooks), to participate in semi-structured interviews, and to complete open-ended surveys, as described hereafter. Participants were aware that the study related to early mathematics, but no formal intervention was provided. Prior to the closing of the center in March 2020 due to COVID-19, I visited the center to take observational notes about the school and classroom settings as well as the books and early mathematics materials accessible to children. After the center closed, I reviewed my protocol to continue the study safely. For instance, I switched the participants’ experiences in exploring early mathematics through picturebooks from reading aloud in the classroom or in the home to reviewing picturebooks without the presence of children.

4.3.4.2 Data sources

Prior to the pandemic, three participants (the two teachers of the center, one parent whose child attended the center) experienced exploring early mathematics through picturebooks with two to five read-alouds, either in the classroom or in the home. After the closure of the center, five participants (the two teachers who previously read aloud picturebooks in the classroom, two administrators of the center, and another parent) experienced the phenomenon of exploring early mathematics through picturebooks by reviewing two picturebooks. All participants were invited to share their experiences and overall sayings about the phenomenon via open-ended surveys and semi-structured interviews. These data sources are detailed hereafter.
4.3.4.2.1 Data sources related to Picturebooks

I purposefully selected a variety of picturebooks for participants to read aloud and/or review (Table 4.1.). Those included general content picturebooks and picturebooks with a focus on early mathematics. I took into consideration recommendations from the Development and Research in Early Math Education (DREME) Network to choose high-quality mathematics picturebooks (Uscianowski & Ginsburg, 2017). In particular, I gave attention to a match between the text, the illustrations, and the mathematical content. To choose general content picturebooks, I followed a guide to select anti-biased books (Derman-Sparks, 2013), regarding gender, race/ethnicity, and disabilities. I also made sure that the story and/or the illustrations would provide opportunities to discuss mathematics. Participants also had the option to read some picturebooks of their choice. One participant selected two picturebooks that were not on my initial list. I labeled these two picturebooks with an * in Table 4.1.

Table 4.1. Selection of picturebooks

<table>
<thead>
<tr>
<th>Title</th>
<th>Author &amp; Illustrator</th>
<th>Focus</th>
<th>Experiences (number of participants)</th>
</tr>
</thead>
<tbody>
<tr>
<td>More than One</td>
<td>Miriam Schlein &amp; Donald Crews</td>
<td>Mathematics</td>
<td>Read-aloud (3) &amp; Review (3)</td>
</tr>
<tr>
<td>Anno’s counting book</td>
<td>Mitsumasa Anno</td>
<td>Mathematics</td>
<td>Read-aloud (1)</td>
</tr>
<tr>
<td>Pairs of socks</td>
<td>Stuart J. Murphy &amp; Lois Ehlert</td>
<td>Mathematics</td>
<td>Read-aloud (1)</td>
</tr>
<tr>
<td>How to Two</td>
<td>David Soman</td>
<td>Mathematics</td>
<td>Read-aloud (1)</td>
</tr>
<tr>
<td>After the Fall</td>
<td>Dan Santat</td>
<td>General</td>
<td>Read-aloud (1)</td>
</tr>
<tr>
<td>How Alma got her names</td>
<td>Juana Martinez-Neal</td>
<td>General</td>
<td>Read-aloud (1)</td>
</tr>
<tr>
<td>Benny Doesn't Like to Be Hugged</td>
<td>Zetta Elliott &amp; Purple Wong</td>
<td>General</td>
<td>Read-aloud (1)</td>
</tr>
<tr>
<td>Just In Case You Want to Fly</td>
<td>Julie Fogliano &amp; Christian Robison</td>
<td>General</td>
<td>Read-aloud (1)</td>
</tr>
<tr>
<td>Peter’s chair *</td>
<td>Ezra Jack Keats</td>
<td>General</td>
<td>Read-aloud (1)</td>
</tr>
<tr>
<td>Emily’s sharing and caring book *</td>
<td>Cindy Post Senning</td>
<td>General</td>
<td>Read-aloud (1)</td>
</tr>
<tr>
<td>School’s First Day of School</td>
<td>Adam Rex &amp; Christian Robinson</td>
<td>General</td>
<td>Review (5)</td>
</tr>
</tbody>
</table>

* picturebooks provided by participants

4.3.4.2.2 Read-alouds & reviews of picturebooks

Prior to the pandemic, I provided participants with an audio recorder to record their read-alouds at a convenient time and location. Audiorecordings allowed me to gather evidence about
the text reading as such, but also of exchanges occurring between the reader and the child(ren), and questions raised as the text was read. The two teachers read aloud five picturebooks to their class. The parent read aloud two picturebooks to her child while they were at home. I gathered audio recordings shortly afterwards and transcribed them for analysis. After the center closed due to the pandemic, I invited five participants (the two teachers, two administrators, one new parent) to review two picturebooks—*More than One* (Miriam Schlein & Donald Crews) and *School’s First Day of School* (Adam Rex & Christian Robinson). The participants reviewed the picturebooks on their own and completed open-ended surveys and semi-structured interviews as described below. In summary, all participants explored early mathematics through picturebooks i.e., were exposed to the phenomenon of exploring early mathematics through picturebooks, either as they read aloud or reviewed picturebooks.

4.3.4.2.3 Open-ended Surveys

I provided open-ended surveys to participants to collect evidence regarding their experiences soon after they read (Appendix B) or reviewed a picturebook (Appendix C). Questions included: what did you think of the book? What surprised you? What mathematics did you/would you discuss? What other topics did you/would you discuss? I used these surveys to confirm patterns that emerged from the read-alouds and the semi-structured interviews.

4.3.4.2.4 Semi-structured Interviews

In addition to the open-ended surveys, I invited participants to a semi-structured interview shortly after they read aloud or reviewed a picturebook (Appendix D). Questions included: “what was your experience reading [title of the book]. What did you notice about the book? What surprised you?” I left the questions open so participants could reflect on their own experiences or share children’s experiences. Participants were also invited to share their sayings
around exploring early mathematics through picturebooks. Questions included: What practices do you engage with to support early mathematics and book reading? Overall, how do you feel about early mathematics and book reading? Participants were also invited to define terms such as early mathematics and DAP. Towards the end of the interview, I provided participants with a handout (Appendix E) to guide the discussion further around early mathematics areas, the story plot and characters, and the interest and engagement a child may display when exposed to the book. The interviews were audio-recorded and transcribed for analysis.

4.3.4.2.5 Observational notes

I visited the classroom regularly in the morning for two weeks prior to the pandemic, to review their practices related to early mathematics and picturebooks. I took observational notes during these visits to provide contextual background throughout the findings.

4.3.5 Data analysis

I analyzed data to address each RQ as described hereafter.

4.3.5.1 What are Head Start participants’ experiences in exploring early mathematics through picturebooks?

Several cycles of coding were performed to assess the participants’ experiences in exploring early mathematics through picturebooks, either as they read aloud or reviewed picturebooks.

I first coded all read-alouds (i.e., the statements and questions raised as the participants read picturebooks), then the interviews related to the participants sharing their experiences in reading aloud or reviewing picturebooks. Because the interviews included data related to both participants experiences (RQ1) and sayings (RQ2), I first extracted the content related to each book either read or reviewed using NVivo®.
For both data sources, the first cycles of coding were provisional. I used two predetermined lists of codes—one focusing on Head Start mathematics areas (i.e., numbers & operations, geometry & spatial sense, patterns and measurement; US Department of Health and Human Services, 2010), and one focusing on DAP (i.e., attention to child development, contexts of learning, intentional teaching) (NAEYC, 2020).

I started applying codes related to early mathematics and created a codebook to be consistent across read-alouds and interviews. A sample is presented in Table 4.2.

**Table 4.2. Sample of codebook around early mathematics**

| EXP EM (Numbers & operations) | A participant’s specific experience related to a book reading—as observed during a read-aloud or as reported in an interview or survey—that relates to the content of numbers & operations in view of book reading. This includes references to one-to-one correspondence, counting objects, counting sequence, subitizing, cardinality, combining and separating, as well as comparing and ordinal numbers. | TR01: What does it mean when something has more than one?  
Class: It has two.  
TR01: What else? What are the numbers that could be more than one?  
One child: Three |

I then applied codes related to DAP. As with early mathematics, I described each code related to DAP in a codebook. For instance, evidence of participants noticing a child as an individual was coded as attention to child development and the uniqueness of the child. For contexts of learning, I created sub-codes to distinguish social context (e.g., a positive relationship between a participant and a child) with cultural context (e.g., reference to the multicultural representation of characters). For intentional teaching, I created sub codes related to the presence of scaffolding, questions raised by participants to prompt and/or extend children’s thinking, or an invitation to recall prior knowledge. A sample of the codebook is presented in Table 4.3.
Table 4.3. Sample of codebook around DAP

| EXP DAP Child development (notice) | A participant’s specific experience related to a book reading, as observed during a read-aloud or as reported in an interview or survey, relates to child development and its influence by individual patterns (e.g., age, temperament, personality, and aptitudes) in view of book reading. Most specifically, the participant’s experience provides evidence of an adult noticing the child as an individual (e.g., the adult rephrases the child’s saying or add on based on the child’s strengths, interests, and personality). | TR02: Which one is hard?  
A child: The rock  
TR02: The rock is hard |

The next cycles of coding were performed as follows. For each read-aloud, I counted the number of utterances—an uninterrupted chain of spoken language issued by a given participant—related to each code as well as the overall number of utterances. For instance, a participant reading a page of a book, without interruption, was counted as one utterance. An exchange between the reader and a child was counted as two utterances. Multiple codes could be associated with one utterance. For instance, one utterance could include evidence of geometry and scaffolding. For the interviews related to the participants sharing their experiences in reading aloud or reviewing picturebooks, I recorded which codes emerged for each picturebook (either read-aloud or reviewed by the participant). I did not track the number of utterances as I was interested in the overall mathematics areas they discussed from the two picturebooks they reviewed. Although the coding process involved several cycles, I stayed attentive to the coding order. For instance, I started by coding More than One for the three participants, and then coded the rest of the read-alouds one participant at a time.

Open-ended surveys were used to confirm or disconfirm codes that emerged from the interviews. For instance, I checked that what a participant said during an interview regarding the early mathematics content of a picturebook aligned with what the participant wrote in the survey.
completed right after the read-aloud or picturebook review. In other words, I confirmed that the
codes emerging from the interviews would be in accordance with the surveys completed shortly
after reading aloud or reviewing a picturebook.

4.3.5.2 What do Head Start participants say about exploring early mathematics through
picturebooks?

Additional cycles of coding of the semi-structured interviews were performed to
investigate what participants said about the phenomenon of exploring early mathematics through
picturebooks. The first cycle of coding was open-ended (Saldana, 2016), drawing from the
participants’ own language as a first wave of coding aligned well with the theoretical framework
and vision of the participants’ perspectives as a building block of the analysis. I went through a
second cycle to combine some of the codes and organized them around the themes of early
mathematics, book reading, and exploring early mathematics through picturebooks. For instance,
“book everyday” or “book sent home” were grouped into “literacy practices”; “counting songs”,
“exercise songs” or “counting bears” were grouped into “mathematics practices”. A sample of
the codebook is presented in Table 4.4.

Table 4.4. Sample of codebook participants’ sayings and corresponding quotes

<table>
<thead>
<tr>
<th>SAY EM Practice (Numbers &amp; operations)</th>
<th>A participant describes, during an interview, recurrent practices around numbers &amp; operations in place in the home or in the classroom.</th>
<th>AD01: we use a lot of manipulatives and, um, allow the children to do things like, um, stack blocks, uh, do comparisons. Um, uh, there's a lot of counting, they're counting games, they're kind of counting opportunities.</th>
</tr>
</thead>
</table>

I looked for patterns across participants, but I also considered individual sayings that
would contribute to a better understanding of the phenomenon.
4.3.6 Validity and reliability of the study

Several steps were used to assure the validity and reliability of the study, the first one being obtaining approval from the NC State Institutional Review Board. I also constantly reflected on any biases, values, and experiences I bring as a researcher that may impact the study. Finally, participants were assured of the confidentiality of the data collected, and that no right or wrong answers were expected and that their standpoints were valued. To demonstrate that the study was reliable and could be repeated with comparable results (Yin, 2017), I documented in detail each step of the data collection. I used a case study protocol as described in Yin (2017), that includes an interview protocol (Appendix D), as well as codebooks for the coding of the data (Appendix F). I also used a case study database (Yin, 2017) that included the data collected as described previously but also analytic memos that I collected as the study unfolded. Finally, I maintained a chain of evidence (Yin, 2017) with cross-referencing between the various sources of data collected. The use of multiple sources of evidence provided arguments that the study was valid and laid on “correct operational measures” (construct validity, Yin, 2017, p. 42). Quotes from the participants were used to support the authenticity of the study (Whittemore, Chase, & Mandle, 2001). I also addressed any rival explanations that emerged from the data sources to support the internal validity of the study (Yin, 2017).

4.4 Findings

4.4.1 What are Head Start participants’ experiences in exploring early mathematics through picturebooks?

I reviewed the participants’ experiences in the phenomenon as they read or reviewed picturebooks, in view of the early mathematics areas that emerged from the picturebooks and the alignment of these experiences with DAP.
4.4.1.1 What early mathematics areas emerge throughout these experiences?

Overall, all early mathematics areas emerged as participants read aloud or reviewed picturebooks (Table 4.5.).

Table 4.5. Early mathematics areas that emerged as participants read aloud or reviewed picturebooks

<table>
<thead>
<tr>
<th>Utterances across all read alouds</th>
<th>Read-alouds</th>
<th>Picturebook Reviews</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># of utterances</td>
<td>% of total # of utterances</td>
</tr>
<tr>
<td>All utterances</td>
<td>1738</td>
<td>100%</td>
</tr>
<tr>
<td>Early mathematics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Numbers &amp; operations</td>
<td>518</td>
<td>29.8%</td>
</tr>
<tr>
<td>Geometry &amp; spatial sense</td>
<td>439</td>
<td>25.3%</td>
</tr>
<tr>
<td>Measurement</td>
<td>34</td>
<td>1.9%</td>
</tr>
<tr>
<td>Patterns</td>
<td>28</td>
<td>1.6%</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>&lt; 1%</td>
</tr>
</tbody>
</table>

Numbers & operations was the most common early mathematics area that emerged from the read-alouds (representing 85% of the total early mathematics utterances). Those included engaging young children with: using the counting sequence; counting objects (by ones or by groups); discussing the quantity of a set; combining and separating items (including whole numbers and fractions); comparing quantities; and discussing ordinal numbers. The area of numbers & operations also emerged as a predominant early mathematics area when adult participants reviewed picturebooks. For instance, participants mentioned that they would discuss counting items, ordering numbers, comparing quantities, recognizing numerals, and combining/separating items as they read More than One. All other mathematics areas—geometry & spatial sense, measurement and patterns—were less frequent than the area of numbers & operations. Geometry & spatial sense mostly related to the use of spatial sense vocabulary (e.g.,
on, behind) as participants read aloud picturebooks. Measurement was found through references to size, height, and time in five of the twelve read-alouds. Patterns were rarely discussed. One exchange across all read-alouds related to patterns as one participant discussed different patterns found on socks as she was reading *Pairs of socks*. Another participant also referred to patterns as she reviewed *School’s First Day of School* (“you could teach patterns on that page”).

Picturebooks as such also influenced the mathematics areas participants would discuss as they explore early mathematics through picturebooks. For instance, all participants referred to geometry & spatial sense as they reviewed *School’s First Day of School* (e.g., “How many shapes do you see?” “What type of shapes make up that house?”), but none mentioned it as they reviewed *More than One*. Another example can be found from the read-alouds. A participant, reading two picturebooks without a mathematics focus, engaged with the concepts of geometry and measurement while reading the book *Peter’s Chair*, and engaged with numbers & operations while reading *Emily’s Sharing and Caring*. Similarly, another participant engaged mostly with numbers & operations while reading *Alma*, while she engaged with numbers & operations, geometry & spatial sense and measurement as she was reading *After the Fall*. In other words, there was variation across the readers and between books.

To summarize, all mathematics areas emerged from the participants’ experiences in exploring early mathematics through picturebooks. The area of numbers & operations was predominant.

### 4.4.1.2 How do those experiences align with DAP?

To report how the participants’ experiences in exploring early mathematics through picturebooks aligned with DAP, I looked for evidence of the participants’ attention to child
development, contexts of learning, and intentional teaching as they read aloud and reviewed picturebooks. An overview of the results is presented in Table 4.6.

**Table 4.6.** DAP that emerged as participants read aloud or reviewed picturebooks

<table>
<thead>
<tr>
<th></th>
<th>Read-alouds</th>
<th>Picturebook reviews</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># of utterances</td>
<td>% of total # of utterances</td>
</tr>
<tr>
<td>All utterances</td>
<td>1738</td>
<td>100%</td>
</tr>
<tr>
<td>DAP</td>
<td>885</td>
<td>50.9%</td>
</tr>
<tr>
<td>Child development</td>
<td>638</td>
<td>36.7%</td>
</tr>
<tr>
<td>Contexts of learning</td>
<td>86</td>
<td>4.9%</td>
</tr>
<tr>
<td>Intentional teaching</td>
<td>161</td>
<td>9.2%</td>
</tr>
</tbody>
</table>

Attention to child development emerged from both read-alouds and picturebook reviews. Overall, children seemed engaged during read-alouds, as a 50-50 balance was found between the children’s vs adults’ utterances across read-alouds. Children’s statements were noticed throughout the read-alouds through participants asking questions and rephrasing a child’s answers and represented about 36% of the total utterances. For example, a participant asked the children how many whales could be in the ocean (“How many? What other numbers?”), as she was reading *More than One*, and rephrasing the number provided by two of the children (“Ten? You think there is ten whales in the ocean?”; “Five whales?”).

The attention to child development also emerged in the picturebook reviews. *More than One* was perceived as engaging for young children by participants, as children would be “interested” and “kind of intrigued” with a book that would “catch a child’s attention.”

Regarding *School’s First Day of School*, participants pointed out that readers, to maintain children’s engagement, would have to “break it down in part” or “expand math throughout the whole week” to respect preschoolers’ attention span as the book was “really, really long.” Some evidence of misalignment between the participants’ experiences and attention to child
development could be found in most read-alouds through children’s statements being unnoticed. In other words, although the attention to child development appears to be perceived as important by participants, attention to all children was challenging when the whole class was read to.

The attention to contexts of learning emerged from two lenses: the presence of a warm and positive social relationship between adult(s) and child(ren) and the reference to various cultural contexts. Warm exchanges were observed across read-alouds such as “I think you’re right” or “I like what you said” and represented about 5% of the total number of utterances. Although no references to various cultures emerged from the read-alouds, most participants, including two who identified as African American in their survey, pointed out the diverse representation of characters in School’s First Day of School describing the picturebook as “very multicultural” and inclusive with “children with darker skin, children with lighter skin,” “kids are different colors, girls, boys,” and “one young lady in a wheelchair.” A male participant appreciated the representation of a male figure as he reviewed More than One, mentioning that he “loved the fact that they're sitting with their dad and reading” in opposition to a “female figure” because “sometimes that gets overlooked.”

Finally, mixed results were found regarding the attention to intentional teaching as participants read aloud or reviewed picturebooks. For instance, a total of 365 questions emerged from all read-louds, but only 28 questions built up from what the child said in order to extend the child’s thinking. Also, stimulation of children’s prior knowledge was rare and represented less than 1% of the total utterances. Finally, evidence of scaffolding was found, even though sparsely. For instance, one participant inquired about the meaning of “stretch”. As one child said, “stretch your body”, the participant added on with “to reach for something up”. These scaffolding utterances represented about 3% of the total number of utterances across all read-alouds. These
observations from read-alouds seem to contrast with participants’ interviews. Participants referred to intentional teaching as they reviewed *More than One*, noticing, in particular, how the book connected to children’s prior knowledge and how the book provides “an opportunity to expand learning and do some intentional teaching.” Participants also noted the richness of *School’s First Day of School* to scaffold mathematical areas. For example, a participant highlighted how it could be used by a teacher “to notice and go back and draw more out of the story so that they can use the book over and over again, to, um, to, to bring children's attention to the different, um, mathematical areas.”

In summary, the participants’ experiences in exploring early mathematics through picturebooks seem to mostly align with DAP. However, although participants seemed to value intentional teaching, its implementation throughout read-alouds was sparse.

### 4.4.2 What do Head Start participants say about exploring early mathematics through picturebooks?

I report hereafter the Head Start participants’ sayings with first, a focus on early mathematics, then book reading, and finally exploring early mathematics through picturebooks.

#### 4.4.2.1 What Head Start participants say about early mathematics

I present what participants said about early mathematics through three sub-sections—

When invited to provide a definition of early mathematics, some participants referred to “simple stuff, like one plus one […] or three minus one,” “basic like counting, um, counting, like give them a certain amount, one to five.” One participant added operations such as “being able to engage in the process of either physically dividing objects or being able to track either the
addition or subtraction of objects.” Another participant also included the area of geometry & spatial sense “and basic shapes to connect to the world.” Interestingly, when discussing a book rich in mathematics areas, such as School’s First Day of School, additional mathematics areas emerged from a participant’s sayings, such as comparing sizes of items, prior to receiving the handout. Participants also pointed to early mathematics as opportunities to talk about mathematics (e.g., “a child being able to have a conversation around either counting, uh, combining things, uh, combining objects.”). These discussions around mathematics occurred during read-alouds, but also throughout the day. During one of my visits in the classroom, I observed a discussion around mathematics as children were having breakfast. One of the teacher participants took the chance to discuss wholes and parts of a whole as she served all children half of a muffin. The other teacher participant referred to that discussion later on during the day, as she was reading After the Fall, explaining “just like this morning, when you were talking about the muffin. The muffin was a whole muffin, right? But if you break it, how many pieces do you have?” Evidence of discussions around mathematics was found in the context of the home as well, when a participant reported a follow-up discussion after reading More than One, about one bag of tangerines being more than one (i.e., 13 tangerines).

Participants described early mathematics practices in place in the home and in the classroom. In the home, practices involved the use of activity books (e.g., “books that I got from Five Below and they're, um, they're math, it's math for three to, for ages three to four”) or the use of snacks as an opportunity to count (e.g., "count the M&Ms and then you can have them"). In the classroom, practices involved discussing the calendar, counting, and moving songs, and counting bears and other hands-on activities, embedded throughout the day. These classroom practices were extended to the home, with materials sent to families, aligning with what was
done in the classroom. Parents received every week “a calendar with what the child is doing in the classroom” as well as follow-up activities “for instance, if they go to the grocery store to count items, to count, uh, to recognize numbers, um, any, any opportunities they have to add, um, add items together, um, they're encouraged to do that.”

Overall, participants saw the benefit of early mathematics as “early mathematics deals with everything.” Participants also acknowledged that mathematics should be done every day and be visual or hands-on. In general, the values and standpoints of the participants in early mathematics often aligned with DAP, with respect to child development, the context of learning, and the presence of intentional teaching. For instance, participants highlighted the importance of repetition in mathematics—“repetition is the key. You have to be repetitive with kids at this age”—and how families “could do repetition of the same activity that was done in the classroom.” Early mathematics was considered in view of children’s interests, as the engagement of the children was critical. A parent participant for instance reported that "if [child] is in a good mood, he’ll count, um, if [child] is not in a good mood…yeah, he will probably not.” Early mathematics was also described as a tool to support socio-emotional skills and “teach independence” as activities in early mathematics “takes a lot of patience for [children]” and could “help them build their attention span as they deal with different components of mathematics.”

4.4.2.2 What Head Start participants say about book reading

I present what participants said about book reading through three additional sub-sections features of the picturebooks, the practices they have in place around book reading, and opportunities picturebooks offered. All participants agreed that picturebooks should be engaging for children and selected based on the child’s interest—"I select them according to how the
children, um, respond to certain subjects… like, if somebody is interested in cars or if they're showing interest in blocks or whatever show…interesting. Uh, I'll go by what their interest is, you know?” The illustration should be colorful as “it has to be something as a color… you don't want to put up a book that’s black or white,” and the length of the picturebooks should align with the age of the child. For instance, one participant, when asked what she was looking for when selecting a picturebook said “color and how long it takes to read it.” Participants reported strategies to keep children engaged, such as “you can change the voice… to keep them interested” or use “puppets.”

Similar to mathematics practices, practices around book reading were in place in both the school and the home. In the school, prior to the pandemic, children had access to books throughout the day at school—“there's reading time at the school and there are books on a reading shelf, that's one of the choices that they have during free time.” Overall, book reading occurred every day and included stories around “counting.” Books were also sent home as the program participated “in Dolly Parton’s Imagination Library”, a program sending books monthly to registered families. In the home, practices varied, with one parent participant mentioning her enjoyment of reading herself and consequently, to her child—"I am reading anywhere, anywhere I read myself, so I don't mind reading to [child].” She also mentioned that questions should be posed during the read-aloud, “not too hard, what I know [child] would remember.” The other parent participant acknowledged the sparsity of book reading with her child when she said, “we don’t do much on reading.” Interestingly, she still envisioned book reading as a series of back-and-forth exchanges: “When I'm reading [child] a book, um, I have [child] engaged in the book too. So basically, um, like with the picturebooks, I asked [child] questions, um, and have [child] point out what [child] sees and stuff like that.” Overall, participants discussed book reading as an
opportunity for children to engage in talking (e.g., “When I read stories, I always ask questions”).

Finally, participants perceived picturebooks as a tool to embrace critical topics for young children, such as socio-emotional skills. For instance, a teacher participant, discussing Emily’s Sharing and Caring reported that it was “a really good book” because “we're always talking to the kids about sharing, it’s important, and caring and how to care for your friends.” Another teacher participant discussed the topic of being scared while reading After the Fall, as “Humpty Dumpty was scared that if he went and back up there, he would fall off and it would be an accident again.” Picturebooks were also praised for supporting children with short attention spans or attention deficit hyperactivity disorder (ADHD)—"I like picture books for my child because [child] has ADHD”.

4.4.2.3 What Head Start participants say about exploring early mathematics through picturebooks.

Participants also discussed exploring early mathematics through book reading. While they relayed positive thoughts regarding the phenomenon, they also highlighted challenges.

Overall, participants reported a positive experience in exploring early mathematics through picturebooks. They related the positivity of their experience to the book itself, such as the presence of colorful illustrations and topics of interests for children (e.g., families, sports, trucks, etc.). Illustrations were perceived as essential to discuss early mathematics areas, even beyond the story itself: "you can even make up a story and you can use the same picture for several different, um, ideas around mathematics.” One participant, discussing Anno’s counting book, a wordless book, took a step further mentioning that “without the words, I think you get more of a response from the kids, and it encourages the teacher to ask more questions without the
reading, without the words.” The positivity also emerged from how the topic could engage the reader as well. For instance, two participants enjoyed *More than One* and its unusual way to make them think about early mathematics, as illustrated in this quote: "I had never seen a book like this and so it was interesting to me because I was like, I've never, you know, we teach them numbers, but I've never taught it.”

Participants also appreciated the variability in picturebooks to discuss mathematics areas, as repetition was seen as critical with young children for several of the participants. For example, one participant stated, “I could take this book and I could read it from cover to cover several days in a row […] Because each time that you look at it, you can have them look at it from a different angle. So, you can just do plants at one point, because you have one, two, three, you have three different types of plants in terms of the trees.” Several participants also referred to the benefit of picturebooks to support, and extend, mathematical language. Building up from *More than One*, a participant reported how confusing the expression “a pair of jeans” can be compared to a pair of shoes, and how the book could provide support to address that. Participants also saw how picturebooks provide hands-on opportunities to connect with mathematics such as "let's count these… count these rectangles and I have them counted in the book. [..].”

Interestingly, one participant extended the phenomenon of exploring early mathematics through picturebooks beyond the child and envisioned it as a learning tool for teachers to become more intentional in their teaching. The participant explained that “intentionality of instruction”, a concept that teachers “struggle with the most” requires “observation” (i.e., noticing children) and “imagination” (i.e., extending the child’s learning). Exploring early mathematics through picturebooks could guide teachers, working with coaches, in noticing more opportunities to extend children’s learning.
Participants also identified some challenges in exploring early mathematics through picturebooks. Participants reported that “some people don't know how to, how to apply or what to say” or that “some parents don't have patience, or some parents may not know how to incorporate or implement math” or that “people don't really think to operate math and reading.” A participant mentioned that *Just in Case you Want to Fly* was “a little bit tricky” because children “didn't pay as much attention to counting and objects” and tended to “more or less steer towards just the pictures that they saw.” The length of the book was also perceived as a potential issue. For instance, *School’s First Day of School* was perceived by a participant as “too long to me and, you know, a lot of words and stuff, my son wouldn't stay interested in it that long.”

4.5 Discussion

The purpose of the study was to better understand the phenomenon of exploring early mathematics through picturebooks, from the perspectives of Head Start participants. Below, I first discussed how the participants’ experiences and sayings position with the phenomenon. I then highlighted potential obstacles to take into consideration. A summary of my findings is presented in Figure 4.1.
The case study supports the endorsement of the phenomenon in view of early mathematics and book reading but also in view of DAP. First, participants expressed curiosity towards early mathematics and saw the potential of exploring early mathematics through picturebooks due to their colorful illustrations and range of interest topics for young children. In fact, most participants could find examples in picturebooks of early mathematics areas once they became aware of the four areas of early mathematics. As one participant said, “early mathematics deals with everything.” Those findings tie well with previous studies reporting that general picturebooks can be “mathematized” to provide young children with opportunities to explore mathematical ideas and ask questions (Dunphy, 2020; Fosnot & Dolk, 2001; Hintz & Smith, 2013; Hynes-Berry & Grandau, 2019). However, my findings may contrast with the
report that the mathematics embedded in the story can be arduous to see and be overlooked by the reader (Dunphy, 2020). For instance, a participant started noticing patterns and measurement in a picturebook rich in early mathematics (i.e., *School’s First Day of School*) while this area was often absent from the participant’s definition of early mathematics. Further investigation should focus on readers’ cognitive processes to better understand the mathematics content they see in a book as well as how they engage the young children with such content.

Second, participants reported practices around early mathematics and book reading that could be extended to explore early mathematics through picturebooks. Picturebooks were commonly used in the classroom but also accessible for families through Dolly Parton's Imagination Library. This program, sending monthly books to young children, has been associated with an increase in the frequency of parents reading to their child and the children’s enthusiasm for books (Conyers, 2012). In parallel, participants provided evidence of discussion around early mathematics in the school and in the home that could be used as a first step towards mathematizing a picturebook (Dunphy, 2020) once guidance to connect both early mathematics and book reading is in place.

Finally, the participants’ sayings about and experiences with exploring early mathematics through picturebooks align with child development and contexts of learning, two cornerstones of DAP. Taking into account children’s interests while selecting a picturebook is a widespread practice for teachers and families (Dunphy, 2020), and parents’ engagement around numeracy and literacy has been related to children’s interests. In other words, a favorable learning environment occurs when both the child is interested, and the parent is engaged in the child’s activity (Lukie, Skwarchuk, LeFevre, & Sowinski, 2014). In addition, participants noticed and appreciated the diverse representation of characters in *School’s First Day of School*, in view of
two identities that were race/ethnicity and disabilities. Although no discussion around cultures emerged from the read-alouds, this finding aligns with the latest DAP framework and its focus on cultural contexts of learning (NAEYC, 2020) and it reiterates the relevance of multicultural literature to support mathematics learning (Iliev & D’Angelo, 2014). One must also point out the participants’ noticing of characters with disabilities, such as a little girl in a wheelchair, playing with another girl during recess in School’s First Day of School, providing an example of the relevance of inclusive literature that goes beyond teaching about a disability (Kleekamp, Monica & Zapata, 2018). Recording participants reading School’s First Day of School to young children would provide additional evidence about the potential of the book to endorse both early mathematics and young children’s identities.

However, potential obstacles emerged and should be taken into consideration to avoid unintended consequences when endorsing early mathematics through picturebooks, and prevent inequitable opportunities among young children. Although participants acknowledged the potential of exploring early mathematics through picturebooks, evidence from the read-alouds showed that in practice, the phenomenon may be arduous to endorse in view of DAP. For instance, noticing individual children may be difficult while reading aloud to a whole class. Also, intentional teaching around early mathematics was sparse throughout the read-alouds (i.e., scaffolding young children’s learning in early mathematics did not naturally come from picturebooks). Overall, no clear evidence of extending young children’s mathematical thinking were found throughout the read-alouds (i.e., follow up questions/statements building up from a previous child’s sayings). Similar quality of book reading has also been reported in the classroom and in home (Anderson et al., 2012; Barnes & Puccioni, 2017; Deshmukh et al., 2019; Zucker et al., 2021), and such findings from the read-alouds aligned with participants’ sayings.
around teachers struggling with noticing opportunities to extend children’s learning, or lacking the knowledge to do so. Finally, as previously discussed, several participants appreciated the diverse representation of characters in *School’s First Day of School*, in view of race/ethnicity and disabilities. However, children’s literature still overrepresents white, middle class, cisgender, and able-bodied characters (Koss, 2015), making it arduous to find picturebooks empowering all children around early mathematics. Also, even though a picturebook has the potential to empower young children’s identities, the role of the reader is critical to fully embrace such potential.

4.6 Limitations & Implications

Even though the case study provides evidence to better understand the phenomenon of exploring early mathematics through picturebooks, the study has some limitations. First, the study protocol had to be amended due to COVID-19 and the subsequent closing of the center. A consequence was that participants did not have the opportunity to read the whole list of picturebooks initially planned to assure that all mathematics areas were covered throughout the lists. The read-alouds were audio-recorded; it might be worthwhile to video record read-alouds in future studies to examine gestures and other visual cues that could inform our understanding of the phenomenon.

Nevertheless, the findings of this study can be understood as a reflective work around the phenomenon of exploring early mathematics through picturebooks. Although participants recognized that the endorsement of the phenomenon could be “tricky,” they expressed interest in it and provided thoughtful insights that have implications for future research. Two potential research pathways can, in particular, be envisioned from the findings. A first pathway would focus on the child and investigate strategies to guide teachers and families in posing thoughtful
early mathematics questions that stimulate children’s thinking as they read, to ensure that all children can fully benefit from the phenomenon. Studies have been pursued on using discussion around early mathematics during dialogic reading in the home (Hojnoski et al., 2014) and in the school (Hojnoski et al., 2016). However, the field would benefit from endorsing the Head Start model to build a strengths-based training empowering Head Start teachers and families while considering social inequities associated with living in poverty. For instance, the case study highlighted participants’ appreciation of engaging with picturebooks that disclose a diverse representation of characters. Further investigation is needed to describe what a training around exploring early mathematics through picturebooks embracing such statement would look like. A second pathway would focus on teachers. As suggested by one of the participants, the phenomenon could be used as a tool to raise teachers’ awareness in noticing and embracing moments throughout the day to support children’s learning. Studies would involve coaching and classroom observations and provide new strategies to support teachers in their classrooms.

Head Start provides a thoughtful strengths-based model to study ECE-related topics as it seeks to not only support young children living in poverty but also empower their families (Bierman et al., 2015). Indeed, the case study countered a deficit model often present in studies around poverty (Smit, 2012). The next step should involve children—what would they say about exploring early mathematics through picturebooks? What do they like about being read to?
CHAPTER 5. Discussion and Conclusion

Chapter 5 presents a discussion around my studies and a conclusion. I begin with a summary of the two studies. I then present a cross-studies analysis. I continue with presenting implications of my dissertation studies. I also present future research. I finish this closing chapter with some concluding thoughts.

5.1 Summaries of my quantitative (Chapter 3) and qualitative (Chapter 4) studies

The purpose of my dissertation was to better understand the phenomenon of exploring early mathematics through book reading from the perspectives of Head Start participants. In other words, my dissertation centers their practices, sayings, and experiences in order to contribute to the field and prevent potential unintended consequences of exploring early mathematics through book reading and picturebooks in early childhood settings. I investigated how the phenomenon positions with Head Start teachers and families’ experiences and existing practices around both early mathematics and book reading as well as with the core elements of DAP (i.e., attention to child development, contexts of learning, and intentional teaching). The study comprised two independent studies—a quantitative and a qualitative study—both laying on Bronfenbrenner’s bioecological framework (Bronfenbrenner & Morris, 2006), recognizing the personal characteristics of the individual, the reciprocal influences between individuals and their environmental context, and the effect of time on changes occurring among individuals and their environment.

The first study (Chapter 3) was a quantitative study. I performed my investigation through multi-level models (Raudenbush & Bryk, 2002) using the Head Start Family and Child Experiences Survey (FACES, 2006) dataset, a measurement tool using representative samples of Head Start programs, centers, classrooms, families, and children. The sub-question guiding the
quantitative study was: Are there relationships between the early mathematics experiences Head Start children are offered, their exposure to book reading, and the presence of DAP? I was interested in pursuing an exploratory study to describe existing home and school practices that could be relevant to the phenomenon. Multi-level models allowed me to investigate these practices across the two years children attended Head Start.

My findings showed that over 90% of the children were exposed to book reading weekly, either in the home or in the school. Also, a large population of children had access to early mathematics experiences weekly either in the school or in the home. In other words, home and school practices seemed to align with the phenomenon and could be combined to offer early mathematics exploration through book reading to young children. In both contexts, some relationships were observed between book reading and early mathematics experiences. For instance, the odds of playing a counting game or reading a book about numbers when book reading occurred were significantly higher when book reading occurred daily or weekly. These findings would suggest that families engaging their young child with book reading would also engage them with early mathematics. The study also focused on the alignment of the phenomenon with DAP. I purposefully selected variables to assess the attention to three core elements of DAP, that are child development (i.e. encouraging a child to be curious or using a curriculum that was developmentally appropriate), contexts of learning (e.g. using a culturally relevant curriculum or talking about family history/ethnic background), and intentional teaching (e.g. using a curriculum addressing early mathematics and/or early literacy, or teaching letters and/or numbers). Regarding the attention to child development in the home, the odds of playing counting games or reading books about numbers were significantly higher when parents encouraged children to be curious. In the school, a curriculum perceived as developmentally
appropriate by teachers was associated with an increase in the odds of working with measurement tools. Regarding the attention to intentional teaching in the home, 90.4% of the parents reported that someone in the family taught the child letters, words, or numbers in the past week, significantly increasing the odds of playing a counting game or reading a book about numbers. Results were mixed in the context of the school. Finally, a critical finding related to the attention to cultural contexts of learning. In the home, 45.1% of the parents reported that someone in the family talked with the child about his/her/their family history or ethnic heritage in the past month, which was associated with significantly higher odds of playing a counting game or reading a book about numbers. In the school, the odds of being offered early mathematics experiences when the curriculum was culturally relevant were 1.4 to 7 times the odds of being offered early mathematics experiences when the curriculum was not. Based on my findings from the first study, I would first encourage researchers to investigate the effect of exploring early mathematics through book reading weekly, as weekly practices around book reading and early mathematics are already in place in the home and in the classroom. If the effect lays on a more frequent exposure, home-school partnerships should be developed to guide families in reading daily, prior to extending the reading to early mathematics.

The second study (Chapter 4) was a qualitative single case study of six Head Start participants, with the objective to inquire into the connections affecting a common situation (Yin, 2017), that was exploring early mathematics through picturebooks. I chose a holistic approach to better reflect on the overall sayings of the participants, that may affect children attending the center, whether they are in the home or in the classroom.

The sub-questions guiding the qualitative study were: 1) What are Head Start participants’ experiences in exploring early mathematics through picturebooks? and 2) What do
Head Start participants say about exploring early mathematics through picturebooks? In other words, the first research question focused on specific experiences participants had as they read or reviewed picturebooks while the second research question related to any additional evidence that would be relevant to better understand the phenomenon in the context of Head Start.

My findings showed that participants expressed interests towards exploring early mathematics through picturebooks. Picturebooks were commonly used in the classroom but also accessible for families. In other words, the endorsement of the phenomenon should not be limited to book access. In parallel, participants provided evidence of mathematics practices and discussions around mathematics in the school and in the home. For instance, in the classroom, children had access to mathematics manipulatives, and were read books about mathematics. In the home, parent participants reported using activity books or seeking opportunities to discuss mathematics throughout the day. In other words, early mathematics was valued in both contexts. The participants’ sayings and experiences in exploring early mathematics through picturebooks aligned with child development and contexts of learning, two cornerstones of DAP. For instance, participants appreciated the diverse representation of characters in *School’s First Day of School*, suggesting that selecting picturebooks to explore early mathematics should go beyond the sole attention to early mathematics content.

Potential obstacles emerged that could restrain the endorsement of the phenomenon. A gap between how participants envisioned the phenomenon and what they did as they read picturebooks seemed to exist. For example, the participants reported the importance of asking questions as they read aloud, but the questions raised as observed during the read-alouds rarely extended children’s thinking through building up from their sayings. Overall, intentional teaching was sparse throughout the read-alouds (i.e., scaffolding young children’s learning in
early mathematics did not naturally come from picturebooks). As in previous studies, my findings provide evidence of the challenges of posing questions of high cognitive demand throughout the read aloud to support young children’s learning in early mathematics. Based on my findings from the second sub-study, I would encourage researchers to build partnership with Head Start programs to develop sessions to guide teachers and families in endorsing the phenomenon of exploring early mathematics through picturebooks. For instance, teachers and families could provide picturebooks they are familiar with, and researchers could guide them in seeing the early mathematics content embedded in the picturebooks, and raising high cognitive demand questions.

These two sub-studies aimed to provide evidence towards a broader research question that was: How does investigating Head Start participants’ experiences, practices, and overall sayings contribute to an enhanced understanding of the phenomenon of exploring early mathematics through book reading? I discuss this question through a cross-studies analysis presented hereafter.

5.2 Cross-studies analysis

My dissertation studies rest on the assumption that the success of exploring early mathematics through book reading would depend on the exposure to (a) book reading and (b) early mathematics content (e.g., numbers & operations, geometry, measurement, patterns, Clements & Sarama, 2004; Copley et al., 2007; Erikson Institute, 2014). I also assumed that such exposure should occur in the respect of DAP, specifically the attention to child development, contexts of learning, and intentional teaching. As I studied these various elements—book reading, early mathematics content and DAP—separately throughout my two sub studies, I also paid attention to how they interact. For instance, book reading connects with the contexts of
learning (e.g., diverse representation of characters; social exchanges throughout a read-aloud) as well as child development (e.g., children’s topics of interests; child’s engagement) and intentional teaching (e.g., questions raised throughout a read-aloud; scaffolding to stimulate children’s thinking). The exposure to early mathematics also connects with the contexts of learning (e.g., mathematics is cultural) and intentional teaching (e.g., scaffolding to stimulate children’s mathematical thinking). In the next section, I decided to highlight such fluidity as I discuss how investigating Head Start participants’ experiences, practices, and overall sayings contribute to an enhanced understanding of the phenomenon of exploring early mathematics through book reading. I therefore reviewed the benefits and obstacles of the phenomenon that emerged from the participants. Throughout, I embedded the core components of DAP. A visual representation of these intertwined connections is presented in Figure 5.1.
5.2.1 Exposure to book reading and early mathematics content

A cornerstone of the phenomenon lays on extending the use of book reading to open the door to early mathematics. I discuss hereafter the benefits and obstacles of endorsing the phenomenon in view of the book reading and early mathematics content Head Start children may be exposed to.

5.2.1.1 Exposure to book reading

My findings showed that Head Start children had access to books and were read to regularly. For instance, about 97% of Head Start children included in the FACES 2006 dataset were read to weekly in the classroom (Chap. 3). These findings are consistent with a frequency of literacy practices of three to four times a week in Head Start in 2009 (Walter & Lippard,
I also reported that book reading practices were in place in the home and in the classroom (Chap. 4). For instance, children had access to books throughout the day in the classroom, and families received books to read in the home through Dolly Parton’s Imagination Library, which has been associated with an increase in the frequency parents read to their child and children’s enthusiasm for books (Conyers, 2012). I also reported that the exposure to book reading differed among children. For instance, 88% of the children were read to weekly in the home, but only 32% of the children were read to daily (Chap. 3). Also, not every parent enjoyed reading (Chap. 4). One must take these findings with care, though. For instance, a lack of enjoyment in reading from a parent does not mean that the child will not be exposed to book reading (Dickinson, De Temple, Hirschler, & Smith, 1992). Also, although the frequency of book reading is important, the quality of shared reading is of utmost importance (Zucker, Cabell, Justice, Pentimonti, & Kaderavek, 2013).

5.2.1.2 Exposure to early mathematics content

Both studies showed evidence that Head Start children were exposed to early mathematics content areas throughout the day either in the classroom or in the home (Chap. 3 and Chap. 4). For instance, more than 80% of the children were exposed to counting, geometry, and/or measurement weekly in the classroom, and about 88% of the children played counting games or read a book about numbers weekly in the home. All early mathematics content areas emerged as participants read aloud or reviewed picturebooks (Chap. 4). The phenomenon of exploring early mathematics through book reading could be implemented as an extension of practices already in place. In fact, book reading could open the door to more early mathematics content; Head Start participants initially perceived early mathematics as counting and basic mathematics, but picturebooks helped them extend their initial definition of early mathematics.
(Chap. 4). This finding contrasts with the literature reporting that, although guides to mathematize general picturebooks can be found in the literature (e.g. Hintz & Smith, 2013), the mathematics embedded in the story can be arduous to see and overlooked by the reader (Dunphy, 2020). My findings also contrast with studies around mathematics instruction in Head Start centers. For instance, classroom observations of 335 Head Start teachers showed no evidence of mathematics instruction for 50% of the teachers observed (Hindman, 2013). Such discrepancy could be explained by differences across Head Start centers in view of funds, populations served, and quality of care and educational experiences (Barnett & Friedman-Krauss, 2016; Connors & Friedman-Krauss, 2017; Joshi et al., 2016).

Interestingly, evidence of mathematics anxiety did not emerge from my findings (Chap. 4). This is important to notice as mathematics anxiety has been described as a limiting factor to children’s exposure to early mathematics content. For instance, an open-ended survey of 31 Head Start teachers showed that teachers’ mathematics anxiety influenced their instructional planning, and teachers who were more confident in their mathematics knowledge planned to teach more mathematics in their classroom (Geist, 2015). Overall, Head Start participants valued early mathematics (Chap. 4), a reassuring finding as teachers’ attitudes towards early mathematics can affect the exposure of young children to early mathematics in the classroom (Çelik, 2017; Geist, 2015) and in the home (Blevins-Knabe et al., 2000; van Voorhis et al., 2013). Finally, my findings aligned with a survey of 38 Head Start parents reporting that 85% of parents believed that doing math at home was important (Sonnenschein et al., 2016). In other words, encouraging early mathematics exploration through book reading could build up from the fact that Head Start teachers and families valued early mathematics.
5.2.2 Engaging with early mathematics through book reading: Intentional teaching in respect of child development and contexts of learning

For the phenomenon to be endorsed successfully, a second element consists of engaging young children with early mathematics. I hereafter present evidence from my findings on how adult readers engaged intentionally with the children to raise questions and scaffold their learning while respecting child development and contexts of learning.

5.2.2.1.1 Intentional teaching…

Head Start participants reported asking questions to support children’s learning as they read aloud (Chap. 4). Besides book reading, 90% of the families reported teaching their child letters, words, and numbers (Chap. 3). Evidence of discussions around early mathematics were also found in both the context of the classroom and the home (Chap. 4), an interesting finding as talking about mathematics has been described as significantly related to the children’s growth in mathematics knowledge (Klibanoff et al., 2006). Interestingly, both caregivers’ and children’s talks seem to matter. For instance, caregivers’ advanced talk about mathematics (e.g., comparing the magnitude of numbers, adding numbers, etc.) had no effect on foundational number measures such as verbal counting or numeral identification, while a child’s advanced talk did (Ramani et al., 2015).

Despite this evidence towards intentional teaching and although books can provide a meaningful context to talk about mathematics (Anderson, 1997; Skwarchuk, 2009), potential obstacles emerged from my studies that limited scaffolding and thus should be taken into consideration. First, a gap sometimes appeared between what participants intended to do as reported in interviews and what they implemented in read-alouds (Chap. 4). For instance, although a participant highlighted the importance of raising questions during read-alouds, the
number of questions that she raised as she read aloud was low. Also, despite the participants’ interest in the phenomenon, only 7% of the questions raised during all read-alouds extended children’s thinking (i.e., follow up questions building up from a child’s statement) (Chap 4). Overall, evidence of scaffolding was sparse and some early mathematics content areas were rarely discussed during read-alouds (Chap.4). The “lack of knowledge” or “patience” from the adult reader was suggested by a participant as a limitation to the endorsement of the phenomenon (Chap 4.). These findings are less surprising if we consider that the challenges of scaffolding early mathematics through book reading is not a new source of concern. For instance, a study focusing on 40 parents reading picturebooks revealed that questions raised throughout read-alouds were often of low cognitive demand (Anderson et al., 2012). Also, videotape analysis of book reading from 700 randomly selected parent-child dyads showed an overall low quality of book reading (Barnes & Puccioni, 2017). Finally, Uscianowski, Almeda, and Ginsburg (2018) examined the complexity of questions raised by parents as they read aloud a book to their child and concluded that parents would benefit from support to raise high abstraction level questions. In other words, depending on the book and the reader, the exposure to early mathematics will therefore differ (Anderson et al., 2005, 2004; Hojnoski et al., 2016). I would therefore encourage researchers to investigate ways to guide teachers and families through modeling videos, reading guides, or small-group practices.

5.2.2.1.2 …in the respect of child development

Evidence from the studies indicated that intentional teaching would occur in view of child development. Reading practices centered on the child, and picturebooks were valued for their topics of interest for children around early mathematics (Chap. 4), providing a favorable learning environment as children’s interests and parents’ engagement around literacy and
Numeracy are related (Lukie et al., 2014). Few obstacles emerged about book reading centering on the whole child. For instance, although the majority of families encouraged their child to be curious, 15% of the families “somewhat” do so (Chap. 3), suggesting that discussions in the home may not always embrace the child’s interests. Also, the length of the book, if too long, could lead to disinterest (Chap. 4). Disengagement of children has been reported in the literature. For instance, in a study focusing on exploring early mathematics through book reading, one dyad withdrew as the child was not interested in the reading session (Hojnoski et al., 2014). Finally, some children’s statements were unnoticed during read-alouds (Chap 4). Such finding may be seen as contrasting with the need for mathematics activities that support social-emotional development as well (Platas, 2017). In other words, further investigation is needed to successfully implement the phenomenon with a large group of young children.

5.2.2.1.3 … and contexts of learning.

Finally, another element to take into consideration relates to the contexts of learning. My findings contributed to a better understanding of that component of the phenomenon. Head Start participants valued the diverse representation of characters in School’s First Day of School (Chap. 4). These qualitative findings supplement quantitative findings from Chap. 3, reporting a relationship between the curriculum being culturally relevant and the odds of being offered early mathematics experiences in the classroom as well as a relationship between parents talking about family history/ethnic background and playing counting games or reading a book about numbers weekly (Chap. 3). These findings around cultural contexts add to the literature describing early mathematics as not culturally neutral (Early Childhood STEM Working Group, 2017). However, such topic is still emerging in the field of mathematics education. There is indeed a need for further studies, as mathematics picturebooks should be, first of all, high-quality picturebooks
(Whitin, 2001), to avoid sending a negative image of mathematics and demotivating young learners (Nesmith & Cooper, 2010). For instance, attention to equity has been reported as sparse in two mathematics education journals between 1968 and 2015 (Inglis & Foster, 2018). Participants also noticed characters with disabilities, highlighting the relevance of inclusive literature that goes beyond teaching about a disability (Kleekamp et al., 2018). The phenomenon will be all the more beneficial to all children if teachers and families access books with diverse representation of characters so that all children can picture themselves as young mathematicians.

5.3 Implications for Head Start programs

This section was written to be submitted to Teaching Young Children.

As an early childhood educator and researcher in early mathematics, I recently engaged in an inquiry to better understand the phenomenon of exploring early mathematics through book reading via the lens of Head Start. Indeed, it is now well established that young children should have access to early mathematics experiences (Day-Hess & Clements, 2017; Erikson Institute, 2014), and a strategy to do so consists of integrating mathematics with book reading (NAEYC & NCTM, 2010). Such practice seems all the more promising that families and preschool teachers are often more comfortable with literacy than mathematics (Cannon & Ginsburg, 2008; Copley et al., 2007). However, mathematics picturebooks are not commonly selected by preschool teachers (Pentimonti, Zucker, & Justice, 2013), and when they are, the mathematics content is usually reduced to counting (Yilmaz Genc et al., 2017). Also, mathematics picturebooks should be, first of all, a “worthy piece of literature” (Whitin, 2002, p. 503), but the literature suggests that their quality is often questionable (Halsey, 2005; Nesmith & Cooper, 2010).

Head Start, and its strong connection between families and schools, was, for me, an ideal setting in which to better understand the phenomenon. My findings showed that participants
expressed interests towards exploring early mathematics through picturebooks. Picturebooks
were commonly used in the classroom but also accessible for families. In parallel, participants
provided evidence of mathematics practices and discussions around mathematics in the school
and in the home. The participants’ sayings and experiences in exploring early mathematics
through picturebooks aligned with child development and contexts of learning, two cornerstones
of DAP. However, potential obstacles emerged that could restrain the endorsement of the
phenomenon. For instance, adult readers may not have the practice or knowledge in engaging
young children with early mathematics while reading picture books.

Building up from both the literature and my inquiry, I present hereafter a progression to
guide families and teachers towards endorsing the phenomenon of exploring early mathematics
through book reading. As presented in Figure 5.2., the progression involves: (a) reading
regularly, (b) high-quality picturebooks, (c) to stimulate young children’s thinking, (d) around
early mathematics. The progression was designed to leverage book reading practices often in
place for the more arduous task of engaging with early mathematics.

Figure 5.2. Core elements to successfully endorse the phenomenon of exploring early
mathematics through book reading
Reading regularly... For the phenomenon of exploring early mathematics through picturebooks to be successful (i.e., provide an opportunity for all children to engage in early mathematics), one must ensure that all children are read to regularly in the classroom and in the home. I found that Head Start children were read to weekly in both their classrooms (96.3% of Head Start children included in the Head Start Family and Child Experiences Survey (FACES) 2006 dataset) and their homes (91.7% of the FACES 2006 children). Although reading weekly would already provide opportunities to explore early mathematics regularly, discussions with families should be encouraged to determine how to increase their frequency as daily reading was less frequent in the home (32% of the FACES 2006 children). Access to books can be assured through libraries or programs such as Dolly Parton’s Imagination Library, as reported by one of the participants in my study.

... picturebooks with a diverse representation of characters... As a book routine strengthens, adult readers must reflect on the quality of picturebooks they select. Is the plot engaging? Does the story empower all children and their identities? Several participants in my study discussed the value of a diverse representation of characters in picturebooks. Indeed, when thoughtfully selected, picturebooks can act for young children as a reflection of themselves as well as a view to the world in which they live (Bishop, 1990), thereby empowering them and their identities, regarding race/ethnicity, ability/disability, gender orientation, etc. Prior to endorsing the phenomenon of exploring early mathematics though picturebooks, teachers and families should be introduced to guides to select anti-biased books (e.g. Derman-Sparks, 2013). Otherwise, the overrepresentation of white, middle class, cisgender and able-bodied characters in picturebooks (Koss, 2015) could reinforce the stereotype that mathematics is not for all. I
therefore strongly encourage early childhood education settings, including Head Start programs, to review picturebooks offered to families and children to assure they all feel empowered.

... to stimulate children’s thinking... Participants acknowledged the importance of raising questions throughout read-alouds aligning with a previous study reporting that Head Start families on average engage in conversations with young children several times a week (Hindman & Morrison, 2011). However, based on the participants’ read-alouds from my study and the literature (Anderson et al., 2004; Barnes & Puccioni, 2017; Hojnoski et al., 2016; Wasik et al., 2016; Zucker et al., 2021), both families and teachers would benefit from training to guide them further in extending children’s thinking. For instance, Bierman and colleagues (2015) described a dialogic reading training for Head Start families including ten home visits and six “booster” sessions. Such training would be essential before opening the door to early mathematics as picturebooks are read. I would therefore suggest early childhood education settings such as Head Start programs to offer sessions focusing on raising questions throughout a read aloud, share videos of high-quality read alouds, and practice in small groups.

... around early mathematics. Once these practices are in place (i.e., reading daily high-quality picturebooks to stimulate children’s thinking), families and teachers should explore early mathematics as they read picturebooks. A first step consists of noticing the mathematics around us, as previously described in the literature. For instance, Let’s Count is an Australian professional learning experience for early childhood educators and families to “notice, explore and talk about mathematics” through workshops (Gervasoni & Perry, 2017; Perry & Dockett, 2018; Perry, Gervasoni, Dockett, & Australasia, 2012). For instance, Head Start teachers and families could build up a collection of pictures reporting examples of early mathematics from the children’s home, neighborhood, and school. The workshop format could be used as a starting
point to review early mathematics content and extended to “mathematized” picturebooks in an
effort to provide young children with opportunities to explore mathematical ideas, construct
meanings, and ask questions (Dunphy, 2020; Fosnot & Dolk, 2001; Hintz & Smith, 2013;
Hynes-Berry & Grandau, 2019). Head Start teachers and families could reflect on guides offered
online or build up their own guides based on their picturebooks of interest.

To conclude, inquiring about the phenomenon from the perspectives of Head Start
participants led to recommendations for teachers and families to extend book reading towards
early mathematics, through four steps to progressively read regularly… picturebooks with a
diverse representation of characters…to extend children’s thinking… around early mathematics.
Parents may do less mathematics than literacy at home (Blevins-Knabe et al., 2000) as they often
consider themselves as not having the mathematics knowledge to do so (van Voorhis et al.,
2013). However, once they know how to support their child, parents are more willing to endorse
early mathematics in the home (Starkey & Klein, 2000). Picturebooks could be a meaningful tool
to guide them through this process. Even further, a partnership between teachers and families
around exploring early mathematics through picturebooks would be all the more relevant
because receiving support from school and home would have a “catalytic effect” on children’s

5.4 Future research

My findings also highlight areas for future research.

First, my studies provide another example of a study built up from the strengths-based
model of Head Start. As variation exists among Head Start programs regarding the population of
children served, funds, and the quality of care (Barnett & Friedman-Krauss, 2016; Connors &
Friedman-Krauss, 2017; Joshi, Geronimo, & Acevedo-Garcia, 2016), a broader study should be
implemented across the United States to further understand the phenomenon. For instance, what would be the perspectives of participants in Vermont, whose population of children served is 83% white? In North Dakota, whose population of children served is 36% Native Americans? (Barnett & Friedman-Krauss, 2016).

Second, my studies suggest that relationships between book reading, DAP and early mathematics depend on the content (Chap. 3). Further investigation should focus on home and school practices such as playing games or reading books about numbers, or working with measurement tools that seem to be practices relevant in the context of exploring early mathematics through book reading. Indeed, working with measurement tools is a common practice in preschool classrooms, as young children play at the sand or water table. Researchers could use this practice as a starting point to engage preschool teachers with early mathematics discussions, prior to extend early mathematics through book reading.

Third, I am very intrigued by one of the participants suggesting that exploring early mathematics through picturebooks could go beyond engaging with young children, but also be used as a tool to help teachers engage in intentional teaching. I can envision a mixed-methods study, combining teachers completing surveys about their perception of intentional teaching and classroom observations, prior and after an intervention involving the exploration of early mathematics through picturebooks. Head Start centers could also provide their CLASS® score (Pianta et al., 2008), often used to assess the quality of teacher-child interactions.

Finally, another implication relates to the need of multicultural literature to support mathematics learning (Iliev & D’Angelo, 2014). Frameworks have been described in the literature to select picturebooks to explore mathematics (e.g. Marston, 2010; van den Heuvel-
Panhuizen & Elia, 2012), but the field would benefit from a framework endorsing both early mathematics opportunities as well as a diverse representation of characters.

5.5 Concluding thoughts

The goal of my dissertation was to engage in an evidence-based reflective work around exploring early mathematics through book reading. In view of the phenomenon, my findings align well with the latest version of the DAP framework and its focus on cultural contexts of learning as well as the Early Childhood STEM Working Group (2017) highlighting that early mathematics is not culture free. Capitalizing on children’s and families’ backgrounds would contribute to a successful endorsement of the phenomenon, benefiting all children. However, I cannot envision the phenomenon of exploring early mathematics through book reading at the early childhood level, and especially in Head Start settings, being successful without considering additional circles of influence. For instance, only 40% of children living in poverty are served by Head Start, and Head Start teachers are commonly underpaid compared to those working in public schools (Barnett & Friedman-Krauss, 2016). If “early childhood mathematics education is now a national priority” (Hachey, 2013, p. 149), one must advocate beyond the classroom. As an early childhood educator focusing on early mathematics research, I hope the next step of my journey will include advocacy, so that all children are part of such a national priority.
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APPENDICES
Appendix A

Demographics Survey

Alphanumeric code: ____________

Please tell me more about yourself!

(This can include information about your gender, age, race/ethnicity, abilities, interests, jobs, etc.)

____________________________________________________________________________________

____________________________________________________________________________________

____________________________________________________________________________________

____________________________________________________________________________________

____________________________________________________________________________________

____________________________________________________________________________________

____________________________________________________________________________________

____________________________________________________________________________________
Appendix B

Read-Alouds Survey

Alphanumeric code: __________

Thank you for your participation in this brief survey after reading each of the three books selected this week. Once completed, please insert the survey in the attached envelope and return it to me next time we meet.

Please complete after reading Picturebook # 1.
1. Circle the title of the book you read today
   ___(to be completed)___   ___(to be completed)___   ___________________ (please complete)

2. What was your overall experience? What did you notice? What surprised you?
   __________________________________________
   __________________________________________
   __________________________________________

3. Did you discuss any early mathematics concepts? Why / why not?
   __________________________________________
   __________________________________________
   __________________________________________
   __________________________________________
Appendix C

Book Review Survey

Alphanumeric code: _________. *Thank you for your participation in the study. Once completed, please insert the survey in the attached envelope and mail it.*

**Picturebook ________ [title]__________**

1. Overall, what do you think of this book? What surprised you?

   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________

2. What mathematics could be discussed with a preschooler thanks to the picturebook?

   __________________________________________________________________________
   __________________________________________________________________________

3. What else could be discussed with a preschooler thanks to the picturebook?

   __________________________________________________________________________
   __________________________________________________________________________
Appendix D


Pre-pandemic

1. You read the book More than One this week. Please describe your experience.
   
   *Prompt questions: What did you like about this book? Why did you not like? How did you choose what you discussed with your child/students? Tell me more about what you chose to discuss and why you chose it. Could you show me some of the pages you discussed with the child?*

2. You also read another book that you select. Please describe your experience.
   
   *Prompt questions: Why did you select it? Could you show me some of the pages you discuss with the child?*

3. Overall, how do you feel about reading picturebooks?
   
   *Prompt questions: What do you like about picturebooks? What don’t you like? How do you feel about supporting your child’s/your students’ learning in mathematics through picturebooks?*

4. Please describe experiences NAME of the CHILD may have had in early mathematics.
   
   *Prompt questions: How engaged is NAME of the CHILD? How often do these experiences occur?*

5. Research says that young children should be provided with experiences in early mathematics that are developmentally appropriate for the child. In your own words, how would you define Early mathematics? How would you define developmentally appropriate?

6. What other thoughts about early childhood education and early mathematics do you want to share that was not captured in this interview, either related to your own school experiences as a child or as a teacher/parent or education in general?

During pandemic (First Interview)

1. Please introduce yourself

2. What practices do you engage with in your center/classroom/home to support early mathematics with young children?

3. What practices do you engage with in your center/classroom/home regarding shared reading?

4. Overall, how do you feel about early mathematics? Reading picturebooks?
   
   *Prompt questions: What do you like about picturebooks? What don’t you like? How do you feel about supporting your child’s/your students’ learning in mathematics through picturebooks?*

5. Research says that young children should be provided with experiences in early mathematics that are developmentally appropriate for the child. In your own words, how
would you define Early mathematics? How would you define developmentally appropriate?

6. What other thoughts about early childhood education and early mathematics do you want to share that was not captured in this interview, either related to your own school experiences as a child or as a teacher/parent or education in general?

**During pandemic (Second Interview)**

1. I provided you with two books to review / read to a child. Please describe your experience.  
   *Prompt questions: What did you like about these books? Why did you not like? Could you show me some of the pages that surprised you?*

2. Overall, how do you feel about reading picturebooks?  
   *Prompt questions: What do you like about picturebooks? What don’t you like? How do you feel about supporting your child’s/your students’ learning in mathematics through picturebooks?*

3. Research says that young children should be provided with experiences in early mathematics that are developmentally appropriate for the child. In your own words, how would you define Early mathematics? How would you define developmentally appropriate?

4. What other thoughts about early childhood education and early mathematics do you want to share that was not captured in this interview, either related to your own school experiences as a child or as a teacher/parent or education in general?
Appendix E

Interviews Handouts
Appendix F

Codebook

List of codes (Research Question #1)

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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</thead>
</table>
| **Participants’ experiences - Head Start early mathematics content (High Five Mathematize)**<br>A participant’s specific experience related to a book reading—as observed during a read aloud or as reported in an interview or survey—that relates to the following early mathematics content | EXP EM (Geometry & spatial sense)<br>A participant’s specific experience that relates to the content of geometry & spatial sense in view of book reading. This includes references to geometry, 2D and 3D shapes, spatial sense, composing & decomposing shapes, shape attributes, and transformation  
EXP EM (measurement)<br>A participant’s specific experience that relates to the content of measurement in view of book reading. This includes references to dimension, direct comparison, measurement attribute, standard and non-standard measurement.  
EXP EM (numbers & operations)<br>A participant’s specific experience that relates to the content of Numbers & Operations in view of book reading. This includes references to one-to-one correspondence, counting objects, counting sequence, subitizing, cardinality, combining and separating, as well as comparing and ordinal numbers.  
EXP EM (patterns)<br>A participant’s specific experience that relates to the content of Patterns in view of book reading. This includes references to classification, seriation, sequence, pattern attributes, growing patterns, and repeating patterns. |
| **Participants’ experiences - Developmentally appropriate practices (DAP)**<br>A participant’s specific experience related to a book reading—as observed during a read aloud or as reported in an interview or survey—that relates to the following DAP | EXP DAP Child development (notice)<br>A participant’s specific experience that relates to child development and its influence by individual patterns. More specifically, the participant’s experience provides evidence of an adult noticing the child as an individual (e.g., the adult rephrases the child’s ideas or adds on based on the child’s strengths, interests, and personality).  
EXP DAP Contexts of learning (social relationship)<br>A participant’s specific experience that relates to the social, cultural, or historical contexts of learning. More specifically, the participant’s experience provides evidence of a positive relationship between an adult and a child.  
EXP Contexts of learning (class culture)<br>A participant’s specific experience that relates to the social, cultural, or historical contexts of learning. More specifically, the participant’s experience provides evidence of a reference to the classroom culture.  
EXP DAP Contexts of learning (culture, language, values, customs, and beliefs)<br>A participant’s specific experience that relates to the social, cultural, and historical contexts of learning. More specifically, the participant’s experience provides evidence of a reference to representation, culture, language, values, customs, and beliefs, not including classroom culture.  
EXP DAP Intentional teaching (scaffolding & definitions)<br>A participant’s specific experience that relates to intentional teaching. More specifically, this includes scaffolding and definitions provided by participants.  
EXP DAP Intentional teaching (questions)<br>A participant’s specific experience that relates to intentional teaching. More specifically, this include questions that are asked / would be asked to the children during a read-aloud.  
EXP DIP (unnoticed)<br>A participant’s specific experience related to a developmentally inappropriate practice. More specifically, the participant’s experience provides evidence of an adult not noticing the child as an individual (e.g., the adult does not rephrase the
child’s saying or does not acknowledge the child’s statement).

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXP DIP (relationship)</td>
<td>A participant’s specific experience related to a developmentally inappropriate practice. More specifically, the participant’s experience provides evidence of a stern interaction between an adult and a child.</td>
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</tbody>
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List of codes (Research Question #2)

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<tbody>
<tr>
<td>Early mathematics</td>
<td>CONTENT (Numbers &amp; operations)</td>
</tr>
<tr>
<td>Early mathematics</td>
<td>CONTENT (Geometry &amp; spatial sense)</td>
</tr>
<tr>
<td>Early mathematics</td>
<td>CONTENT (Measurement)</td>
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<td>Early mathematics</td>
<td>CONTENT (Patterns)</td>
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<tr>
<td>Early mathematics</td>
<td>CONTENT (Others)</td>
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<td>Early mathematics</td>
<td>MATH PRACTICES (Classroom)</td>
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<td>Early mathematics</td>
<td>MATH PRACTICES (Home)</td>
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<td>Early mathematics</td>
<td>MATH PERSPECTIVE</td>
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<td>Exploring book reading</td>
<td>LITERACY PRACTICES (classroom)</td>
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<tr>
<td>Exploring book reading</td>
<td>LITERACY PRACTICES (home)</td>
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<td>Exploring book reading</td>
<td>LITERACY BOOK</td>
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<td>LITERACY PERSPECTIVE</td>
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<tr>
<td>Exploring early</td>
<td>MATH-LITERACY BOOK</td>
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<td>mathematics through book reading</td>
<td>picturebook in view of exploring early mathematics through book reading. This includes illustrations, texts, topics, layout.</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------</td>
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<tr>
<td>MATH-LITERACY PERSPECTIVE</td>
<td>A participant expresses his/her/their perspectives regarding exploring early mathematics through book reading.</td>
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