EXPLORING MEDIATION IN LITERACY DEVELOPMENT: PEER, TEACHER, AND ROBOT INTERACTIONS IN EARLY LEARNING CONTEXTS

by

IMAN BAKHODA LAKALAYEH

A dissertation submitted in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSPHY IN LITERACY, CULTURE, AND LANGUAGE

2024

Oakland University
Rochester, Michigan

Doctoral Dissertation Committee:

Gwendolyn Thompson McMillon, Ph.D., Chair
S. Rebecca Leigh, Ph.D.
W. Geoffrey Louie, Ph.D.

© Copyright by Iman Bakhoda Lakalayeh, 2024
All rights reserved

To my family, my lovely Atousa Hatami, and friends

ACKNOWLEDGMENTS

First and foremost, I would like to express my deepest gratitude to my Dissertation Chair, Dr. Gwendolyn McMillon, for her unwavering support and invaluable guidance. Dr. McMillon graciously stepped in as my advisor after my initial mentor left Oakland University, and her insights and encouragement have been instrumental in shaping my work and this journey. I am also profoundly grateful to Dr. Rebecca Leigh, a committee member and a true friend for life. From the beginning of my program to its conclusion, Dr. Leigh has been a pillar of support. Whenever I encountered challenges, I turned to her, and her profound, philosophical insight has continuously steered me forward. Her kindness and generosity have left an indelible mark on my journey. I would also like to express my appreciation to Dr. W. Geoffrey Louie for his kind and invaluable support. He provided access to his lab and tools, greatly facilitating my research. His insightful feedback and guidance were essential to shaping my study. To my family—my parents and sisters—who made countless sacrifices to support my pursuit of a Ph.D., I owe my deepest thanks. A memory that has shaped me is from when I was twelve: my father, facing financial hardship, negotiated with a language institute to accept a check so I could continue my education. This moment taught me the strength and resilience of a devoted parent, inspiring me profoundly and setting me on the path to becoming who I am today. In addition, the courage, resilience, and bravery my mom taught me guided me to take a step out in the society and follow my dreams. My heartfelt appreciation goes to the love of my life, Atousa. She stood by me during the most challenging moments, offering boundless support as I wrote and defended my dissertation. Atousa, you are my source of hope, happiness, and resilience. Lastly, I would like to thank my friends, Pourya and N.G. (Zang), for their practical assistance and dedication to my work. Their willingness to help run the study and their genuine care for the project's success mean the world to me.

Iman Bakhoda

PREFACE

In this manuscript-style dissertation, multiple research articles are presented, each addressing unique aspects of mediated literacy development. The initial manuscript, Teacher and Emergent Bilingual Student Read-Aloud Mediations, which was submitted to the *Journal of Literacy Research*, is featured in Chapter Two. This study explores the nuances of teacher-student interactions and how these mediate emergent bilingual students' comprehension and vocabulary acquisition. Chapter Three presents the article Learning to Use App Book Features During Buddy Reading, which was published in *The Journal of Literacy and Technology* in April 2024. This manuscript investigates the role of digital features in app books and how peer interactions during buddy reading foster literacy engagement and digital literacy skills. Finally, Chapter Four includes the manuscript Robot-Mediated Read-Aloud Context of Reading Comprehension and Vocabulary Development, which examines the feasibility and challenges of using a robot to support young children's literacy development through one-on-one interactive read-aloud sessions. This manuscript is submitted to *Computer & Education* journal specializing in literacy and educational technology. Together, these chapters contribute a cohesive examination of mediated learning environments, highlighting human, digital, and robotic interventions in literacy education.

ABSTRACT

EXPLORING MEDIATION IN LITERACY DEVELOPMENT: PEER, TEACHER, AND ROBOT INTERACTIONS IN EARLY LEARNING CONTEXTS

By

IMAN BAKHODA LAKALAYEH

Advisor: Gwendolyn Thompson McMillon, Ph.D.

This dissertation presents three studies focused on mediated literacy interventions to support emergent bilingual and young learners' reading comprehension and vocabulary development. Chapter Two examines teacher-student interactions during read-aloud sessions, analyzing how specific mediations enhance bilingual students' engagement and comprehension, as submitted to the *Journal of Literacy Research*. Chapter Three, published in *The Journal of Literacy and Technology*, explores how children learn to use digital features in app books during buddy reading sessions, emphasizing peer mediation's role in developing digital literacy skills. Chapter Four investigates robot-mediated read-alouds, focusing on the feasibility of a robot providing instructional support to young children, which highlights both opportunities and challenges in robotic engagement with literacy tasks. Collectively, these studies underscore the significance of diverse mediated learning approaches—teacher-guided, peer-supported, and robot-facilitated—in enhancing literacy outcomes, offering insights for educators and researchers in developing innovative, inclusive literacy interventions.

TABLE OF CONTENTS

TABLE OF CONTENTS - Continued

TABLE OF CONTENTS - Continued

TABLE OF CONTENTS - Continued

TABLE OF CONTENTS - Continued

TABLE OF CONTENTS - Continued

TABLE OF CONTENTS - Continued

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ZFM: Zone of Free Movement

ZPA: Zone of Promoted Action

ZPD: Zone of Proximal Development

ZAD: Zone of Actual Development

EBS – Emergent Bilingual Student

WIDA – World-Class Instructional Design and Assessment

MLwin – Multilevel Modeling Software

CLCD – Children’s Literature Comprehensive Database

IRB – Institutional Review Board

ESL – English as a Second Language

SES – Socioeconomic Status

CHAPTER ONE
EXPLORING THE IMPACT OF MEDIATED ENVIRONMENTS ON YOUNG CHILDREN'S LITERACY DEVELOPMENT

Abstract

This dissertation focuses on the role of mediated literacy learning environments and the impact of different types of mediation on young children's literacy development. The studies included here are interrelated by their exploration of mediated contexts, specifically (a) teacher-student interactions in read-aloud sessions, (b) peer-mediated engagement with app books, and (c) robot-mediated read-aloud sessions. Each chapter reflects an investigation into how these mediated settings support reading comprehension and vocabulary development, highlighting the value of both human and technological interventions in literacy.

Keywords: Sociocultural theory, Zone of Free Movement, Zone of Promoted Action, Zone of Proximal Development

Theoretical Frameworks

The studies in this dissertation draw from Vygotsky's sociocultural theory, specifically Valsiner's (1997) Zone Theory, which includes the Zone of Free Movement (ZFM), Zone of Promoted Action (ZPA), and Zone of Proximal Development (ZPD). Valsiner's framework, which builds on Vygotsky's (1978) foundational work, helps illustrate how different types of mediation guide children from supported to independent learning. The ZFM and ZPA are integral to this research as they provide the context and instructional guidance that scaffold young learners' cognitive development.

Teacher-Mediated Literacy in Read-Alouds

The first study, *Teacher and Emergent Bilingual Student Read-Aloud Mediations*, focuses on teacher-student interactions and explores how teacher-led mediations support emergent bilingual students' reading comprehension and vocabulary acquisition. This study is informed by research indicating that culturally relevant and dialogic read-alouds are highly beneficial for emergent bilingual students, as these practices enable students to use their background knowledge and cultural experiences in language learning (Christ & Cho, 2021; Valsiner, 1998). Teacher mediations are analyzed within the ZFM and ZPA frameworks to determine how these interactions provide students with the structure and support necessary for developing comprehension skills.

Peer-Mediated Engagement in App Book Reading

The second study, *Learning to Use App Book Features During Buddy Reading*, investigates peer-mediated interactions with digital app books, examining how children help one another use digital features to enhance comprehension and vocabulary skills.

This study aligns with Valsiner's Zone Theory by focusing on how digital app features shape the ZFM and ZPA in a peer reading context, where children's collaborative efforts mediate their movement from supported to independent use of digital literacy tools (Christ et al., 2018). This research contributes to a growing body of literature on digital literacy, underscoring the potential of peer interactions to enhance engagement with multimodal texts in early literacy education.

Robot-Mediated Literacy in Read-Aloud Contexts

The third study, *Robot-Mediated Read-Aloud Context of Reading Comprehension and Vocabulary Development*, examines the feasibility of using a robot to mediate reading comprehension and vocabulary development. In this study, the robot Pepper provides structured support through inferential questioning, using pre-programmed mediations aligned with ZFM and ZPA. Although robots can effectively engage children in structured tasks, this study addresses the challenges of robotic mediation, such as limited adaptability and emotional connection, compared to human mediators (Ahmad et al., 2021). By applying zone theory, this study aims to capture how robotic mediation can scaffold comprehension in literacy activities, offering insights into the design and potential of educational robots.

Summary

The studies in this dissertation provide a comprehensive look at the diverse applications of mediated literacy environments, highlighting the unique roles of teacher, peer, and robotic mediation in supporting young learners' literacy development. Through these investigations, this research contributes to our understanding of how human and technological supports can foster early literacy skills, offering valuable implications for educators and developers of educational tools.

CHAPTER TWO

TEACHER AND BILINGUAL STUDENT READ-ALOUD MEDIATIONS

Abstract

This study explored (a) emergent bilingual students' talk-turns during read-alouds, (b) how earlier talk-turns were related to later talk-turns, and (c) how talk-turns varied across more versus less culturally relevant books. One teacher and her four students' read-alouds across two sessions each were video recorded and transcribed. Emergent coding was used to identify talk-turn codes. Codes were categorized using zone theory constructs (Zone of Free Movement, Zone of Promoted Action, Zone of Proximal Development, Zone of Actual Development). Statistical discourse analysis showed that several Zone of Free Movement mediations (book/lesson/off-task) predicted comprehension talk-turns (developed connections/comparisons/contrasts). Zone of Promoted Action mediations predicted subsequent talk-turns: (a) /modeling were related to children expressing developed factual knowledge, (b) clarification/extension were related to children expressing developed opinions, (c) clarification/agreement were related to children expressing developed inferences, and (d) 11 talk-turns supported children expressing vocabulary knowledge.

Keywords: Emergent bilingual, Read-aloud, Mediation, Comprehension, Vocabulary

Introduction

Emergent bilingual students (EBSs) use a wide range of language resources that support the development of both their first and emerging languages (Ascenzi-Moreno, 2018). *EBS* is an asset-based term that refers to the child's ability to acquire two languages simultaneously (García, 2009). In this study, *EBS* is used to describe heterogeneous language learners from diverse cultural/linguistic backgrounds who engage with English instruction already knowing some English and another language system.

Opportunities for comprehension and vocabulary engagement are often provided for young EBSs through read-alouds (Martin-Beltrán et al., 2017). Particularly, qualitative studies have explored how EBSs express their comprehension and vocabulary knowledge during culturally relevant read-alouds, which mirror their cultural and linguistic repertoires (Cho & Christ, 2021; Lohfink & Loya, 2010). While a few studies have quantitatively explored how, within a read-aloud, teacher talk-turns are related to later student talk-turns (Mascareño et al., 2017; Zucker et al., 2010), there is a paucity in the research regarding the following: (a) quantitative analysis of talk-turns during read-alouds with EBSS, (b) how student talk-turns during the read-aloud might be related to later student talk-turns, (c) how talk-turns might vary across more versus less culturally relevant books, or (d) how talk-turns multiple turns earlier might affect subsequent talk-turns. A talk-turn begins when a particular speaker in a conversation begins talking and ends when someone else in the conversation begins talking.

We explore these issues using statistical discourse analysis (Chiu & Lehmann-Willenbrock, 2016) to identify specific talk-turns that can promote EBSs' expressions of comprehension or vocabulary knowledge during read-alouds. Further, we shift from the earlier research (Mascareño et al., 2017; Zucker et al., 2010), which focused on just one prior talk-turn (previous talk-turn→current talk-turn) to explore how multiple previous talk-turns may be related to the current talk-turn (previous talk-turn, two talk-turns earlier, three talk-turns earlier, etc.→current talk-turn). This may provide a broader and more complex perspective on how talk-turns can support EBS expressions of comprehension and vocabulary during read-alouds.

Valsiner's Zone Theory

Our study is framed using Valsiner's zone theory (1997), which builds on Vygotsky's (1978) concept of the Zone of Proximal Development (ZPD), which refers to the space in which a child is capable of learning, but requires someone more experienced to support that learning. The ZPD is distinct from the Zone of Actual Development (ZAD), which reflects a child's accomplished learning what they know and can do independently. Valsiner (1997) proposed two constructs that shape children's learning from the ZPD to the ZAD: (a) the Zone of Free Movement (ZFM,or the freedom or restriction on children in the environment, such as being able to interact with others, use tools, or engage in particular behaviors, and (b) the Zone of Promoted Action (ZPA), or mediation by others in the environment who help the student learn in particular ways.

The ZFM and the ZPA focus on the contextual constraints and opportunities that could affect the learners' development (Valsiner, 1998). The teacher opens or closes the

ZFM by imposing restrictions about how children can participate in the read-aloud. For example, she might open the ZFM by allowing children to spontaneously participate in the discussion, or close the ZFM by making children wait to participate until they are called on to respond. The ZFM "canalizes the direction of development for the child, [by] providing a framework for cognitive activity" (Blanton et al., 2005, p. 6). Likewise, the teacher or other children mediate the ZPA to persuade others to focus on learning in a specific way (Valsiner, 1997). For example, a teacher or child might ask a question about a vocabulary word meaning with the intent of focusing others' attention on that vocabulary meaning as well. Thus, the ZFM and the ZPA provide a framework for what kinds of mediations thatare occurring in the read-aloud context. This provides a framework for exploring which mediations best support EB students' expressions of comprehension and vocabulary.

A burgeoning body of research has applied Valsiner's (1997) zone theory to explore mathematics teachers' pedagogical development and teacher–student interactions (Bennison, 2020; Goos & Bennison, 2019). Emphasis on the interconnection between a child's developing abilities and the interactive context made zone theory a useful exploratory framework for the microgenetic analysis of developmental contexts dominated by interpersonal interactions, such as mathematics (Blanton et al., 2005). However, despite the Valsiner's (1997) broad understanding of the developmental contexts regarding the zones, previous studies either (a) focused on teacher development, not student development; (b) explored only teacher–student interactions, not student-student interactions; or (c) did not include ZAD in their coding or analysis. Thus, they did not account for all the moment-by-moment talk-turns in conversations (Blanton et al., 2005; Goos & Bennison, 2019). Our study expands these applications of Valsiner's theory to (a) capture the microgenetic, moment-by-moment (talk-turn by talk-turn), dynamic environment occurring during the read-aloud; (b) explore all interactions among all theoretical constructs in one analysis; and (c) use statistical discourse analysis (Chiu & Lehmann-Willenbrock, 2016) to explore how both teacher and EBSs' talk-turns predict EBSs' engagement with comprehension and vocabulary across one, two, and three previous talk-turns.

Interactions During Read-Alouds

Dialogic read-alouds are particularly important for EBSs, as they need opportunities to both hear and use language in meaningful ways to support their English-language development (Giroir et al., 2015). Interactions during read-alouds can occur between a teacher and students or among students. Thus, we review research about teacher-talk and student-talk and how they are related to students' subsequent talk-turns or literacy test outcomes to inform our study's talk-turn analysis.

Since more culturally relevant texts align better with EBSs' language and lives (Ebe, 2010), they may provide unique opportunities to engage in dialogic conversations, such as using their first language or culturally situated knowledge. While studies in which talk-turns have been statistically analyzed have not previously considered the cultural relevance of the text, we present research focused on how the cultural relevance of texts is related to students' comprehension engagement or outcomes to hypothesize how the cultural relevance might be related to talk-turns in our study.

We note the imbalance of power in dialogic conversations between teachers and EBSs and underscore the importance of teachers sharing power with students in these conversations (DiGiacomo, 2020; Wong, 2015). For example, creating space for students to initiate topics in the conversation and explain meanings and concepts from their first language/culture supports their identities and educational agency (Christ & Cho, 2021).

Teacher Talk

Past studies identified several categories of teacher–student interactions: questioning, feedback, comprehension building, and behavioral management. During read-alouds, teachers often asked many questions—literal, inferential, clarification, connection, or vocabulary (Christenson, 2016; Wright & Gotwals, 2017). These mediated the ZPA. Teachers in two studies asked more high-cognitive-demand questions (open questions) than low-cognitive-demand questions (closed questions; Price et al., 2012; Zucker et al., 2010), but teachers in other studies asked primarily low-cognitive-demand questions (Hindman et al., 2019; Mascareño et al., 2017). Further, two studies showed that the type of teacher question (ZPA) was linked to the type of student response (ZPD, ZAD); for example, inferential questions often evoked inferential responses, and literal questions often induced literal responses (Mascareño et al., 2017; Zucker et al., 2010). Teachers also provided multiple kinds of feedback (confirmations, elaborations, evaluations, and hints) during read-alouds (Mascareño et al., 2017). These also mediated the ZPA. How teachers used these kinds of feedback varied greatly across teachers (Mascareño et al., 2017). Further, many teachers' responses did not directly address any book content (e.g., nonspecific praise, ambiguous responses; Hindman et al., 2019).

Teachers also use comprehension-building talk, but less often than questions or feedback (12% in Christenson, 2016). Comprehension-building talk also mediates the ZPA. It includes low-demand (e.g., direct recall, repeating) and high-demand (e.g., predicting, analyzing, connecting) supports (Gómez et al., 2017). When teachers use more high-level talk, students have better vocabulary standardized assessment outcomes (Gómez et al., 2017). In another study, both low- and high-level teacher talk yielded higher student vocabulary scores (Zucker et al., 2013). In a third study, students had better vocabulary and comprehension outcomes when their teachers used both low- and high-level talk rather than only low-level talk or only high-level talk (Mascareño et al., 2016), perhaps because a teacher who adapts the demand level of questions to students' needs helps them acquire deeper target vocabulary knowledge (Blewitt et al., 2009).

Teachers' behavioral management talk is related to students' on-task behavior (Christenson, 2016). It mediates the ZFM. Behavioral management talk includes explaining rules and procedures and asking questions (Christenson, 2016; Gómez et al., 2017; Zucker et al., 2010). Such talk accounts for 13% to 15% of teachers' talk (Christenson, 2016; Price et al., 2012).

Of these studies, none focused specifically on EBSs, and only two studies focused on children learning in Spanish, which was their first language in a Spanish-dominant country (Gómez et al., 2017; Mascareño et al., 2017). Only three studies explored how teacher talk-turns were related to subsequent student talk-turns (Hindman et al., 2019; Mascareño et al., 2016; Zucker et al., 2010). The rest focused on how teacher talk-turns were related to gains on subsequent tests of student knowledge. Our study aims to extend this emerging body of research that explores teacher talk-turns to provide broader understanding of which teacher talk-turns are related to subsequent EBSs' expressions of comprehension and vocabulary.

Student Talk

Read-alouds can also include interactions among students, which can potentially support subsequent student engagement (Williford et al., 2013). When students talk proportionally more during read-alouds, they have higher standardized vocabulary test scores (Hindman et al., 2019). Specifically, students' questioning, explaining, interpreting, co-reasoning, gesturing, connecting, comparing, observing, describing, or inferencing *with one another* (interthinking; Pantaleo, 2007) might mediate the ZPA and hence support subsequent student expressions of comprehension and vocabulary. Likewise, EBSs' cognitive (e.g., information) and linguistic (e.g., clarifications or word meanings) supports for one another might mediate the ZPA and support subsequent student expressions of comprehension and vocabulary (Martin- Beltrán et al., 2017). Further, a student repeating a target word to create a phonological imprint or using a target word in the discussion might mediate the ZPA and students' subsequent expressions about vocabulary (Wright & Gotwals, 2017). However, a student's talk does not always improve other EBSs' outcomes—children often ignore one another's linguistic errors, thus reducing their likelihood of detection and correction (Philp et al., 2014).

We found no previous studies that analyzed sequences of students' talk-turns to determine whether they were linked to subsequent students' expressions of comprehension and vocabulary. Our study aims to extend existing talk-turn research by exploring this.

Text Cultural Relevance and Students' Comprehension Engagement and Outcomes

Qualitative research shows students' readily make inferences and connections when books are more culturally relevant (Cho & Christ, 2021; Worthy et al., 2013). This is because culturally relevant books have dimensions (characters, settings, events, and language) that align with students' identities so that they can use their language and lived experiences to support their meaning-making (Cho et al., 2022; Paris & Alim, 2017). Likewise, quantitative research with older students showed that they had better comprehension test outcomes when they independently read more (vs. less) culturally relevant texts (Christ et al., 2018; Ebe, 2010). Based on these studies, we expect that EBSs in our study may have more talk-turns that reflect their comprehension in their ZAD when the text being discussed is more culturally relevant for them. However, we acknowledge that more culturally relevant text does not necessarily mean more culturally relevant pedagogy (Ladson-Billings, 1994). For an analysis of how culturally relevant the pedagogy presented in this article was, see Christ and Cho, (2022).

Research Question

This study aims to answer the following research question: How does a teacher's or EBSs's talk-turn (reflecting mediation of the ZFM or ZPA, or expressions of comprehension or vocabulary in their ZPD) predict a subsequent student's expression of comprehension or vocabulary in their ZAD?

Based on prior research, we expect to find relations between the teacher's kind of question on a talk-turn (e.g., an inferential question) and the student's kind of subsequent talk-turn response (e.g., an inferential response). However, previous research does not suggest how multiple previous talk-turns might affect a later talk-turn, or how talk-turns other than questions might affect subsequent talk-turns. Our investigation of these aspects of read-aloud talk-turns is exploratory.

Methods

We used qualitative coding and quantitative analyses in this study. Qualitative, emergent coding (Corbin & Strauss, 2014) allowed us to capture the kinds (codes) of talk-turns that existed in our data set. Quantitative, statistical discourse analysis (Chiu & Lehmann-Willenbrock, 2016) allowed us to identify the relations between each kind of talk-turn and subsequent child talk-turns.

Setting and Participants

Our study took place in a midwestern elementary school. It was chosen due to its high numbers of EBSs (47%), of which 50% had refugee backgrounds.

The focal teacher in our study, Ms. Mason (all names are pseudonyms), was chosen because she was a teacher of EBSs whose level of English proficiency was appropriate for read-alouds. She said that her students enjoyed read-alouds, and she was interested in integrating culturally relevant books. Ms. Mason was a white, bilingual (English/Spanish) second-grade teacher. She had a master's degree in elementary education and an emergent bilingual endorsement, and she had taught students who had emerging English skills for five years (across elementary grades).

Student participants included the four children who were in Ms. Mason's second-grade, small, pullout literacy group. Fawzia was a Muslim girl from Somalian descent whose family immigrated to the United States 5.3 years earlier and spoke Somali at home. Bashiir was a Muslim boy from Somalian descent whose family immigrated to the United States 4.0 years earlier and spoke Somali at home. Amisha was a Buddhist girl of Nepalese descent whose family immigrated to the United States 1.3 years earlier and spoke Nepali at home. Juddha was a Buddhist boy of Nepalese descent whose family immigrated to the United States 1.6 years earlier and spoke Nepali at home. He sometimes helped translate for Amisha. The school provided each student's World-Class Instructional Design and Assessment (WIDA) score, which is used to assess English proficiency (WIDA, 2016). WIDA scores for Fawzia (3.3), Bashiir (3.1), Amisha (2.1), and Juddha (2.9) were in the range of emerging (2) and developing (3) English proficiency.

Researcher Positionality

Table 2.1. presents my positionalities and how these potentially affected the research. Our diverse positionalities allowed us to collaboratively engage in the research, considering a wider range of perspectives than if any one of us had conducted the research independently.

Read-Aloud Books and Sessions

The second and third authors, in collaboration with Ms. Mason, selected four picture books. First, the second and third authors used a culturally relevant text rubric (Sharma & Christ, 2017) to guide selecting several books from each of the following categories, to represent a range of cultural relevance to this group of students: books that represented Somali culture, books that represented Nepali culture, books that represented cultural differences (but not Somali or Nepali culture), and books that represented European American middle-class culture. This range allowed us to explore how cultural relevance might intersect with talk-turns. More culturally relevant books were used first to potentially increase students' comfort and engagement, and less culturally relevant books were used later. We also considered conceptual and linguistic complexity and book length in deciding if books might be appropriate for this group based on their WIDA scores.

Second, Ms. Mason considered the possible books we provided and decided which books she wanted to use. She also considered the conceptual and linguistic complexity and book length in her selection process, and whether these were appropriate given her students' English-language skills.

The final books selected represented the following:

- Somali culture and a refugee experience: *My Friend Jamal* (McQuinn, 2008), hereafter *Jamal*, read in Week 1;
- Nepali culture: *I See the Sun in Nepal* (King, 2010), hereafter *Nepal*, read in Week 2;
- cultural differences, but not a Somali or Nepali refugee experience: *The Sandwich Swap* (Queen Rania, 2010), hereafter *Sandwich*, read in Week 3; and

- European middle-class culture that is often overrepresented in classrooms (Currie, 2013): *Lilly's Big Day* (Henkes, 2014), hereafter *Lilly*, read in Week 4.

Ms. Mason read the books aloud in English (as she could not read in Nepali or Somali), and the students discussed each book with her using predominantly English, but also words and concepts from their home languages (Nepali or Somali). Students also helped the teacher with pronunciations and meanings for words relevant to their culture and home language. Each book was read and discussed across two 20-minute sessions (2 hours and 40 minutes in all).

Conceptually, the books and sessions (first vs. second) reflect the Zone of Free Movement, as they can restrict or expand the availability of educational tools and activities. As the content of the books or the session might affect the teacher's and students' talk, we entered these book titles and session numbers as control variables in our analyses.

Data Collection and Preparation

The eight read-aloud sessions were video recorded by Author 4. She mostly observed during sessions, but occasionally supported Ms. Mason with tasks, such as helping the children complete the culturally relevant text rubric after they completed each read-aloud. Based on the videos and transcriptions, both Ms. Mason and the children seemed comfortable having her in the classroom. A transcriptionist transcribed the videos organized into talk-turns (designated by when speakers changed), so that each turn was on one row of a database, and the speaker (all names are pseudonyms), book, and session number were identified. Author 4 checked and corrected the transcription. Talk-turns were counted in the database by the statistical program. The dataset had 3,315 talk-turns, including 1,806 by students.

Power Analysis

With 1,806 student talk-turns, statistical power for talk-turns at 〈 = .05 for an effect size of 0.1 is 0.99 (see Cohen et al., 2003; Konstantopoulos, 2008). Thus, we can be confident in the results at the talk-turn level. However, with just four students, statistical power at the student level is negligible, so student-level results (i.e., differences between students, such as age, race/ethnicity, WIDA scores, etc.) will not be discussed.

Data Coding

Coding Talk-Turns

Three of the authors engaged in the following iterative process of code development, each time with two samples of about 30 talk-turns from each session. First, we identified the construct from Valsiner's (1997) zone theory that seemed to align with each turn of talk: ZFM, ZPA, ZPD, or ZAD (Valsiner, 1998). Then, we used open coding and constant comparative analysis to identify codes for each talk-turn within each construct (Corbin & Strauss, 2014). For example, we identified "Can you please look up here, so I know you're listening," as mediating the ZFM, and the code "request to behave in a certain way" was developed to indicate such responses. Then, we grouped related codes within a construct together. For example, within ZFM, the codes were classified as either restricting ZFM (e.g., "request to behave in a certain way") orexpanding ZFM. How related codes are grouped within each construct is presented in Table 2.2. Note that the ZAD codes were our dependent (outcome) variables. Other codes were our independent (explanatory) variables.

After the coding development was complete, and the constructs, codes, and categories were consistently applied by the first two authors, two graduate assistants each separately coded the entire data set (all 3,315 talk-turns) using the final codes. The coding results showed high inter-rater reliability for all zone variables (Krippendorff's [2012] 〈 = .807; agreement = 82%). Discrepancies were discussed until consensus was achieved, then the consensus codes were used for analysis.

Coding the Cultural Relevance of Books

After the first session with each book, both the child and their teacher individually rated how culturally relevant each book was for the child using a rubric (see Figure A, Appendix A). Past research showed that children's and teachers' ratings can predict different aspects of student comprehension test outcomes after independent reading (Christ et al., 2018), which is why we used scores from both teachers and students. So, each child had their own self- rating and teacher rating for the cultural relevance of each book, which were used in the analysis (see the ratings in Appendix B). Aligned with previous research, a cultural relevance rubric asked the scorer to rate whether the student and the main character in the story shared the same: ethnicity or religion, gender or age, talk, places they had been, or experiences (Christ et al., 2018; Ebe, 2010). The content validity of the rubric is based on its alignment with other scholars' theoretical support for considering these aspects of cultural relevance, which reflect students' multiplicities of identities across a spectrum of very relevant to irrelevant narrative text characteristics

(Ebe, 2010; Ladson-Billings, 1994). For each dimension, the scorer rated the criterion as "the same as me," "kind of like me," or "isn't the same as me." These multiple criteria and gradations helped capture students' multiplicities of identities (Paris & Alim, 2017). Test-retest reliability for culturally relevant book ratings was not established. Cultural relevance ratings for each book, by both the student and teacher, were entered into a database for analysis.

Data Analysis

We used statistical discourse analysis (Chiu & Lehmann-Willenbrock, 2016) to model how the teacher's and students' earlier talk-turns (explanatory variables: ZFM, ZPA, ZPD) affected students' later talk-turns (dependent variables: ZAD, N = 1,806 student turns of talk). (The 1,509 teacher talk-turns were captured as lag variables within each student turn observation; e.g., "*teacher_agree [-1]*" indicated that the teacher agreed in the previous turn before the current student turn.) Information about analytic issues and how we addressed them using statistical strategies is presented in Appendix C.

To determine the factors linked to specific students' ZAD talk-turns, statistical discourse analysis modeled discrete dependent variables at the talk-turn level (Chiu & Lehmann-Willenbrock, 2016) via MLwin 3.05 software (Charlton et al, 2020). A 4-level (dependent variables within turns within students within sessions) Logit variance components model (Goldstein, 2011) tested for significant differences in the dependent variables across talk-turns, students, and sessions.

$$P(\mathbf{ZAD}_{yijt}) = F(\beta_y + \mathbf{e}_{y(ij)t} + \mathbf{f}_{yj} + \mathbf{g}_{yt}) \tag{1}$$

The probability, P(**ZAD**), that dependent variable *y* (*developed factual knowledge*, *developed opinion*, *developed inference*, *developed connection/comparison/contrast*, or *developed vocabulary*) occurred at turn *i* by student *j* in session *t* is the expected value of the dependent variable via the Logit link function (F) of the overall mean β_y and the unexplained components (*residuals*) at the turn, student, and session levels ($\mathbf{e}_{y(ij)t}$, $\mathbf{f}_{yj}$, $\mathbf{g}_{yt}$).

$$P(\mathbf{ZAD}_{yijt}) = F(\beta_y + \mathbf{e}_{y(ij)t} + \mathbf{f}_{yj} + \mathbf{g}_{yt} + \beta_{yq}\mathbf{Demographics}_{yj} + \beta_{yr}\mathbf{Book\_title}_{yt} + \beta_{y(st)}\mathbf{Book\_cultural\_relevance\_ratings}_{y(jt)} + \beta_{yu}\mathbf{Session\_Number}_{yt} + \beta_{y(xj)t}\mathbf{Earlier\_action}_{y([i-3]j)t} + \ldots + \gamma_{yz}\mathbf{Earlier\_actions}_{y([i-1]j)t} \quad (2)$$

As the researchers considered students' language abilities and interests in selecting read-aloud books, we entered student demographic variables before book cultural relevance ratings. As structural variables might affect process variables, we entered demographics and book ratings before student talk-turns. We entered the talk-turn three turns ago, followed by the talk-turn two turns ago, and then in the previous turn (chronological order).

The vector **Demographics** included variables for student *gender*, *country of birth*, *language*, *date of entry to the United States*, and WIDA scores (*listening*, *speaking*, *reading*, *writing*, *overall*). As multicollinearity is likely among this small sample of students, we entered demographic variables individually in the above order (Kennedy, 2008). In multilevel analyses, LLΔ χ^2 tests are not reliable, so we used Wald tests to identify significant effects (Goldstein, 2011).

As omitting nonsignificant isolated variables does not cause omitted variable bias, we safely removed them to increase precision and reduce multicollinearity (Kennedy, 2008). We applied this procedure to all vectors of variables.

Next, we added the **Book_title** (*Jamal*, *Nepal*, and *Sandwich*; baseline = *Lilly*). Then, we added **Book cultural relevance rating** variables—the perceived cultural relevance of each book for each student, along multiple dimensions (ethnicity or religion, gender or age, talk, places, experiences), as rated by both each student and the teacher. Then, we added whether this was the second (vs. first) session with this book (**Session_number**).

Afterward, we added variables from three turns ago (3) (*teacher* [vs. student], ZFM [*request student behavior*, *give activity instructions*, *exclude suggested topic/activity*, *narrows ZFM*, *request to participate*, *off-task*, *negotiate*], ZPA [*closed clarification question*, *open clarification question*, *open connection/comparison/contrast question*, *closed connection/comparison/contrast question*, *open vocabulary question*, *read*, *model response*, *give information*, *reiterate information*, *clarify*, *extend idea*, *agree*, *reject*], ZPD [*developing inference*, *developing connection/comparison/contrast*, *developing vocabulary*, *developing opinion*], **Earlier_Actions**). Then, we added the same variables but for later turns (2), (1) (**Earlier_Actions**). We tested these variables with earlier lags (4, –5, –6, –7, and –8), but none were significant.

Path analyses estimate direct and indirect effects via mediation tests in forward chronological order: (4) → (3) → (2) → (1) → dependent variable (Kennedy, 2008). We examined the residuals for significant outliers. To test whether these results were robust to distribution assumptions, we repeated the above analyses with the Probit link function rather than Logit (Kennedy, 2008).

Results

The variance components model showed that the students' five types of performance within their ZAD (i.e., expressing developed factual knowledge, developed opinion, developed inference, developed connections/comparisons/contrasts, and developed vocabulary) all varied mostly across turns (~77%) and less across sessions (~23%). All results discussed below describe the first entry into the regression, controlling for all previously included variables. All variables and interactions that are not reported were not significant or reflect student demographic variables that we cannot report with confidence. Analysis of residuals showed no significant outliers. Probit and other robustness tests showed similar results. Ancillary regressions and statistical tests are available upon request. Summary statistics are provided in Appendix D and E.

Factual Knowledge

EBSs' expressions of comprehension or vocabulary in their ZPD and mediations of the ZPA were linked to a subsequent student's expression of developed factual knowledge—that is, evidence of performing in their ZAD (see Table 2.3, top section). When a student expressed developing factual knowledge (ZPD) three turns earlier (3), they were 49% more likely than otherwise to show developed factual knowledge (ZAD) three turns later (49% was computed from the odds ratios [Kennedy, 2008] of regression coefficient 4.501 in Table 2.3, model 4). This reflects student development across read-aloud talk-turns.

Further, when a teacher or a student reiterated information three turns earlier (3), this mediated the ZPA so that the student was 35% more likely than otherwise to express developed factual knowledge three turns later (35% = odds ratio of 1.766 in Table 2.3, model 4). Additionally, when a teacher or student modeled a response in the previous turn (1), this mediated the ZPA so that subsequently a student was 48% more likely than otherwise to express developed factual knowledge (ZAD) in the next turn of talk. This model accounted for nearly 6% of the differences in developed factual knowledge (see Table 2.3, top section, model 7, explained variance = .059).

Developed Opinion

Mediations of the ZFM and ZPA were linked to an EBS subsequently expressing a developed opinion (ZAD, see Table 2.3, second section from top). Using the book *Jamal* restricted the ZFM with regard to expressing a developed opinion, as compared to other books. When reading *Jamal*, students' developed opinion in a talk-turn was 34% less likely, accounting for nearly 16% of its variance (see Table 2.3, developed opinion section, model 2, explained variance).

In contrast, talk-turns such as a teacher or student clarifying or extending an idea in the previous turn mediated the ZPA so that a student's developed opinion in the next turn was 24% and 46% more likely than otherwise, respectively. This model explained over 20% of the variance in developed opinions.

Developed Inference

Mediations of the ZFM and ZPA were linked to a student expressing a developed inference (ZAD; see Table 2.3). When discussing the book *Lilly*, rather than other books, the ZFM was restricted, so a student was 43% less likely to express a developed inference, accounting for nearly 27% of the variance in developed inferences (see Table 2.3, developed inference section, model 2, explained variance). Likewise, a student was 37% less likely to express an inference when discussing a book during its second session (restricted ZFM), which accounted for nearly 12% of the variance (~12% = 0.387 – 0.268; see Table 2.3, models 2 and 3, explained variance).

After a student mediated the ZPA by clarifying two turns earlier, agreeing two turns earlier, or agreeing one turn earlier, the student in the current turn was, respectively, 35%, 32%, or 30% more likely than otherwise to express a developed inference. Overall, this model explained over 45% of the variance in developed inference.

Developed Connection, Comparison, or Contrast

Mediations of the ZFM and ZPA were linked to a student expressing a developed connection, comparison, or contrast with the book (hereafter, connection/comparison/contrast)—evidence of performing in their ZAD. When discussing *Jamal*, rather than other books, a student was 7% more likely to express a connection/comparison/contrast. Also, a student was 14% more likely to express a developed connection/comparison/contrast when discussing a book in its second session rather than the first. By contrast, after a teacher's or student's off-task behavior one, two, or three turns ago (expanded ZFM), a student's developed connection/comparison/contrast was 27%, 25%, and 17% *less* likely than otherwise, respectively. After a teacher's or student's off-task behavior three or two turns earlier, off-task behavior in the next turn was, respectively, 45% or 46% more likely, both mediating 60% of the link with a student's developed connection/comparison/contrast in the current turn ($z = 3.56$, $p < .001$; $z = 2.88$, $p = .004$). Also, after a student's attempted negotiation two turns earlier with the teacher (expanded ZFM), a student's developed connection/comparison/contrast in the current turn was 40% less likely than otherwise.

When a teacher or student mediated the ZPA by asking a closed clarification question in the previous turn, a student was 14% *less* likely than otherwise to express a connection/comparison/contrast in the next turn. However, when a teacher or student focused the ZPA by asking an open connection/comparison/contrast question one turn earlier, a student was 15% more likely than otherwise to express a connection/comparison/contrast in the next turn.

These variables also showed significant interactions. When discussing *Jamal* in its second session, a student's developed connection/comparison/contrast was 33% *less* likely than otherwise. Also, when a teacher or student was off-task two turns earlier while discussing *Jamal*, a student's developed connection/comparison/contrast in the current turn was 37% *less* likely than otherwise. When a teacher or student was off-task in the previous turn, while discussing a book in its second session, a student's developed connection/comparison/contrast in the current turn was 43% *less* likely than otherwise. These interactions accounted for over 7% of the variance in developed connection/comparison/contrast (see Table 2.3). Altogether, this model accounted for nearly 19% of the variance in developed connection/comparison/contrast.

Developed Vocabulary

An EBS's expressions of vocabulary in their ZAD, and teacher or student mediations of the ZFM or ZPA, were linked to students' subsequent expressions of developed vocabulary (ZAD). A student who rated a book as culturally relevant (ZAD) was 5% more likely than others to express developed vocabulary in each talk-turn (i.e., equivalent to 94% greater likelihood of one additional instance of developed vocabulary in each session; computed from the mathematical union of independent probabilities for the 56 mean turns by a student in a session; $94\% = 1 - [100\% - 5\%]^{56}$).

When discussing *Nepal* or *Sandwich* rather than other books (ZFM), a student was 41% and 39% more likely, respectively, to express developed vocabulary (ZAD). Books and book ratings accounted for over 25% of the variance in developed vocabulary (~25% = 0.282 – 0.027; see Table 2.3, developed vocabulary section, models 1 and 2, explained variance). In contrast, when discussing a book during the second session (ZFM), a student was 35% *less* likely to express developed vocabulary (vs. in the first session). Session accounted for nearly 11% of the variance in developed vocabulary (see Table 2.3).

When a teacher or student mediated the ZPA by asking a closed clarification question three or two turns earlier, a student was 37% or 33% more likely to express developed vocabulary (ZAD), respectively (see a transcript example in Appendix F). Likewise, when a teacher or student mediated the ZPA by asking an open vocabulary question three, two, or one turn earlier, a student was 38%, 38%, or 27% more likely to express developed vocabulary (ZAD), respectively (see a transcript example in Appendix G).

Also, when a teacher mediated the ZPA by reading three or two turns earlier, a student was 35% or 31% more likely to express developed vocabulary (ZAD), respectively. Additionally, when a teacher or student mediated the ZPA by providing information three turns or one turn earlier, or reiterating information two turns earlier, a student was 37%, 23%, and 31% more likely to express developed vocabulary (ZAD), respectively. Finally, when a teacher or student mediated the ZPA by agreeing with an idea three turns earlier, a student was 30% more likely to express developed vocabulary.

Some of these variables also showed significant interactions. In the second session with a book, a teacher reading three turns earlier was 33% *less* likely to occur (because more of the book reading occurred in the first session), and a teacher or student providing information three turns earlier was 27% *less* likely (because more new information was provided in the first session)—these mediated 13% of the link between the second session and a student's expression of developed vocabulary (z = -2.63, p = .009; z = -2.93, p = .003, respectively). Further, in the second session with a book, a teacher was 44% *less* likely to read two turns earlier, which mediated 17% of the link between the second session and a student's expression of developed vocabulary (z = –2.27, p = .023). Also, after a teacher reading three turns earlier, an open vocabulary question was 40% more likely, which mediated 12% of the link between reading three turns earlier and a student's expression of developed vocabulary (z = 2.96, p = .003).

After a teacher or student provided information three turns earlier, providing information in the previous turn was 34% more likely, which mediated 10% of the link between providing information three turns earlier and a student's expression of developed vocabulary ($z = 2.10$, $p = .035$). After a teacher reading two turns earlier, an open vocabulary question in the previous turn was 44% more likely and providing information in the previous turn was 37% more likely, so these mediated 29% of the link between reading two turns earlier and a student's expression of developed vocabulary ($z = 2.07$, $p = .039$; $z = 2.09$, $p = .037$). This model explained over 51% of the variance in developed vocabulary.

Discussion

Pedagogical Contributions

Our findings underscore the importance of dialogic interactions to support EBSs' participation in read-alouds, and inform how teachers might adjust both the ZPA and ZFM to support EBSs' expressions of developed comprehension and vocabulary during read-alouds.

Zone of Promoted Action

Our findings show that specific mediation of the ZPA supported EBSs' expressions of specific aspects of comprehension or vocabulary. First, teacher and student reiterations and modeling were related to students' expressions of developed factual knowledge. This extends previous research, which found teacher low- and high-level comprehension-building talk is important to supporting students' comprehension and vocabulary test outcomes (Gómez et al., 2017; Mascareño et al., 2016; Zucker et al., 2013), by identifying specific prior teacher comprehension-building talk-turns (reiteration, modeling) that are related to specific subsequent student comprehension talk-turns (factual knowledge). Further, it extends previous research on student talk, which focused on the kinds of interactions students contributed (Williford et al., 2013), by identifying how specific kinds of student talk-turns facilitated subsequent student talk-turns that demonstrated particular aspects of comprehension.

Second, clarifying and extending were related to students' expressions of developed opinions, clarifying and agreeing were related to students' expressions of inferences, and providing more information was related to students' expressions of developed vocabulary knowledge. This extends previous research, which noted that multiple kinds of teacher feedback occurred during read-alouds (Hindman et al., 2019; Mascareño et al., 2017), but did not explore how these were related to subsequent students' comprehension talk-turns. Further, it extends previous research that showed EBSs provide cognitive and linguistic support for one another (Martin- Beltrán et al., 2017), by showing the specific mechanisms by which these support students' comprehension.

Third, many mediations of the ZPA predicted developed vocabulary outcomes. Particularly when the teacher read more, or the teacher or students asked more open-ended vocabulary questions, then students were more likely to express developed vocabulary knowledge. This extends previous research, which focused on the extent to which teachers asked low- versushigh-cognitive-demand questions (Price et al., 2012; Zucker et al., 2010) and the connection between the type of teacher question and the type of student response (e.g., inference) (Mascareño et al., 2017; Zucker et al., 2010), by identifying the connection between a particular kind of question (open-ended vocabulary) and the subsequent quality of a student's response (developed vocabulary knowledge). Further, it extends previous research that underscores the importance of student talk for increasing their standardized vocabulary test scores (Hindman et al., 2019) by demonstrating the specific importance of students asking questions and providing information to support subsequent students' developed vocabulary talk-turns.

These findings highlight specific conversation moves that teachers can use and encourage their students to use, to support EBSs' expressions of comprehension and vocabulary during read-alouds. They also demonstrate the need to shift away from the predominant focus of previous research on teacher questioning (Blewitt et al., 2009; Christenson, 2016; Zucker et al., 2010) to further explore the important roles of teacher feedback and comprehension building and student talk-turns as well. Further, these findings highlight the importance of teachers sharing power with students during read-alouds to initiate talk and respond to one another (see Christ & Cho, 2022)for further discussion about sharing power with students related to this data set).

Zone of Free Movement

Three critical aspects of the ZFM were related to several talk-turn outcomes: book, session, and off-task behavior variables.

Our findings underscore the importance of careful book selection to support EBSs' expressions of comprehension and vocabulary. A particular book was not simply better or worse. Instead, it supported some outcomes but hindered others. For example, *Jamal* (ZFM) predicted subsequent student expressions of developed opinions and developed connections/comparisons/contrasts (ZAD). *Lilly* (ZFM) predicted subsequent student expressions of developed inference (ZAD). *Nepal* and *Sandwich* predicted subsequent student expressions of developed vocabulary (ZAD). As different books support different particular outcomes, we suggest that teachers should consider choosing books accordingly. These findings extend previous research, which predominantly focused on how students were engaged or had better comprehension outcomes during culturally relevant read-alouds (Christ et al., 2018; Ebe, 2010; Worthy et al., 2013), by highlighting the complexity of how different books offer different engagement opportunities across more and less culturally relevant texts.

Further, the cultural relevance ratings for books was a significant predictor of students' expressions of vocabulary. This extends previous research, which showed that cultural relevance text ratings were related to students' comprehension test outcomes after independent reading (Christ et al., 2018; Ebe, 2010), by showing that cultural relevance text ratings are also related to students' expressions of vocabulary knowledge during read-alouds. Thus, we provide evidence that more culturally relevant text, which aligns better with EBSs' language and lives, provides unique opportunities to engage in dialogic conversations, such as using their first language or culturally situated knowledge.

Likewise, the session (the first vs. second time they discussed the book) was related to EBSs' expressions of comprehension and vocabulary. For example, students made significantly more inferences in the first session, but significantly more connection/comparison/contrasts in the second session. Interestingly, more vocabulary was introduced in the first session, but more vocabulary expressions occurred in the second session, possibly reflecting how predominantly native-English-speaking students learn vocabulary via repeated exposures to vocabulary words across classroom settings (Christ & Chiu, 2018). We found sessions also affected predominantly native-English-speaking and underserved kindergarten students' talk-turns as well; however, these students made more inferences in the second session (Christ et al., 2022). These differences may have to do with the students' age and language differences across the two studies. These findings provide empirical evidence of the benefits of reading a book across sessions.

Finally, opening ZFM to include off-task talk or negotiations of discussion content often diminished connection/comparison/contrast outcomes, but not other outcomes. This extends previous research, which identified the kinds of teachers' behavior management talk (Christenson, 2016; Gómez et al., 2017; Zucker et al., 2010), the amount of this talk that occurs during read-alouds (Christenson, 2016; Price et al., 2012), and that this talk is related to more on-task talk (Christenson, 2016), by showing that off-task talk affects different aspects of comprehension talk-turns differently. Possibly, connection/comparison/contrast outcomes required more global attention to the text and meaning-making, rendering it more vulnerable to interruptions. Thus, depending on the discussion focus, the importance of ZFM restrictions may vary.

Theoretical Contributions

This study extended previous empirical applications of zone theory (Blanton et al., 2005; Goos & Bennison, 2019) in three ways. First, we explored all the theoretical constructs in one statistical model, thereby reducing omitted variable bias (Kennedy, 2008). Second, unlike past studies' post-instruction assessments of students' ZAD via static, product-oriented instruments (e.g., Daniel et al., 2016; Lenhart et al., 2020), our study modeled students' dynamic ZAD (moment-by-moment by using talk-turns) from within the temporal and social context of their read-alouds. Third, unlike past studies that only examined teacher mediations of students (Mascareño et al., 2017; Zucker et al., 2010), our study examined mediations by both teacher and students. This was also the first application of zone theory to explore a literacy learning context (see Bennison, 2020; Goos & Bennison, 2019).

Methodological Contributions

Most past studies only focused on one previous talk- turn's link to a focal talk-turn, but our results showed that earlier talk-turns (up to three turns earlier) can influence children's expressions of comprehension or vocabulary in their ZAD. Thus, future studies should consider statistically modeling longer sequences of turns beyond two talk-turns using analyses such as statistical discourse analysis. Multiturn analysis aligns with Valsiner's (1997) theory, which suggested focusing on moment-by-moment analysis.

Further, our study demonstrated the importance of considering how both student and teacher talk-turns might mediate student ZAD responses. Past studies mostly focused on how teacher talk mediated student outcomes (Deshmukh et al., 2019; Hindman et al., 2019; Mascareño et al., 2017), or how peer-peer turns were qualitatively related (Martin-Beltrán et al., 2017). In contrast, our findings showed that student talk-turns, as well as teacher talk-turns, mediated students' expressions of comprehension or vocabulary in their ZAD. These results suggest the importance of understanding and modeling interactions among all participants in read-alouds.

Limitations and Future Research Directions

This research has three important limitations that future studies can address. First, our study only included four child participants. While our statistical power for analyzing talk-turns was adequate, our power for drawing comparisons across students was not. While comparing students was beyond the scope of our study, future research might gather data with a larger group of students so that comparisons across students would be possible. Second, as our study focused on the context of EBSs' read-alouds with their teacher, the findings cannot be generalized to other contexts. Future research might apply zone theory to explore other contexts. Third, our study only coded students' externalizations (i.e., their verbalizations and gestures) but did not capture their intra-psychological states. This might explain our finding only one relation between ZPD and ZAD (i.e., for opinions). Future studies can collect intra-psychological states and include these in the analysis as well.

Conclusion

Our study underscores the importance of EBSs' talk-turns during read-alouds, as they contribute to subsequent students' expressions of comprehension. Thus, teachers should create space for student talk, beyond just answering teachers' questions.

Additionally, our study highlights what kinds of teacher or EBS supports facilitate particular subsequent expressions of EBSs' comprehension during read-alouds. This information can be used to guide teacher and student mediation, as follows.

- Use reiterating information and modeling responses to support EBSs' expressions of developed factual knowledge.
- Use clarifying and extending information to support EBSs' expressions of developed opinions.
- Use clarifying information and agreeing to support EBSs' expressions of developed inferences.
- Use open-ended vocabulary questions to support EBSs' expressions of developed vocabulary knowledge.

Further, our findings underscore the importance of using culturally relevant texts (see Sharma and Christ [2017] for how to select these texts). Particularly, more culturally relevant texts provide more opportunities for EBSs to use their linguistic repertoires to share developed vocabulary knowledge during read-alouds. Finally, our findings support engaging in read-alouds with EBSs across multiple days, as their kinds of responses can shift across time (e.g., more inferences on Day 1, and more connections on Day 2).

Acknowledgments

We are grateful for the generous support of the Oakland University Research Committee, and the teacher and students for sharing their learning with us.

Table 2.1.

Researcher Positionalities

Author	Positionality	How this positionality might affect the research
1	The first author is a bilingual (Persian/English), white, Persian, international PhD student in language, literacy, and culture. He has been living in the United States for three years. He follows sociocultural epistemology and ontology and believes that there are multiple interpretations of one objective reality.	His positionality guides him to approach this research from a sociocultural lens that emphasizes the duality of human–environment interactions, which supported his consideration of the dynamic read-aloud interactions through the lens of zone theory to inform our code development and interpretation of the data. However, his lack of experience with U.S. schools also limited his ability to interpret the data related to understanding U.S. school systems and instruction.

Table 2.2.

Constructs, Categories, Codes, and Examples From Transcripts

Constructs	Categories	Codes	Examples from transcripts
Zone of Free Movement (ZFM)	Restricted ZFM	Request to behave in a certain way	Ms. Mason: It is really important that we're not talking when others are talking, right.
		Provide instructions for the activity	Ms. Mason: That's okay, I'm gonna have you turn and talk about connections that you have with the story, things that are the same, and things that are different from you in the story. Okay.
		Exclude a suggested activity or topic	Ms. Mason: (*to Bashiir*) We'll look at it later (*referring to the international flags in the illustration that Bashiir wants to continue investigating*).
		Request to participate	Juddha: (*raising his hand*)
		Invite students to participate in discussion	Ms. Mason: (*inviting Bashiir to participate*) Bashiir, how about you, buddy [what do you think]?
		Engage in off-topic/task conversation or behavior	Amisha: (*pulling her sweater up over her head*) I want to take off this.
	Expanded ZFM	Negotiate (to participate in different ways than the teacher proposed)	Juddha: (*to Ms. Mason*) I want to partner with you [for the pair-share activity discussing the book].
Zone of Promoted Action (ZPA)	Questions	Question for clarification—closed	Ms. Mason: (*asking about the meaning for the word "Didi"*) Like an aunt? (*She wants to know if this is the word's meaning.*)
		Question for clarification—open	Amisha: (*asking about the characters in the book*) Who is [the] English [-speaking one]?
		Question for CCC (connect, compare, contrast)—open	Ms. Mason: (*addressing Bashiir*) What do you have for your [sacred book]…for Islam? (*She is trying to build connections across sacred books—the Bible had just been mentioned on a previous page, and there is an illustration of the Koran on this page.*)

Table 2.2 Continued

Constructs	Categories	Codes	Examples from transcripts
		Question for CCC (connect, compare, contrast)—closed	Ms. Mason: (*showing a picture of a child in Nepal wearing a school uniform in the book*) Okay. Did you wear uniforms like this?
		Question for vocabulary—open	Ms. Mason: (*showing an illustration of a chair in the book*) What do you call this in Somali?
	Inputs	Question for vocabulary—closed	Amisha: Do you know how to say in Nepali "chicken"?
		Read (the book)	Ms. Mason: (*reading to the class*) At dawn I see the sun. It paints the mountains pink and gold…
		Model (response)	Ms. Mason: (*showing a sad expression on her face*) She's sad. She's disappointed.
		Provide information	Ms. Mason: (*pointing at the illustration*) So this is a Japanese flag, here's a Jordan flag…
	Responses	Reiterate	Ms. Mason: (*repeating the same question*) Who's a friend you have at school?
		Clarify	Ms. Mason: (*clarifying the meaning of the word "bride"*) Bride is the woman getting married.
		Extend	Ms. Mason: (*extending Bashiir's statement that his mom "buys things" at the store*) So she maybe goes to the store to buy oranges.
		Agree	Fawzia: (*nodding to show that she agrees that in Africa she played with her friends*)
		Reject	Ms. Mason: No, I think that's Norway (*referring to the flag that Bashiir is pointing to and calling the Nepali flag*).
Zone of Proximal Development (ZPD)	Developing potentiality	Developing inference	Bashiir: (*responding to Ms. Mason's question about what Lilly will do when the flower girl freezes and does not walk down the aisle*) Um, help her? …I don't know, I'm just guessing.

Table 2.2 Continued

Constructs	Categories	Codes	Examples from transcripts
		Developing connection, comparison, or contrast	Bashiir: (*trying to make a connection about the farm animals in the book* Sun) When goats…don't think…they are…they don't lay milk…they're just regular… (*He is misunderstanding that in this book, the water buffalo provides the milk, and seems to mistake this animal for a goat.*)
		Developing vocabulary	Amisha: Wedding means, um, wife and, and… (*stops talking and looks unsure about what else to day*).
		Developing opinion	Bashiir: (*in response to Ms. Mason asking them to make a connection to the wedding in the story*) I don't like weddings. (*This is developing because he provides no support for his opinion.*)
		Developing factual knowledge	Bashiir: Nepali is right there (*pointing at a flag in the illustration, but it is not a Nepali flag*).
Zone of Actual Development (ZAD)	Developed ability	Developed factual knowledge	Bashiir: There's no Somali flag (*looking at the illustration, which does not include a Somali flag*).
		Developed opinion	Bashiir: (*pointing at the word "stupid" in the book, which was used while the children were fighting*) This is a bad word.
		Developed inference	Amisha: (*discussing how the children made up after the fight, and in response to the teacher's statement that the children never said they were sorry*) Hug means sorry. (*She uses her prior knowledge and the illustration in the book of the girls hugging to infer that the hug was their way of apologizing.*)
		Developed connection, comparison, or contrast	Juddha: Everybody is nice to me [here in the United States], but my best, best friend is in Nepal. (*She is making a connection to the children in the book holding hands and playing with their friends.*)
		Developed vocabulary	Bashiir: Karun means chicken [in Somali].

Table 2.3.

Summary of Multivariate Outcome, Multilevel Cross-Classification Results with Regression Coefficients (Standard Errors in Parentheses), Asterisks to Indicate Significance, and Significant Odds Ratios Marked as +/-%

	Developed factual knowledge + developed opinion + Developed inference + Developed CCC (connection, comparison, contrast) + Developed vocabulary												
Explanatory Variable	Model 1 WIDA	Model 2 + Book		Model 3 + lesson		Model 4 + lag 3		Model 5 + lag 2		Model 6 +lag 1		Model 7 + Interaction	
	ZAD-Developed factual knowledge												
ZPA-Reiterates (-3)						1.76	*	1.76	*	1.87	*	1.85	*
						(0.77)	+35%	(0.77)	+35%	(0.78)	+37%	(0.79)	+37%
ZPD-Developing factual knowledge (-3)						4.50	***	4.49	***	4.6	***	4.61	***
						(1.28)	+49%	(1.2)	+49%	(1.28)	+49%	(1.28)	+49%
ZPA-Modeling (response) (-1)										3.97	**	3.98	**
										(1.17)	+48%	(1.17)	+48%
Explained variance	0	0		0		0.04		0.04		0.06		0.05	
	ZAD-Developed opinion												
ZFM-Jamal		-1.646	**	-1.635	**	-1.630	**	-1.634	**	-1.683	***	-1.702	***
		(0.483)	-34%	(0.482)	-34%	(0.481)	-34%	(0.481)	-34%	(0.478)	-34%	(0.481)	-35%
ZPA-Clarifying (-1)										1.052	**	1.063	**
										(0.388)	+24%	(0.387)	+24%
ZPA-Extends (-1)										3.078	***	3.079	***
										(0.625)	+46%	(0.626)	+46%
Explained variance	0	0.159		0.158		0.157		0.157		0.199		0.202	

Table 2.3. Continued

	Developed factual knowledge + developed opinion + Developed inference + Developed CCC (connection, comparison, contrast) + Developed vocabulary													
Explanatory Variable	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6		Model 7	
	WIDA		+ Book		+ lesson		+ lag 3		+ lag 2		+lag 1		+ Interaction	
	ZAD-Developed Inference													
ZFM-Lilly			2.569	***	2.493	***	2.486	***	2.439	***	2.468	***	2.486	***
			(0.649)	+43%	(0.566)	+42%	(0.566)	+42%	(0.557)	+42%	(0.593)	+42%	(0.595)	+42%
ZFM-Second Lesson					-1.936	*	-1.934	*	-1.954	*	-2.093	*	-2.136	*
					(0.898)	-37%	(0.898)	-37%	(0.884)	-38%	(0.958)	-39%	(0.974)	-39%
ZPA_ Clarifying (-2)									1.739	*	1.645	*	1.645	*
									(0.711)	+35%	(0.772)	+34%	(0.771)	+34%
ZPA-Agrees (-2)									1.542	**	1.537	**	1.538	**
									(0.527)	+32%	(0.566)	+32%	(0.566)	+32%
ZPA-Agrees (-1)											1.392	*	1.391	*
											(0.565)	+30%	(0.565)	+30%
Explained variance	0		0.268		0.387		0.387		0.417		0.449		0.455	
	ZAD-Developed CCC (connect, compare, contrast)													
ZFM-Jamal			0.286	*	0.262	*	0.260	*	0.261	*	0.260	*	-0.764	
			(0.116)	+6%	(0.117)	+6%	(0.117)	+6%	(0.118)	+6%	(0.119)	+6%	(0.409)	
ZFM-Second Lesson					0.596	***	0.611	***	0.627	***	0.616	***	-0.765	
					(0.115)	+14%	(0.116)	+15%	(0.117)	+15%	(0.117)	+15%	(0.584)	
ZFM-engaging in off topic							-0.717	**	-0.288		-0.137		-0.133	
/Task talk or behavior (-3)							(0.246)	-17%	(0.266)		(0.269)		(0.276)	
ZFM-engaging in off topic									-1.085	***	-0.790	**	-1.234	**
/Task talk or behavior (-2)									(0.296)	-25%	(0.301)	-19%	(0.423)	-27%
ZFM-negotiate (participants									-2.191	*	-2.194	*	-2.077	*

Table 2.3. Continued

	Developed factual knowledge + developed opinion + Developed inference + Developed CCC (connection, comparison, contrast) + Developed vocabulary													
Explanatory Variable	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6		Model 7	
	WIDA		+ Book		+ lesson		+ lag 3		+ lag 2		+lag 1		+ Interaction	
differently than the teacher proposed) (-2)									(1.043)	-40%	(1.029)	-40%	(1.034)	-39%
ZFM-engaging in off topic/task											-1.187	**	-1.832	**
talk or behavior (-1)											(0.404)	-27%	(0.597)	-36%
ZPA- Question for clarification-closed (-1)											-0.575	*	-0.685	*
											(0.261)	-14%	(0.266)	-16%
ZPA-Question for CCC-open (-1)											0.630	*	0.507	*
											(0.251)	+15%	(0.256)	+12%
ZFM-Jamal													-1.553	***
***ZFM-Second Lesson**													(0.246)	-33%
ZFM-Jamal *ZFM-engaging in off													-1.911	*
topic/task conversation or behavior (-2)													(0.814)	-37%
ZFM-Second Lesson*ZFM-engage in													-2.544	*
off topic/task talk or behavior (-1)													(1.164)	-43%
Explained variance	0		0.006		0.03.		0.042		0.083		0.113		0.189	
	ZAD-Developed vocabulary													
ZAD-WIDA_2018_sum	0.794	*	1.000	*	0.966	*	0.974	**	1.064	**	1.101	**	1.009	*
	(0.371)	+19%	(0.405)	+23%	(0.374)	+23%	(0.363)	+23%	(0.401)	+24%	(0.401)	+25%	(0.451)	+23%
ZFM-Nepal			2.345	***	2.213	***	2.244	***	2.161	***	2.121	***	2.233	***

Table 2.3. Continued

	Developed factual knowledge + developed opinion + Developed inference + Developed CCC (connection, comparison, contrast) + Developed vocabulary												
Explanatory Variable	Model 1	Model 2		Model 3		Model 4		Model 5		Model 6		Model 7	
	WIDA	+ Book		+ lesson		+ lag 3		+ lag 2		+lag 1		+ Interaction	
		(0.413)	+41%	(0.385)	+40%	(0.366	+40%	(0.393)	+40%	(0.398)	+39%	(0.455)	+40%
ZFM-Sandwich		2.054	***	2.329	***	2.255	***	2.093	***	2.023	***	2.076	***
		(0.556)	+39%	(0.536)	+41%	(0.507)	+41%	(0.546)	+39%	(0.545)	+38%	(0.623)	+39%
ZAD_ Student's sum of cultural relevance		0.440	**	0.439	***	0.453	***	0.451	**	0.446	**	0.428	**
ratings for a book		(0.130)	+11%	(0.124)	+11%	(0.119)	+11%	(0.130)	+11%	(0.131)	+11%	(0.146)	+11%
ZFM- Second Lesson				-1.725	**	-1.498	**	-1.244	*	-1.194	*	-0.024	
				(0.520)	-35%	(0.493)	-32%	(0.532)	-28%	(0.534)	-27%	(0.767)	
ZPA-Question for clarification-closed						1.938	***	2.002	***	1.942	***	2.014	***
(-3)						(0.423)	+37%	(0.464)	+38%	(0462)	+37%	(0527)	+38%
ZPA-Question for vocabulary-open (-3)						2.037	**	1.979	**	1.780	*	1.772	*
						(0.661)	38%	(0.736)	+38%	(0778)	+36%	(0.846)	+35%
ZPA-Reading (the book aloud) (-3)						1.773	***	1.559	***	1.616	**	1.655	**
						(0.469)	+35%	(0.533)	+33%	(0.528)	+33%	(0.594)	+34%
ZPA-Provide information (-3)						1.909	***	1.886	***	1.705	**	1.740	***
						(0.468)	+37%	(0.509)	+37%	(0.515)	+35%	(0.580)	+35%
ZPA-Agrees (-3)						1.397	***	1.269	***	1.205	**	1.156	*
						(0.395)	+30%	(0.428)	+28%	(0.428)	+27%	(0.497)	+26%
ZPA-Question for clarification-closed								1.583	**	1.618	**	1.656	**

Table 2.3. Continued

	Developed factual knowledge + developed opinion + Developed inference + Developed CCC (connection, comparison, contrast) + Developed vocabulary									
Explanatory Variable	Model 1 WIDA	Model 2 + Book	Model 3 + lesson	Model 4 + lag 3	Model 5 + lag 2		Model 6 +lag 1		Model 7 + Interaction	
(-2)					(0.516)	+33%	(0.516)	+33%	(0.585)	+34%
ZPA-Question for vocabulary-open (-2)					2.035	***	2.054	***	1.847	**
					(0.539)	+38%	(0.531)	+39%	(0.627)	+36%
ZPA-Reading (the book aloud) (-2)					1.452	**	1.025		1.189	
					(0.523)	+31%	(0554)		(0.617)	
ZPA-Reiterates (-2)					1.448	**	1.351	**	1.389	*
					(0.508)	+31%	(0.508)	+29%	(0.579)	+30%
ZPA-Question for vocabulary-open (-1)							1.235	*	2.408	**
							(0.560)	+27%	(0.755)	+42%
ZPA-Provides information (-1)							1.019	*	0.945	
							(0.457)	+23%	(0.518)	
ZFM-Second Lesson									3.675	*
***ZPA-Question for vocabulary-open (-1)**									(1.500)	+48%
Explained variance	0.027	0.282	0.389	0.442	0.455		0.457		0.513	

CHAPTER THREE
LEARNING TO USE APP BOOK FEATURES DURING BUDDY READING

Abstract

We explored how peer buddies and digital features shaped the Zone of Free Movement (what is available in the learning environment) and Zone Promoted Action (what attempts to draw learners' attention in the learning environment) during interactive, multimodal peer buddy reading to support a shift from a peer buddy's Zone of Proximal Development (what they are ready to do with support) to their new Zone of Actual Development (what they can newly do independently—i.e., learning) for activating digital features in the app book. Nineteen focal kindergarteners' video-recorded app book reading across a total of 15 peer buddy reading sessions (225 minutes total) were transcribed for analysis. Emergent coding and constant comparative methods were used to develop codes and identify patterns. Findings showed that buddies employed the following four actions to mediate their peer buddy's shift toward effective use of the app book features: (1) verbal mediation and pointing out digital features; (2) modeling digital feature use; (3) integrated verbal mediation, pointing, and modeling digital feature use; and (4) physical support for activating a digital feature. Further, to facilitate these mediations, we found that buddies needed to share the iPad (i.e., providing access to hotspots in the Zone of Free Movement) and collaboratively engage together (i.e., a shared focus within the Zone of Proximal Attention).

Keywords: Buddy reading, app books, digital books, electronic features, digital features, Zone Theory

Introduction

Technological progress has created an educational opportunity for children to use interactive, multimodal digital texts both at home and in school (Wang et al., 2019; Blackwell et al., 2015; Kabali et al., 2015; Rideout, 2017; Shuler, 2012). Interactive, multimodal app book reading is distinguished from reading traditional texts due to its multimodal features (e.g., sounds, animation, hotspots) that can be activated by children's touch. An app book, also known as a digital book or e-book, is an interactive, multimodal form of literature accessible through electronic devices like tablets and smartphones. Unlike traditional books, app books incorporate dynamic features such as animations, sounds, and interactive hotspots that can be activated through touch, offering a more engaging reading experience by combining visual, auditory, and tactile elements (Kucirkova, Littleton, & Cremin, 2017; De Jong & Bus, 2003). In contrast to traditional text reading, app book features create new and more complex pathways of engaging children in reading (Geist, 2014; Marsh et al., 2015).

Digital features in these books can potentially assist children in making meaning (Wang et al., 2019). Thus, children's ability to use these features is important (Wang et al., 2019; Blackwell et al., 2015; Kabali et al., 2015; Rideout, 2017). However, while research has explored how children learn to engage in collaborative meaning-making while buddy reading with app books (Christ et al. 2018), it has not explored the more basic question of how children learn to use the digital features in app books. In prior research on app book buddy reading, the emphasis has largely been on understanding how buddies contribute to each other's comprehension through meaning-making processes (Christ et al. 2018; Wang et al., 2019; Brown, 2016; Simpson et al., 2013). Recognizing the potential of digital features in these app books to enhance comprehension, this study undertakes a fine-grained, microgenetic analysis of the peer buddy reading context to understand how both a child's buddy and the app book features themselves potentially mediate a child's learning to use a digital feature. This study can inform improved design of peer buddy reading learning contexts and app book features.

Theoretical Framework

From a sociocultural perspective (Vygotsky, 1978), young children acquire knowledge via interactions with others and through the use of cultural instruments such as multimodal interactive app books (Plowman et al., 2010; Stephen, Stevenson, & Adey, 2013). The digital features, such as hotspots, navigation, etc., have the potential to mediate children's world through creating interactive media environments that support children's meaning-making experience (Kucirkova, Sheehy, & Messer, 2015; Marsh, 2016; Neumann & Neumann, 2014). Additionally, the digital buddy reading environment is replete with collaborative exploration and practice (e.g., sharing ideas, explanation). This environment could also assist students' experience of reading as a sociocultural phenomenon (Javorsky & Trainin, 2014).

To better understand how both digital features and buddies may mediate young children's learning to use digital features, this study adopted Valsiner's (1987) Zone Theory to undertake a microgenetic analysis. Inspired by Vygotsky's notion of Zone of Proximal Development, Valsiner (1987) introduced interactive zones as a developmental model by conceptualizing two more zones, the Zone of Free Movement (ZFM) and the

Zone of Promoted Action (ZPA), which support or constrain a child's development. The ZFM refers to the boundaries, constraints, and restrictions that are applied to the context (Lightfoot, 1988; Blanton et al., 2005). For example, ZFM considers what digital features are available in the book, and what functions they allow. The ZPA refers to the "set of activities, objects, or areas in the environment" (Valsiner, 1987, pp. 99–100) that are used to convince a child to act in a certain way (Blanton et al., 2005). For example, ZPA considers how a digital feature might light up, encouraging a child to touch it; or a buddy might suggest pressing a feature. The ZFM and ZPA could potentially support a student to shift from their Zone of Proximal Development (i.e., when they need support to use a digital feature effectively) to their new Zone of Actual Development (i.e., when they can newly use the digital feature effectively and independently; see Figure 3.1).

Further, since both buddies and features can potentially shape the ZFM and ZPA during interactive app book peer buddy reading, we adapt Valsiner's Zone Theory by creating subcategories that reflect this: Zone of Free Movement shaped by a buddy (ZFM-B), Zone of Free Movement shaped by a digital feature (ZFM-F), Zone of Promoted Action shaped by a buddy (ZPA-B) and Zone of Promoted Action shaped by a digital feature (ZPA-F; see Figure 3.2).

Research Question

Our research question is the following: How do buddies and digital features shape the Zone of Free Movement (what is available in the learning environment) and Zone of Promoted Action (what attempts to draw learners' attention in the learning environment) during interactive, multimodal peer buddy reading to support development from their

Zone of Proximal Development (what they can do only with support) to their new Zone of Actual Development (what they can do independently) for activating digital features in the book?

Literature Review

Buddy reading offers a social atmosphere in which emerging and beginning readers may collaborate to engage with text (Christ et al., 2013; Flint, 2010). Broadly, buddies' patterns of interactions during app book reading impact to what extent the buddies support one another's engagement with the text (Christ et al., 2015). Young children have been observed engaging in the following patterns during buddy reading: (a) parallel functioning where each buddy works on their own without interacting with the other buddy; (b) collaborative interactions through which buddies interactively engage with the text; and (c) tutor-tutee interactions where one buddy instructs the other buddy about how to engage with the text.

More specifically, studies have shown specific impacts of children's interactions during buddy reading with digital books. For example, a case study by Erdemir and Brutt-Griffler (2020) underscored the importance of social interactions that provide language feedback for English Language Learners' vocabulary learning during app book buddy reading. Likewise, a series of studies by Shamir and colleagues showed that interaction between buddies during CD-ROM book reading supported their book comprehension (Shamir, 2009; Shamir & Korat, 2007; Shamir, Korat, & Barbi, 2008).

Further, studies of buddy reading with digital books have demonstrated that specific interactions support children's learning outcomes. For example, the social interactions between buddies engaged with e-readers or app books abound with monitoring behaviors, such as asking questions, drawing attention, and meaning negotiation that support deeper comprehension (Christ et al. 2018; Brown, 2016). Likewise, Christ et al. (2019) studied 53 kindergarteners' app book buddy reading interactions and observed that buddies supported one another's better inference, critical thinking, and vocabulary meaning generation by asking questions, drawing attention to book content, debating, or negotiating. Additionally, Brown (2016) qualitatively explored second graders' interactive e-book reading and found that buddies provided verbal support to help one another navigate the e-book.

Across previous app book buddy reading studies, the focus has been predominantly on buddies' meaning-making processes to improve their comprehension (Christ et al. 2018; Wang et al., 2019; Brown, 2016; Simpson et al., 2013). However, since using digital features can support their comprehension process, it seems warranted to also explore how children learn to use digital features through app book buddy reading as well. Exploring this is the focus of the present article.

Methods

We employed a case study approach (Yin, 1984, p. 23) which provided an in-depth exploration of how buddies and digital features mediated both the Zone of Free Movement (ZFM) and the Zone of Promoted Action (ZPA) in ways that canalized buddies' movement from their Zone of Proximal Development (ZPD; i.e., when they need support to use a digital feature effectively) to their new Zone of Actual

Development (ZAD; i.e., when they can newly use the digital feature effectively independently).

The data used in this paper were collected as part of a broader study (Christ et al. 2018; , Christ et al. 2019) in which children across four classrooms engaged with 12 app books. For each book, the teacher first read it aloud and modeled activating the digital features while projecting it on a screen using a document camera (so children could see finger touch and swipe movements). Then, afterward, children were given two opportunities in the same week to read the modeled book with a same-aged buddy. This paper focuses on a subset of the buddy reading data to explore how children successfully supported one another to learn to use the digital features.

Setting

This paper focuses on data from two classrooms in a Midwest suburban school. These two classrooms' data were chosen because the video-recordings best showed children's finger movements while interacting with the app books (videos for the other two classrooms were more difficult to see and interpret). The school was chosen for the broader study because its students were diverse ethnically, linguistically, and socio-economically. The kindergarten classrooms were chosen based on teachers in the school who allowed their students to participate in the study.

Selection of Focal Data from the Prior Study

The first author viewed all 253 buddy reading videos from the two focal classrooms that were part of the larger dataset. Videos to be included in this study were chosen if they had an example of (a) one child initially unable to use a digital feature, and

(b) the second child somehow mediating that first child’s activation of the digital feature, which resulted in (c) the first child successfully using the digital feature. All videos that did not meet these criteria were excluded from the study. Selecting this subset of data allowed us to focus on how buddies successfully mediated one another’s learning to use digital features while reading the app book together. In all, 15 focal videos were identified for analysis.

Participants

The 19 children who appeared in the selected focal videos were included as participants in this study. Of these, 10 were female and nine were male. Five children were Black, three were Asian, and 11 were White. All children were between 5 and 6 years old. All names used in this study are pseudonyms to maintain the confidentiality and privacy of the participants

App Books

Across the 15 selected focal videos, eight app books out of the 12 from the broader study were represented. Table 3.1 presents the names of the app books that were included in the analysis and their interactive features.

Data Collection Procedures

The 15 selected focal videos were part of the broader study’s 253 buddy reading videos. In the broader study, before buddy reading, children were told to “read with your buddy” and “help your buddy read the book.” The sessions were video-recorded to capture the details of buddies’ interactions with one another and the app book. Across the 15 videos, 225 minutes of buddy reading interactions were analyzed.

Data Coding and Analysis

The unit of analysis was the interactive turn each buddy took during collaborative reading. A "turn" started when one child spoke or touched and ended when the other child began talking or touching. Sometimes turns overlapped somewhat as both children talked/touched simultaneously.

We began coding with a sample of three of the focal videos, across which children showed different kinds of interactions related to using the digital features. Initially, the first author determined which Valsiner's Zone Theory construct (ZFM, ZPA, ZPD, or ZAD; Valsiner, 1998) seemed to correspond with each turn from the video data. Next, the first and second authors used emergent coding and constant comparative analysis (Corbin & Strauss, 2014) to generate codes that described how the turn was addressing that theoretical construct (e.g., a child addressed the ZPA by modeling how to touch and use a hotspot in the book). We discussed and honed the codes over time and across the three sample focal videos through a process of separately applying the codes, meeting to discuss coding discrepancies, and then developing consensus and refining the codes or their definitions to align with our developed understandings. This process yielded clearer definitions for each code. Through this process, the codes related to ZFM, ZPA, ZPD, and ZAD emerged (see Table 3.2) and were used for coding. After the final codes were developed, a sample of five additional sessions from the data pool were coded by two coders. Inter-coder agreement was 93.1%. Once we had established the reliability of the codes, the remaining seven sessions were coded by just one coder.

Finally, to identify patterns that depicted how the ZFM and ZPA turns were related to the canalization of a child's movement from their ZPD to ZAD regarding the use of a digital feature, we used constant comparative methods (Corbin & Strauss, 2014). Four patterns were found and are presented in the findings section.

Results

We found four patterns that described ways buddies mediated each other's shifts toward effective use of electronic features: (1) Children verbally mediated their buddy's digital feature use (i.e., telling them how to engage with the feature) and also pointed out the digital feature (without activating it); (2) Children mediated their buddy's digital feature use by modeling digital feature use; (3) Children mediated their buddy's digital feature use by integrating verbal mediation, pointing out the digital feature, and modeling digital feature use; and (4) Children mediated their buddy's digital feature use by physically supporting them to use a digital feature.

Verbal Mediation and Pointing Out Digital Features

Buddies used verbal mediation and pointing out digital features to guide their partner's feature use after they were initially unable to use the digital feature independently. Verbal mediation provided oral instructions about how to use a digital feature and pointing showed where the digital feature was located on the page (without activating it). The following excerpt was from a video of Thiago and Sarah (pseudonyms) engaging with the app book, *The Artist Mortimer*. The page that they discussed in this excerpt had navigation features, such as turning the pages backward or forward, which was activated by touching the upper left or right part of the page.

Line	Student	Transcript	Code	Theoretical construct
A1	Thiago	[the iPad is between the children so that both buddies have easy access]	Share the device	ZFM-Buddy
A2	Thiago	Do you want to turn the page?	Buddy asks question	ZPA-Buddy
A3	Sarah	OK [trying to turn the page, but not finding the right spot to activate the page turn]	Developing ability to use the digital navigation feature (but not yet successful)	ZPD
A4	Thiago	No, come up here [showing the right corner of the screen] or up here [showing the left corner of the screen]	Buddy provides verbal mediation and points to show where the digital feature is located on the page (without activating it)	ZPA-Buddy
A5	Sarah	[Sara followed the successfully turns the page forward by touching the right corner of the iPad]	Developed ability to use the digital navigation feature (activated it)	ZAD

In this example, Thiago framed the Zone of Free Movement by sharing the device (line A1) and Zone of Promoted Action by suggesting his buddy turn the page (line A2). Sarah was unable to turn the page, showing that her ability to effectively use the digital navigation feature was still developing (Zone of Proximal Development, line A3). Thiago mediated Sarah's developing ability by providing a verbal mediation and pointing to show where the digital feature was located on the page (line, A4). This mediation provided enough support to canalize Sarah's developing ability into a developed ability to use the digital navigation feature (line A5). Figure 3.3 visually presents how movement in the zones interact to canalize learning in this example. The items in the figure numbered A1-A5 correspond with the transcript lines A1-A5.

In another video-recorded buddy reading session, Abby and Kate read the last page of the app book *Pat the Cat*. On this page, buddies could select a menu to start the app book. The following interactions occurred between the buddies while they were preparing to read the book together.

Line	Student	Transcript	Code	Theoretical construct
B1	Abby	[Takes control of the iPad]	Turn taking/controlling device	ZFM-Buddy
B2	Abby	[Tries to go to the menu page, but unsuccessfully]	Developing ability to use the digital navigation feature (but not yet successful)	ZPD
B3	Abby	How can I find menu?	Request information	ZPA-Buddy
B4	Kate	[Takes control of the iPad]	Turn taking/controlling device	ZFM-Buddy
B5	Kate	[Finds the icon that goes to menu] You press this [showing the icon]	Buddy provides verbal mediation and points to show where the digital feature is located on the page (without activating it)	ZPA-Buddy
B6	Abby	[Takes control of the iPad]	Turn taking/controlling device	ZFM-Buddy
B7	Abby	[Presses the menu icon and successfully use the digital menu feature]	Developed ability to use the digital navigation feature (activated it)	ZAD

In the above example, the Zone of Free Movement-Buddy was framed by Abby taking control of the iPad (line B1). She demonstrated developing ability (ZPD) to use the digital menu feature when she tried unsuccessfully to activate it (line B2). Then, she requested help from her buddy (line B3), which shaped the Zone of Promoted Action-Buddy. Kate provided verbal mediation for Abby ("you press this") and also pointed to show her where to activate the menu on the page (line B5). This mediation helped to turn Abby's developing ability to developed ability in using the digital menu feature (ZAD).

Figure 3.4 visually presents how movement in the zones interact to canalize learning in this example.

Modeling Digital Feature Use

In another form of mediation, buddies physically modeled how to use the digital feature after their buddy tried unsuccessfully to use it. This mediation physically showed the buddies how to use the app book's features without articulating any verbal hints. The following excerpt is from an interaction between Ann and Tanner as they read the app book, *A Shiver of Sharks*. The app book read the words aloud, highlighted words as it read them, and had hotspots. The hotspot on the page they were reading was a shark that moved and showed its teeth when activated.

Line	Student	Transcript	Code	Theoretical construct
C1	Ann	[Shares the iPad]	Share the device	ZFM-Buddy
C2	Ann	[Tries to activate the shark hotspot] How its [shark's] teeth come out?	Developing ability to move the hotspot (but not yet successful)	ZPD
C3	Tanner	[Touches the shark's head to activate the hotspot. The shark's moves and shows its teeth.]	Buddy models digital feature use to activate the hotspot	ZPA-Buddy
			Developed ability to move the hotspot	ZAD
C4	Ann	Watch its teeth [successfully touches the shark's head to activate the hotspot]	Developed ability to move the hotspot	ZAD

The interaction started with Ann shaping the Zone of Free Movement (ZFM-Buddy) by sharing the device with her buddy (line C1). Immediately, Ann wanted to activate the shark hotspot; however, she was unsuccessful, showing that her ability to activate the hotspot was still developing (line C2, Zone of Proximal Development). To mediate her developing ability to use the hotspot, Tanner created the Zone of Promoted

Action by modeling how to activate the hotspot (line, C3). This mediation helped to bridge Ann's developing ability to developed ability to use the hotspot independently (ZAD; C4). Figure 3.5 visually presents how movement in the zones interact to canalize learning in this example.

Likewise, in another buddy reading session, Vivian and Kyla read the app book, *Being Global*. On the page they were reading, there were two automatically animated color circles that could also be reactivated as a hotspot. The content along with the color circles explained the concept of *Globe* to the children.

Line	**Student**	**Transcript**	**Code**	**Theoretical Construct**
D1	Kyla	[Kyla holds the iPad closer to herself, but so that the buddy can still reach it, while the book reads aloud.]	Turn taking/controlling device	ZFM-Buddy
D2	Vivian	[Two automatically animated color circles catch Vivian's eye while the text is reading aloud.]	Automatic animations	ZPA-Feature
D3	Vivian	[Vivian touches the color circles, which re-activates them]	Developed ability to move the hotspots	ZAD
D4	Kyla	[Kyla is tapping outside the circle on the screen to try to change the circle's color, but she is unsuccessful because she is not tapping directly *on* the spot to change the color of the circles.]	Developing ability to move the hotspots (but not yet successful)	ZPD
D5	Vivian	I hit it [the color circles] they both blue. [Shows Kyla how to re-activate the color circle hotspot by tapping *on* the color circle.]	Buddy models digital feature use to activate the hotspot Developed ability to move the hotspot	ZPA-Buddy ZAD
D6	Kyla	No, they are not [activated because of you. Kyla thinks she is re-activating the color circle, but she is still not activating them.]	Developing ability to move the hotspots (but not yet successful)	ZPD

D7	Vivian	Now, they both blue [tapping on the color circles several times to re-activate them and make them both blue again.]	Buddy models digital feature use to activate the hotspot	ZPA-Buddy
D8	Kyla	[Kyla figures out that she has to tap *on* the color circle to change the color, and does so successfully.]	Developed ability to move the hotspots	ZAD

Vivian framed the Zone of Free Movement-Buddy by taking control of the iPad and moving it closer to herself, but still allowed her buddy access (ZFM-B; line D1). Then, the color wheel automatic animation focused the Zone of Promoted Action by catching Vivian's attention (ZPA-feature; line D2). Kyla unsuccessfully attempted to re-activate the color wheels, demonstrating her ZPD (line D4, D6). Then, Vivian further focused the ZPA by modeling the digital feature use by re-activating the color wheel hotspot by tapping on them (ZPA-buddy; lines D5, D7). This mediation helped to bridge Kyla's developing ability to a developed ability to use the hotspot independently (ZAD; line D8). Figure 3.6 visually presents how movement in the zones interact to canalize learning in this example.

Integrated Verbal Mediation, Pointing, and Modeling Digital Feature Use

Buddies also integrated the use of verbal mediation, pointing, and modeling digital feature use to assist their buddies in effective use of the app book features. The following excerpt is from a video of Nina and Quinlan engaging with the app book, *The Artist Mortimer*. The book had hotspots and read aloud to the children as each page was turned.

Line	Student	Transcript	Code	Theoretical Construct
E1	Nina	[Places the iPad in the middle where both buddies have close access]	Share the device	ZFM-Buddy

E2	Quinlan	Where do you press to turn the page?	Request information	ZPA-Buddy
E3	Nina	I don’t know [begins pressing different spots on the screen, trying to figure this out]	Developing ability to use the digital navigation feature (but not yet successful)	ZPD
E4	Quinlan	[Simultaneously pressing different spots on the screen, also trying to figure this out]	Developing ability to use the digital navigation feature (but not yet successful)	ZPD
E5	Nina	[Finds the spot to turn the page, and turns the page]	Developed ability to use the digital navigation feature (activated it)	ZAD
E6	Quinlan	[Asks again] Where do you press to turn the page?	Request information	ZPA-Buddy
E7	Nina	Here [Points to the spot to activate the digital navigation feature]	Buddy provides verbal mediation and points to show where the digital feature is located on the page (without activating it)	ZPA-Buddy
E8	Quinlan	Oh [Presses the digital navigation feature, and the page turns backward]	Developed ability to use the digital navigation feature (activated it)	ZAD
E9	Nina	[Turns the page forward and backward to show Quinlan]	Buddy models digital feature use (particularly how you can turn the page both forward and backward)	ZPA-Buddy
E10	Quinlan	[Activates the digital navigation feature to turn the page forward]	Developed ability to use the digital navigation feature (activated it)	ZAD

By sharing the device, Nina created the Zone of Free Movement-Buddy where both buddies had access to the device (line E1). When Quinlan asked about how to turn the page, he focused on the Zone of Promoted Action-Buddy (line E2). Then, both buddies demonstrated actions in their Zones of Proximal Development, as they investigated (unsuccessfully) how to use the digital page-turn feature (lines E3-E4). When Nina figured out how to press the correct spot to use the page-turn feature, this represented her transition from a developing (ZPD) to developed ability to use this feature (ZAD; line E5). After this, Quinlan asked again for help activating the page-turn feature, further focusing the Zone of Promoted Action-Buddy (line E6). Therefore, Nina mediated Quinlan's developing use of the page-turn feature both verbally ("here"), by pointing to the place to activate the page turn (line E7), and by modeling the digital navigation feature uses (line E9). This mediation supported Quinlan's transition from developing (ZPD) to developed use of this digital navigation feature (ZAD) (lines E8 and E10). Figure 3.7 visually presents how the context was microgentically framed to effectively canalize the buddies' developmental process in acquiring app book page turn skills.

Likewise, the same pattern is illustrated in the following excerpt of Stella and Jayden reading the app book, *The Going to Bed Book*. The page they read had star hotspots that twinkled when activated.

Line	**Student**	**Transcript**	**Code**	**Theoretical Construct**
F1	Jayden	[Places the iPad in the middle where both buddies can access it]	Share the device	ZFM-Buddy
F2	Stella	I am popping [activates the star hotspots by tapping them]	Buddy provides verbal mediation ("I am popping") Buddy models digital feature use (activating stars hotspot) Developed ability to move the hotspots	ZPA- Buddy ZPA-Buddy ZAD
F3	Jayden	[Jayden is rubbing his finger on the screen, trying to activate the stars to make them twinkle, but this is the wrong action and does not activate them.]	Developing ability to move the hotspots (but not successful yet)	ZPD

F4	Stella	[Stella shows Jayden how to *tap* the stars to activate them.]	Buddy models digital feature use	ZPA-Buddy
F5	Jayden	[Taps finger on the screen and successfully activates the stars.]	Developed ability to move the hotspot	ZAD

In this example, the availability of the device for both buddies framed the Zone of Free Movement (line F1; ZFM-Buddy). Initially, Stella demonstrated a developed ability to activate the star hotspots (line F2; ZAD). She verbally explained what she was doing to Jayden and pointed to the place on the screen to activate the hotspot (line F2), which framed the Zone of Promoted Action (ZPA-Buddy). However, this mediation did not result in Jayden being able to use the hotspot (line F3; ZPD). Thus, Stella modeled how to activate the hotspot for him (line F4). This modeling helped to shift Jayden's ability to activate the hotspot from his ZPD (line F3) to his ZAD (line F5). Figure 3.8 visually presents how movement in the zones interact to canalize learning in this example.

Physical Support for Activating a Digital Feature

One kind of physical support for helping a buddy enact digital feature use occurred when a student took their buddy's finger and moved it on the screen to show them how to effectively use the electronic feature. The following excerpt occurred between Adena and Jasper while they were reading the app book, *Barnyard Dance*. The app book read the text aloud, highlighting the text as it read it, and had hotspots. One hotspot made a cow play a violin when activated.

Line	Student	Transcript	Code	Theoretical Construct
G1	Adena	[Turns the page]	Navigating throughout the app	ZFM-Buddy

G2	Adena	[Tries to activate the feature to make the violin play, but was unsuccessful.]	Developing ability to move the hotspots (but not successful yet)	ZPD
G3	Jasper	[Tries to activate the feature to make the violin play, but was also unsuccessful.] We are doing it together [i.e., trying to activate the hotspot].	Developing ability to move the hotspots (but not successful yet)	ZPD
G4	Adena	[Tries multiple ways to activate the hotspot--taps, touches, then runs finger back and forth on screen. When she runs her finger back and forth on screen, this activates the hotspot.]	Developed ability to move the hotspots	ZAD
G5	Adena	Now you try. [Takes Jasper's finger moves it back and forth on the screen to activate the violin hotspot.]	Buddy enacts the motion for their partner	ZFM/ZPA-Buddy
G6	Jasper	[Independently moves his finger back and forth to activate the violin hotspot.]	Developed ability to move the hotspots	ZAD

The interaction was initiated with Adena framing the Zone of Free Movement for her buddy (ZFM-Buddy) by navigating to the page with the cow playing the violin hotspot (line G1). At first, both buddies explored how to use the hotspot, which showed developing knowledge (ZPD; lines G2-G3). Adena figured out how to use the hotspot first (ZAD; line G4), and then tried to support her buddy, Jasper, by moving his finger over the screen in a back-and-forth motion to activate the hotspot (line G5). Her focus on the violin hotspot reflected the Zone of Promoted Action (ZPA-Buddy). Her control of

Jasper’s finger, by restricting his movements to activate the hotspot, reflected the Zone of Free Movement (ZFM-Buddy). Mediating both zones bridged Jasper's developing ability to use the hotspot (ZPD) to a developed ability (ZAD, line E7). Figure 3.9 visually presents how movement in the zones interact to canalize learning in this example.

Another kind of physical support for helping a buddy enact digital feature use occurred when a child prevented their buddy from doing a certain action. The following interaction between Kevin and Mia occurred while they were trying to record their voice by touching a recording icon programmed in the *Pat the Cat* app book. The color of the voice recording icon changed from green (when it was ready to be pressed and start recording) to red (when it was already recording and should not be pressed until the recording is complete). That is, tapping on the green or red icon turned it on and off, respectively.

Line	**Student**	**Transcript**	**Code**	**Theoretical Construct**
H1	Kevin	[Takes control of the iPad while the text reads aloud]	Turn taking/controlling device	ZFM-Buddy
H2	Kevin	[The green recoding icon is flashing, and catches his eye.]	Voice recording feature	ZPA-F
H3	Kevin	[Taps on the green icon, then the red icon, then the green icon, etc. several times.]	Developing ability to activate the recording feature	ZPD

H4	Mia	You have to wait [after you press the green icon.] [Holds his hand to keep him from touching the red icon]	Buddy restricts their partner to provide prompt	ZFM/ZPA-Buddy
H5	Kevin	[Stops to see what happens.]	Developing ability to activate the recording feature	ZPD
H6	Mia	[Reads the text in order to be recorded] CAT…	Developed ability to activate the recording feature	ZAD
H7	Kevin	[Listens to Mia's recording. Then presses the green icon and begins to read to begin his own recording.] CAT…	Developed ability to activate the recording feature	ZAD

The interaction started when Kevin took control of the iPad and placed it in front of himself, which created the Zone of Free Movement- Buddy (ZFM-Buddy; line H1). The recording voice feature itself created the Zone of Promoted Action (ZPA-Feature) by flashing to grab Kevin's attention (line H2). Kevin showed that his ability to use the recording feature was at the developing state when he pressed the feature several times in succession without recording, which is not how the feature was intended to be used (ZPD- line H3). Mia mediated Kevin's use of the recording feature in two ways (lines H4 and H6). First, Mia's focus on the recording feature reflected the Zone of Promoted Action (ZPA-Buddy). Second, her restriction of his finger movements (so he would not stop the recording feature prematurely), reflected the Zone of Free Movement (ZFM-Buddy). Mediating both zones canalized Kevin's learning from developing the ability to use the recording hotspot correctly to a newly developed ability to do so (line H7). Figure

3.10 visually presents how movement in the zones interact to canalize learning in this example.

Discussion

What We Can Learn from Our Application of Zone Theory

Using Zone Theory allowed us to trace the buddies' development using a microgenetic process, which revealed that verbal mediations, modeling, and physical mediations were employed to improve effective activation of app features. However, for this development to occur, the digital features needed to be within the Zone of Free Movement (i.e., the buddy was physically able to interact with the book, and digital features were available in the book), and buddies needed to share a focus in the Zone of Promoted Action (e.g., working on activating a specific hotspot together). Using Zone Theory showed not only the mediations that were necessary to canalize learning, but also the context in which this learning could occur (i.e., Zone of Free Movement) and the canalization process (i.e., moving from not being able to activate the digital feature independently [ZPD] to being able to effectively activate it independently [ZAD]).

Further, our findings expanded how Zone Theory has been applied to data analysis. For example, while previous research focused on how another person expanded or constricted the Zone of Free Movement (Blanton et al., 2005; Hussain et al 2012), our study also considered how technology itself sometimes plays this role (e.g., buddies were restricted based on the digital features that were available on each page of the app book). Particularly in this digital age, exploring how digital features expanded or constricted the possibilities for children's engagement seemed important. Moreover, while previous research focused on how another person shifted the Zone of Promoted Action (Blanton et al., 2005; Hussain et al 2012), our findings demonstrated that digital features did this as well (e.g., automatic animations that attracted their attention to a hotspot). Therefore, we were able to explore two ways that the Zone of Free Movement and Zone of Promoted Action were shifted to support canalizing a child's learning to effectively activate a digital feature.

Extensions and Insights about the Mediation of Buddies' Digital Feature Use

Our findings underscore the importance of the social and interactional context of buddy reading for supporting learning on how to effectively use digital features, and that there are multiple ways to mediate this learning (i.e., verbal mediation and pointing out digital features, modeling digital feature use, integrated verbal mediation, pointing, modeling digital feature use, and physical support for enacting digital feature use). While previous research explored buddies' use of digital features as part of the meaning-making process (Christ et al. 2019; Korat & Falk, 2017; Xu et al., 2020), their focus was not on how children learned to effectively use the features themselves. Our research extended these studies by exploring this aspect. For example, while prior studies showed that automatic animations garnered children's attention (Christ et al. 2018; Smeets & Bus 2014; Verhallen & Bus, 2010), our study showed how this attention was used to canalize children's learning to use these hotspot features. Likewise, previous studies demonstrated that children struggled to navigate app books effectively when reading individually (Plowman & McPake, 2013; Kelley & Warburton, 2011; Sung et al., 2019a); however, our research extended this by showing how buddies' mediations supported learning how to use the navigational features—e.g., Buddy provides verbal mediation and points to show where the digital feature is located on the page (without activating it) (E7). Finally, while previous research identified the use of verbal mediations and modeling to support app book meaning-making (Wang et al., 2014; Javorsky & Trainin, 2014), our findings also showed that buddies use physical mediations (e.g., moving their buddy's finger to swipe) to mediate one another's use of digital features. Buddies used these physical mediations to both create a narrower Zone of Promoted Action (e.g., Transcript G) and Zone of Free Movement (e.g., Transcript H).

Implications for Practice

Our results suggest important implications for early childhood classroom practices. First, it is clear children need to share access to the iPad (i.e., the Zone of Free Movement needs to include both buddies having access to the book). Without sharing, they cannot engage in any shared focus (i.e., the Zone of Promoted Action), which is needed to canalize learning.

Second, our findings showed a shared focus can be accomplished two ways—via programmed digital features that jointly draw buddies' attention to a feature, or one buddy drawing the other buddy's attention to said feature. Therefore, choosing app books with digital features that draw children's attention, and encouraging children to help their buddy use the features while reading, are two ways to support a shared focus. Further, app book programmers should consider the design of app features in terms of drawing children's attention to them.

Third, our findings suggest that teachers should encourage children to engage in the following effective mediation behaviors to support their buddy's learning of how to effectively activate a digital feature: (1) verbal mediation and pointing out digital features; (2) modeling digital feature use; (3) integrated verbal mediation, pointing, and modeling digital feature use; and (4) physical support for enacting digital feature use.

Limitations and Suggestions for Future Research

There were three important limitations of our study, and each suggested a direction for future research. First, the findings in this research were limited to an exploration of kindergarteners who were mostly in the emergent stage of reading. Future research might explore app book buddy reading with children at other ages and stages of development. Second, our study focused on buddies' interactions with one another and the app book. Future research might compare these findings with the kinds of mediations provided by a teacher or parent who is supporting children's learning to use digital features. Third, we took a microgenetic look at the canalization process within short episodes of buddy reading interactions. Future research might trace these processes for children across time.

Conclusion

This study microgenetically traced the learners' development of their ability to use digital features in the context of collaborative app book buddy reading. Findings showed that learners provided (1) verbal mediation and pointing out digital features; (2) modeling digital feature use; (3) integrated verbal mediation, pointing, and modeling digital feature use; and (4) physical support for activating a digital feature to support their buddy's digital feature use. These mediational moves canalized buddies' learning process, shifting from their developing ability to use a digital feature into a developed ability. Teachers should promote buddies' use of these mediational moves during app book buddy reading.

Funding

This work was generously supported by the Spencer Foundation and the International Literacy Association's Elva Knight Grant.

Table 3.1

App Book Features

App book	Automatic animation	Navigation features	Hotspots	Other
Barnyard Dance Going to Bed Book Artist Mortimer	Images in illustrations move (e.g., rocking boat)	Page turn	When hotspots in illustration are pressed, animations are activated • 60% to 80% congruent	None
X is for X-Ray Being Global Shiver of Sharks	Images in illustrations move (e.g., monkey swinging on a vine)	Page turn and menu	When hotspots in illustration are pressed, animations are activated • 100% congruent	None
Hop on Pop	Panning is used to focus the readers' attention to the pages Images in illustrations move	Page turn and menu	When hotspots in illustration are pressed, the word appears and is read aloud • 100% congruent	None
Pat the Cat	Images in illustrations move	Page turn	None	Users can record their reading and play it back

Table 3.2

Zones, constructs, definitions, and codes

Zones	Constructs	Definition	Codes
Zone of Free Movement (ZFM)	ZFM-Buddy	The availability and accessibility of the device	1. Turn taking/controlling device 2. Share the device 3. Request to share the device 4. Turning the page 5. Navigating throughout the app 6. Buddy enacts the motion for their Partner 7. Buddy restricts their partner to provide prompt
	ZFM-Feature	The availability and accessibility of features in each page	1. Navigation 2. Highlight text 3. Read aloud text 4. Congruent hotspots 5. Incongruent hotspots 6. Automatic animations 7. Voice recording feature
Zone of Promoted Action (ZPA)	ZPA-Buddy	The actions and behavior that support the other buddy's development	1. Request information 2. Buddy asks question 3. Buddy provides verbal mediation and points to show where the digital feature is located on the page (without activating it) 4. Buddy models digital feature use to activate the hotspot 5. Buddy provides verbal mediation 6. Playing the recorded voices 7. Buddy enacts the motion for their Partner 8. Buddy restricts their partner to provide prompt
	ZPA-Feature	The electronic features that attract the buddy's attention	1. Navigation 2. Highlight text 3. Read aloud text 4. Congruent hotspots 5. Incongruent hotspots 6. Automatic animations 7. Voice recording feature
Zone of Proximal Development (ZPD)	ZPD	The buddy shows their developing ability regarding the use of the digital features	1. Developing ability to use the digital navigation feature (but not yet successful) 2. Developing ability to move the hotspot (but not yet successful) 3. Developing ability to activate the recording feature

Table 3.2 Continued

Zones	Constructs	Definition	Codes
Zone of Actual Development (ZAD)	ZAD	The buddy shows their developed ability to use the digital features	1. Developed ability to use the digital navigation feature (activated it) 2. Developed ability to move the hotspots 3. Developed ability to activate the recording feature

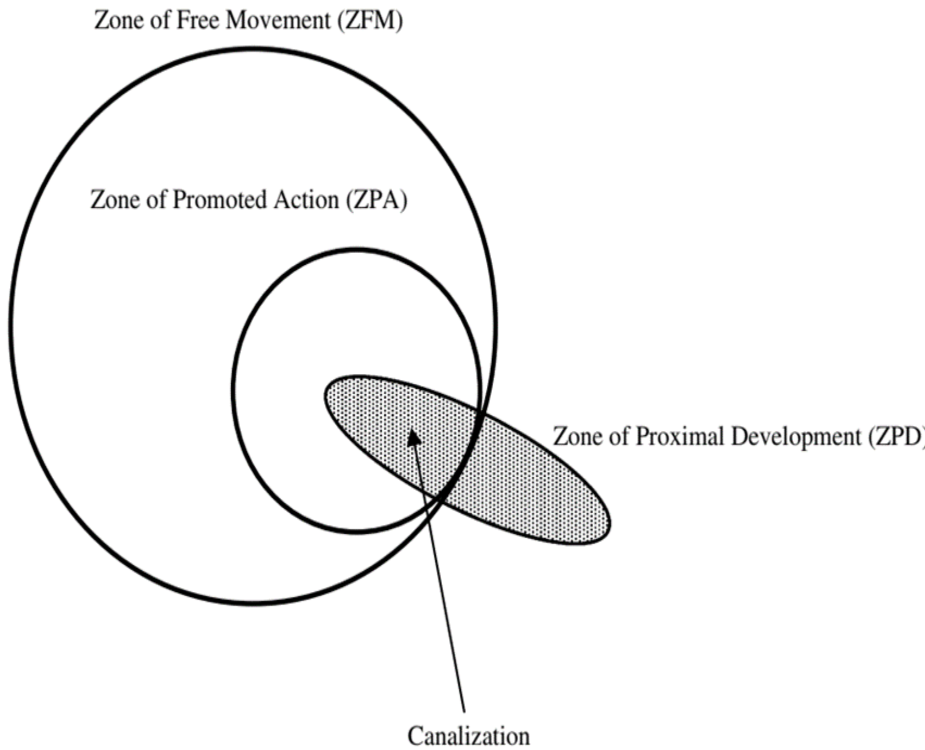


Figure 3.1

The Interconnection between Zones (Blanton et al., 2005)

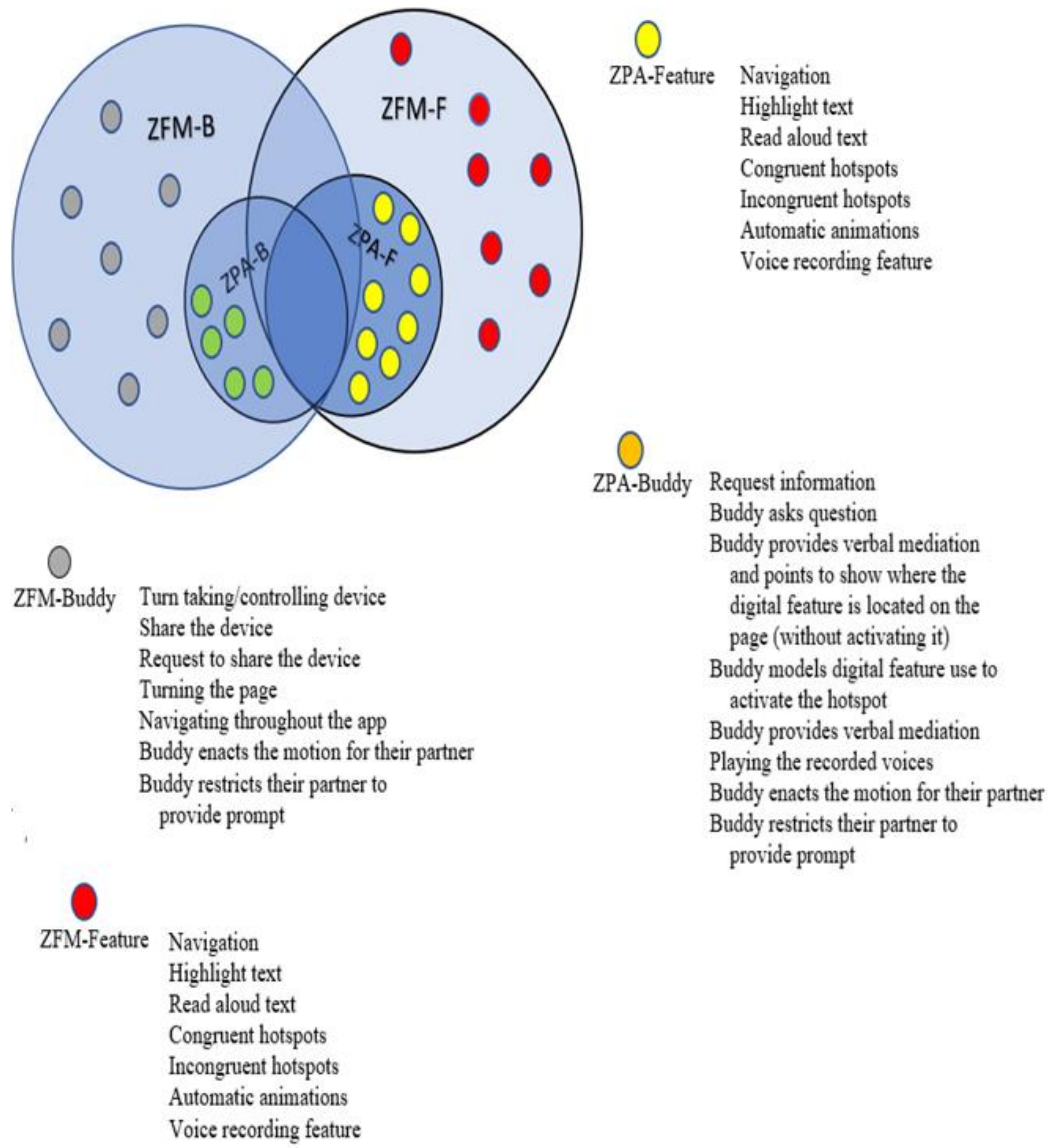


Figure 3.2

The Adapted Version of Valsiner's Zone Theory

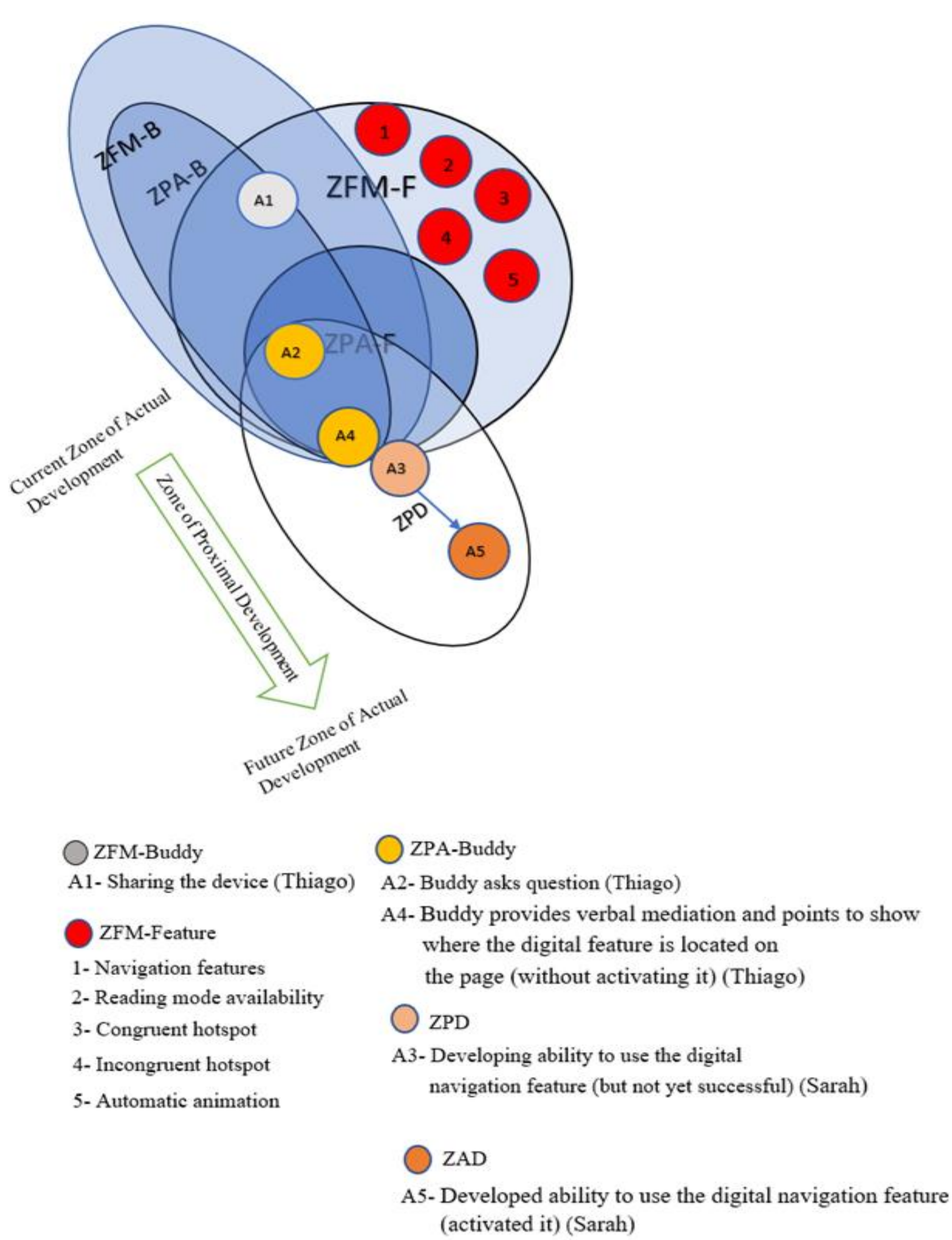


Figure 3.3

Visualization of Zones for Verbal Modeling in Transcript A

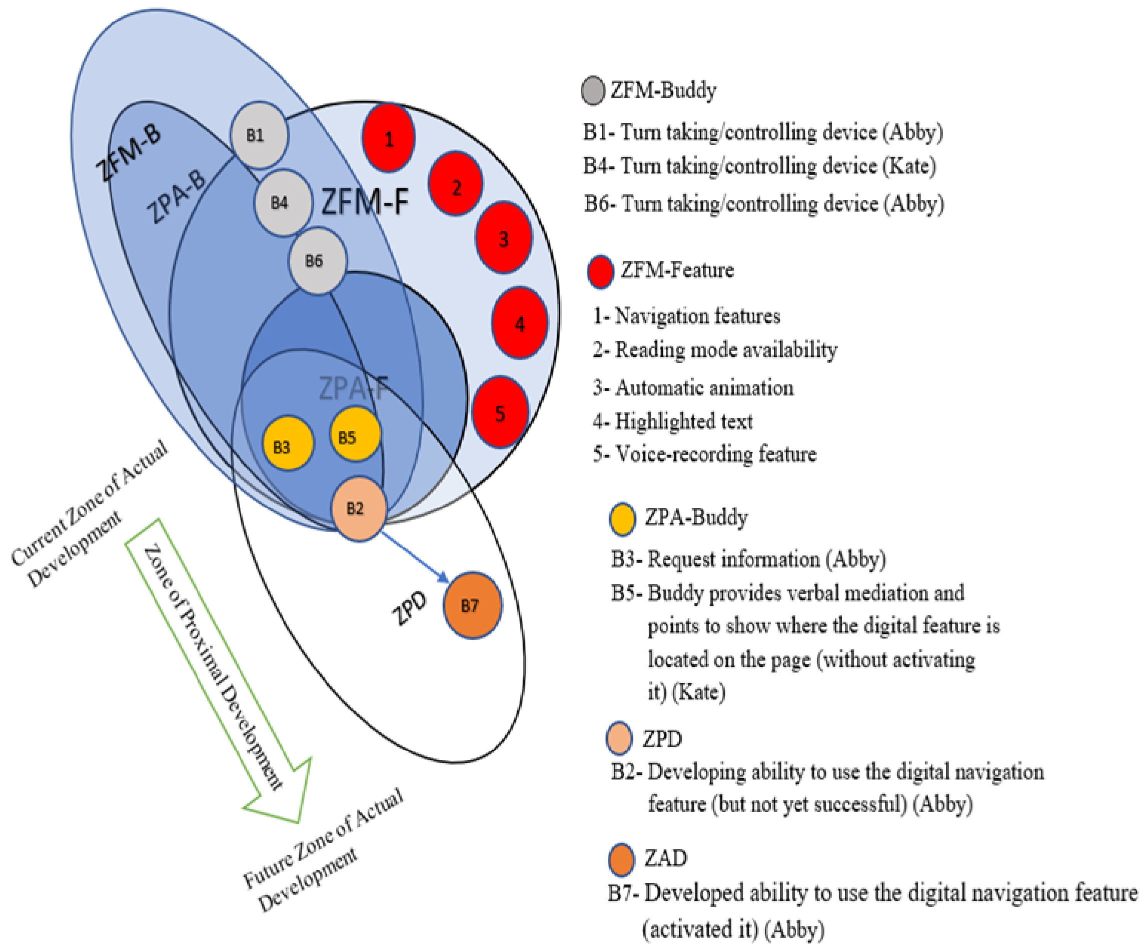


Figure 3.4

Visualization of Zones for Verbal Modeling in Transcript B

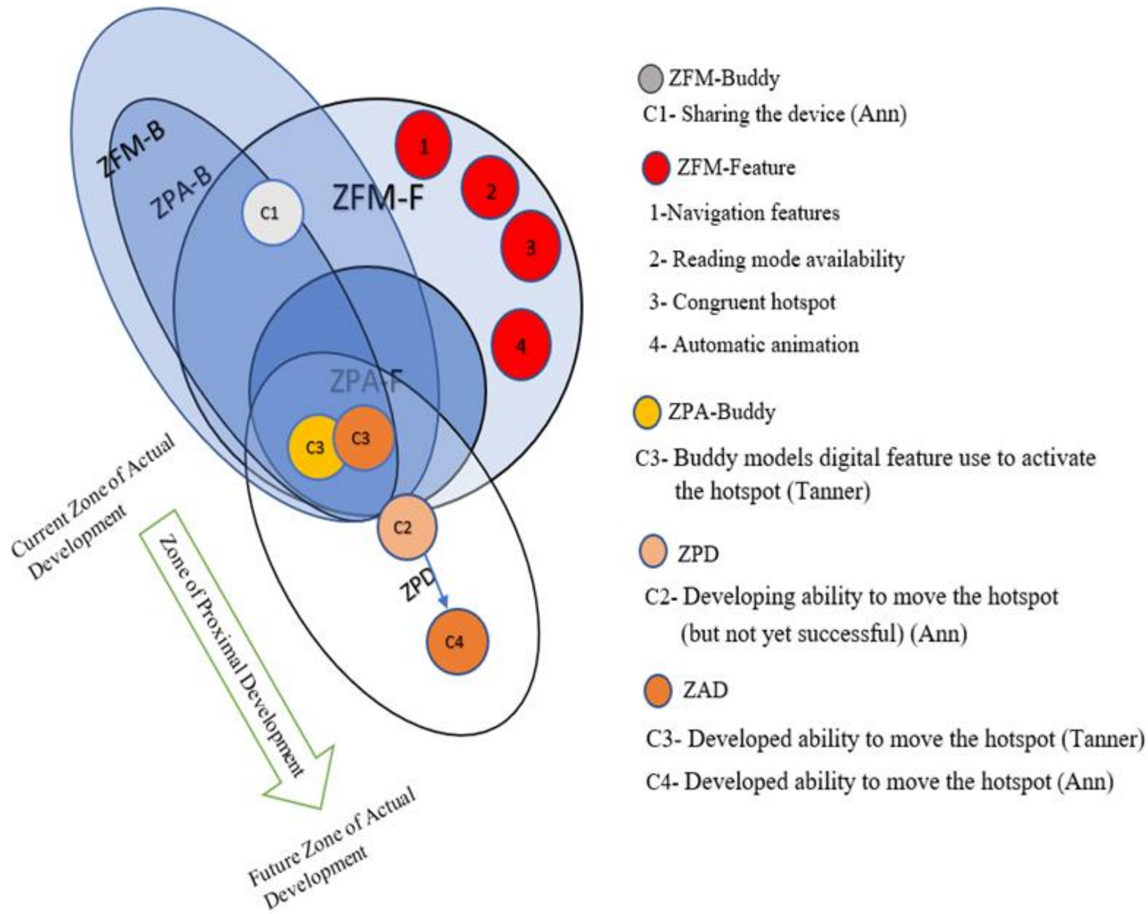


Figure 3.5
Visualization of Zones for Physical Modeling in Transcript C

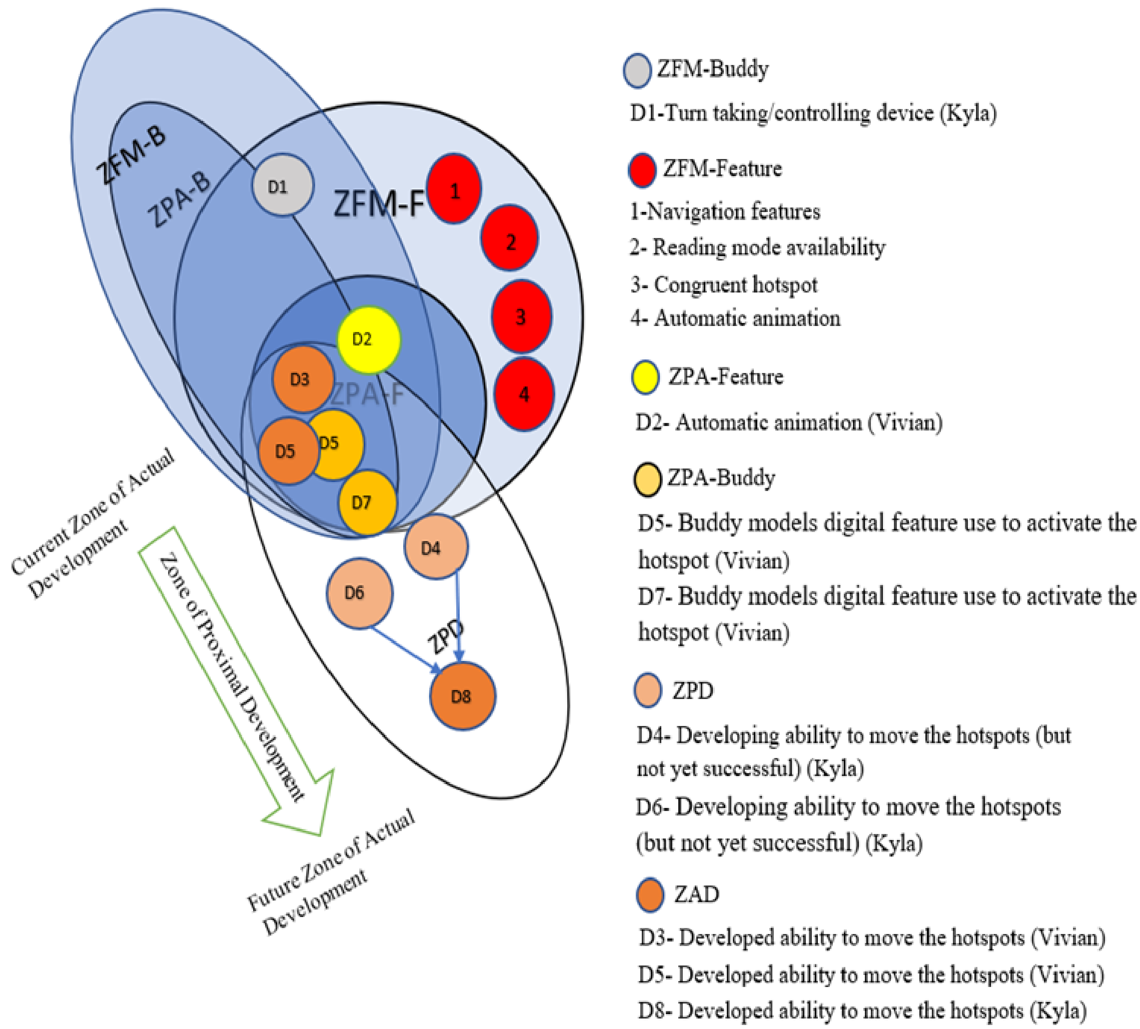


Figure 3.6

Visualization of Zones for Physical Modeling in Transcript D

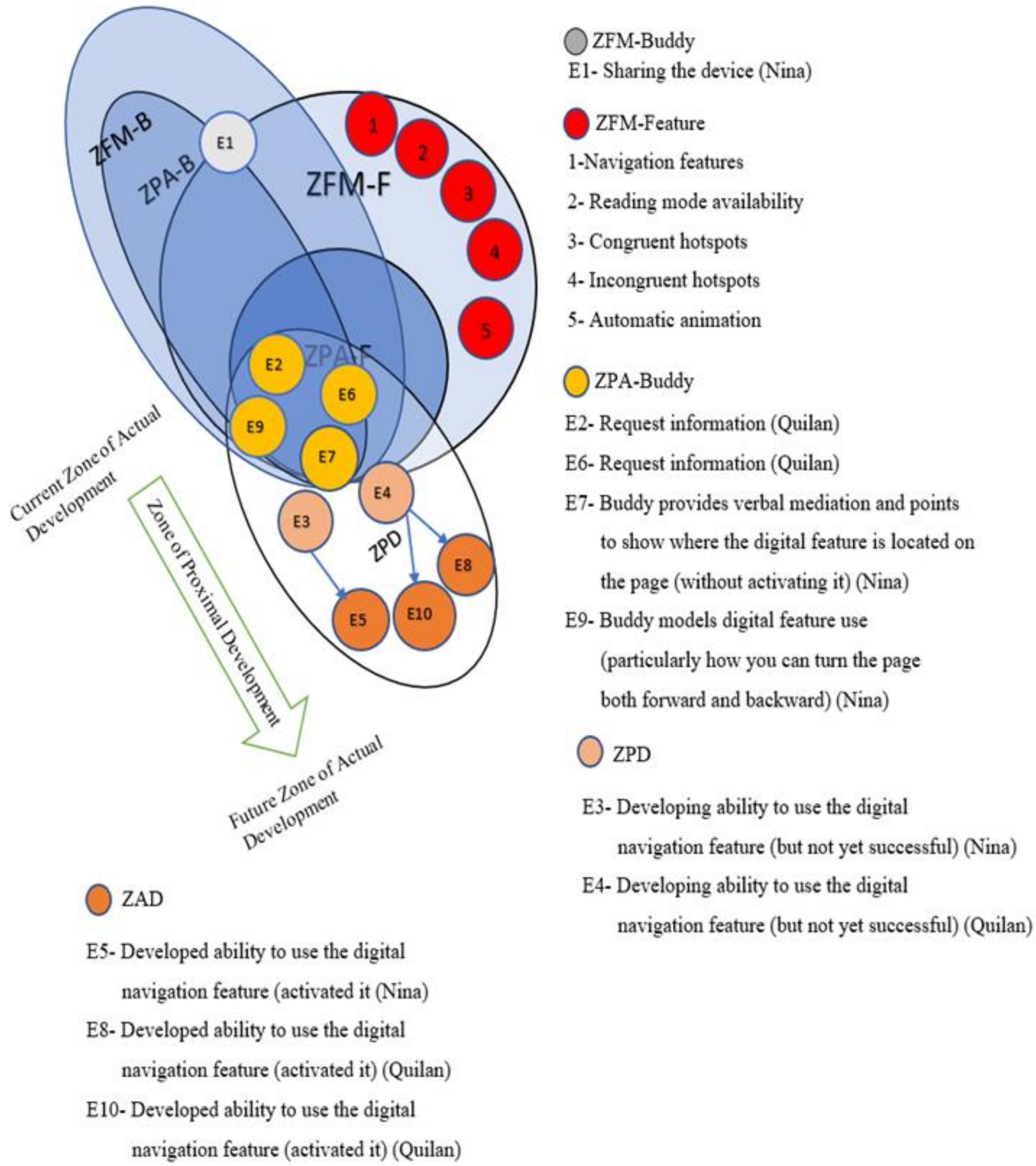


Figure 3.7

Visualization of Zones for Integrated Verbal-physical Mediation in Transcript E

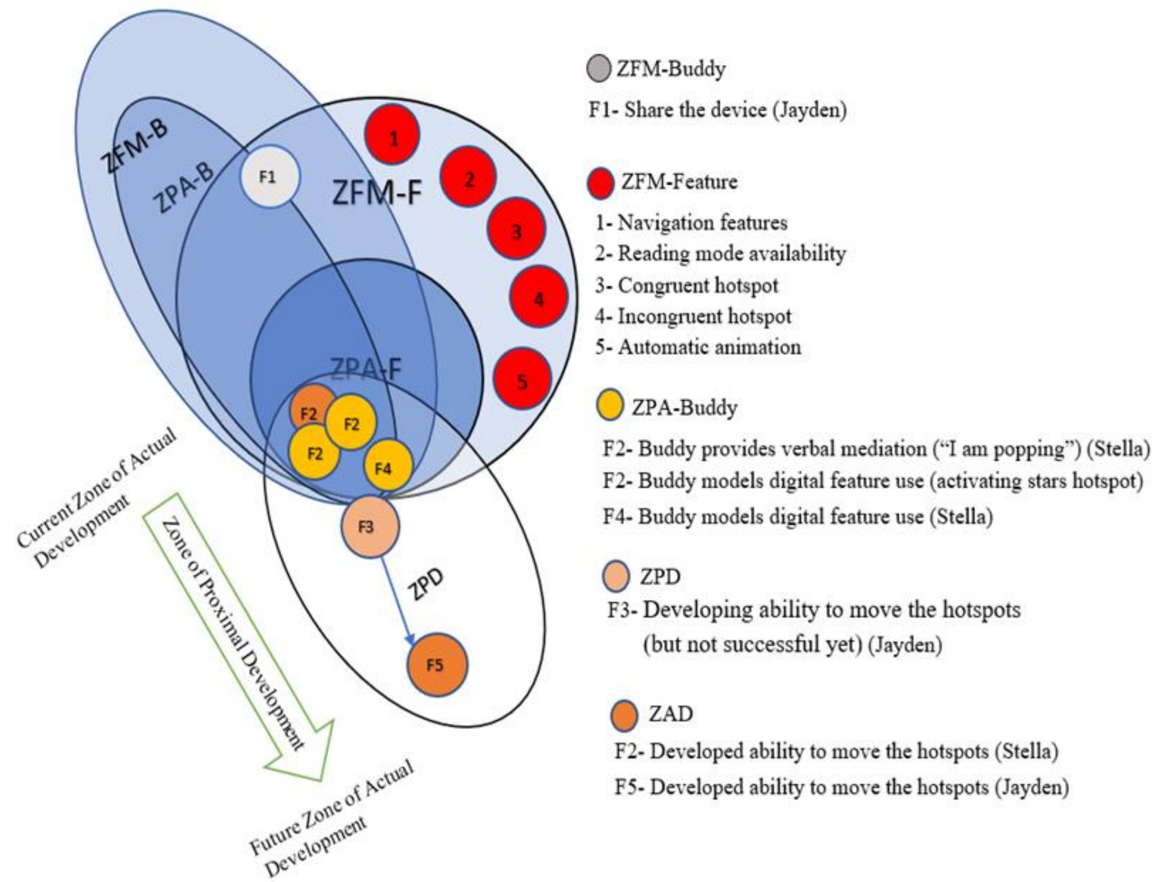


Figure 3.8

Visualization of Zones for Integrated Verbal-physical Mediation in Transcript F

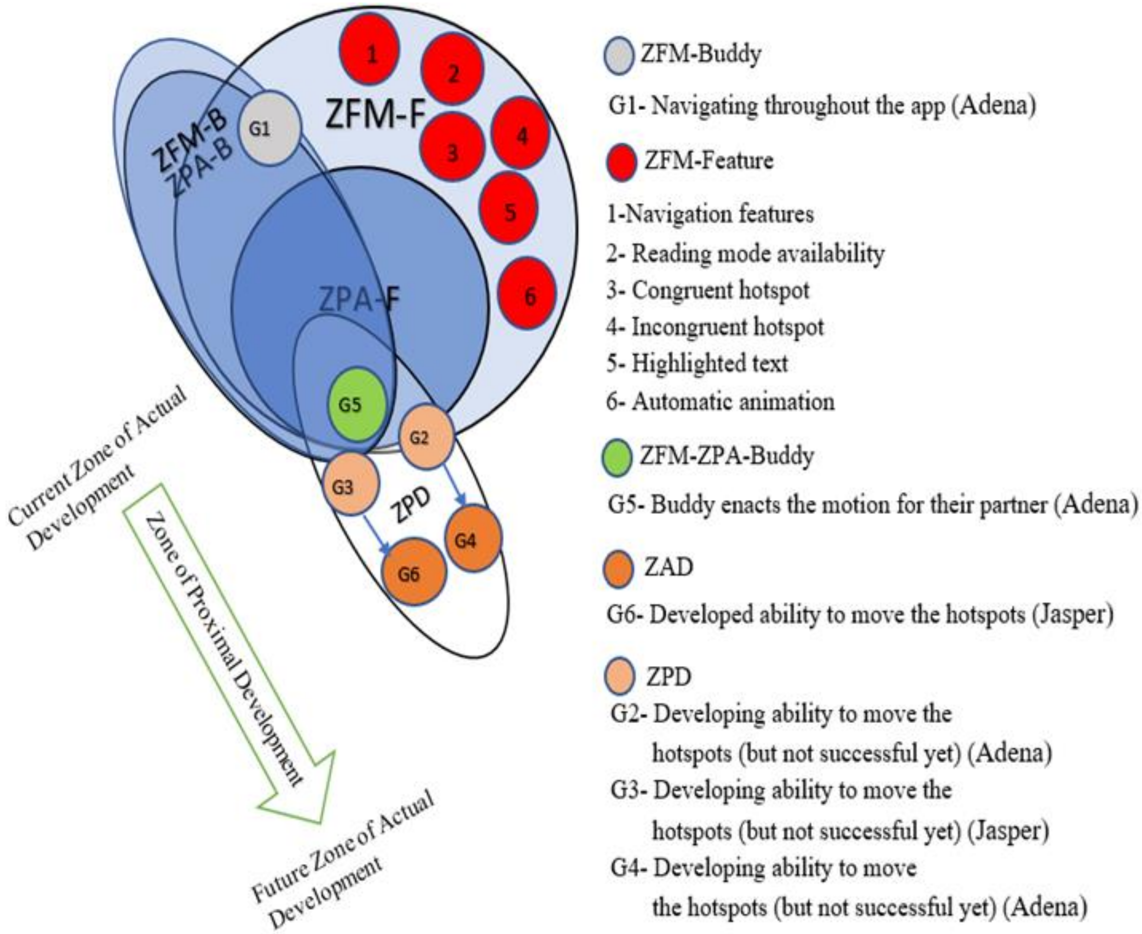


Figure 3.9

Visualization of Zones for Physical Enacting Mediation in Transcript G

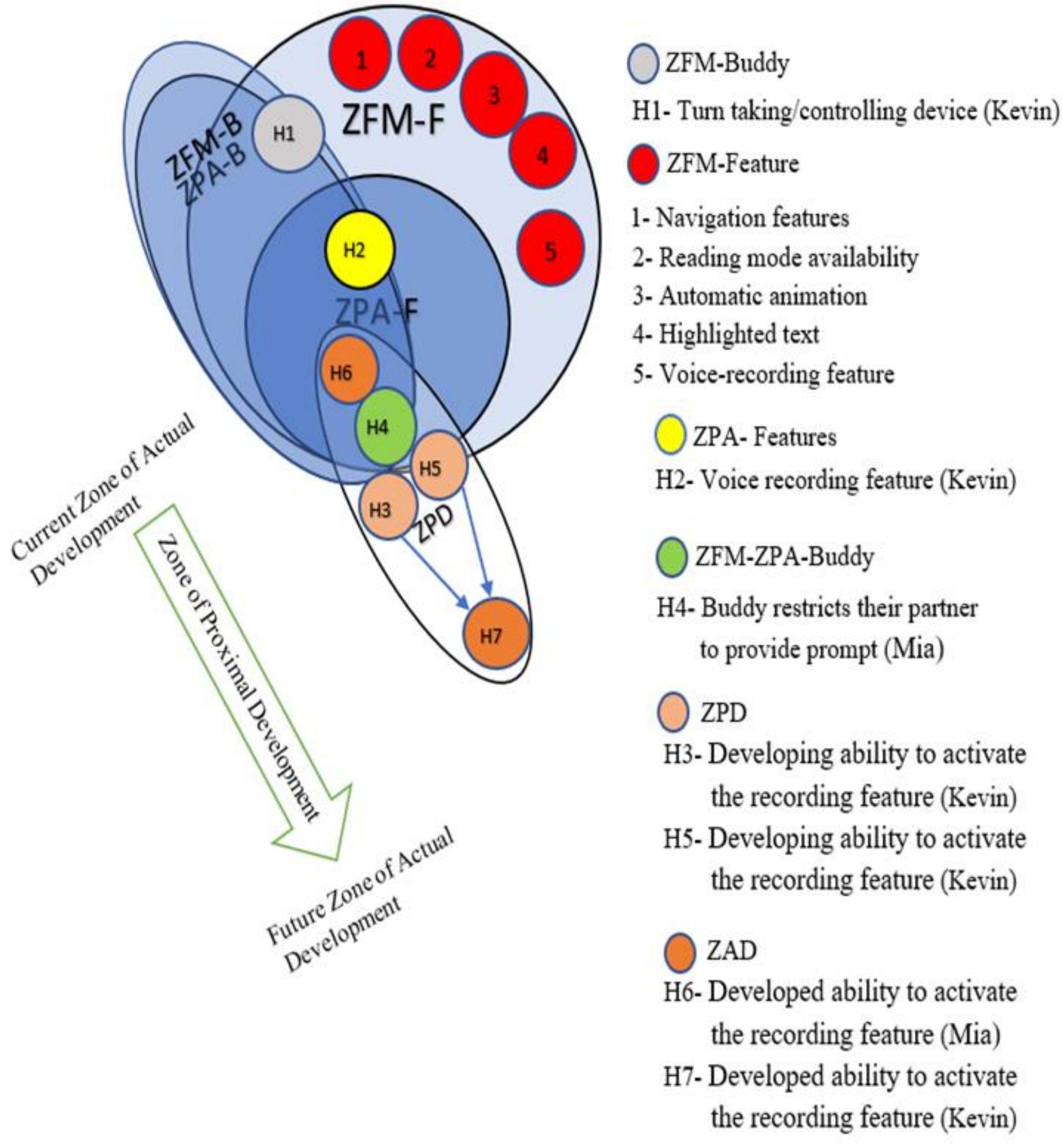


Figure 3.10

Visualization of Zones for Physical Enacting Mediation in Transcript H

CHAPTER FOUR

ROBOT-MEDIATED READ-ALOUD CONTEXT OF READING COMPREHENSION AND VOCABULARY DEVELOPMENT

Abstract

This study investigated the feasibility of employing a robot to provide mediations during one-on-one interactive read-aloud sessions with young children. Although robots are increasingly recognized as valuable tools in educational environments, limited research has explored their effectiveness in promoting reading comprehension and vocabulary development through interactive reading activities. This research involved 20 children, aged 3 to 6 years, with the robot Pepper reading *This Is Not My Hat* to each child and posing inferential questions aimed at encouraging critical thinking. These interactions were video-recorded and analyzed using qualitative emergent coding and constant comparative analysis to uncover the supports and barriers in the robot's capacity to mediate learning in early learners. Initial findings indicate that while the robot effectively engages children and provides structured feedback, critical elements such as emotional connection and adaptive flexibility—key features of human interaction—pose significant challenges. The outcomes of this study will contribute to enhancing the integration of robots in educational settings, particularly in literacy development, and offer valuable insights for future improvements in robotic design and their application in education.

Keywords: Interactive read-aloud, robot, mediation, inference, emergent coding

Introduction

Robots are recognized as an innovative educational tool that has the potential to alter present educational practices and promote student learning in diverse learning situations (Anwar et al., 2019; Chu et al 2022; Evripidou et al., 2020; Lin et al., 2022). The promising future of educational robots has been observed in supporting learners' outcomes related to problem-solving, self-efficacy, creativity, collaboration, cooperation, and computational thinking (Evripidou et al. 2020; Chevalier et al., 2020). In addition, human–robot interactions often increase the level of learners' engagement (van den Berghe et al., 2019).

Despite these promising results across the last two decades, robots are far from being employed as an autonomous instructor in a classroom due to the uncertainty in their effectiveness of providing emotional and instructional feedback in the way that humans do (Blanchard et al 2009; Bourguet et al., 2020). For example, while there have been several studies of robots used as educational tools, very little attention has been given to how robots' mediations affect children's performance (Ahmad et al., 2019; De Haas et al., 2017; Gordon et al., 2016; de Haas et al 2020). Lack of pedagogical foundation in education has created a research design that has been devised to apply feedback strategies extracted from teacher-students' interaction into the robot-learner tutoring context without examining their impact on learners' performance (e.g., Mazzoni & Benvenuti, 2015; Westlund & Breazeal, 2015; Gordon et al., 2016; Kennedy et al., 2016). Given that robots have significant cognitive and physical constraints compared to humans, it is not certain that the impact of human feedback would be the same as robots (de Haas et al 2020).

Understanding the supports and barriers related to the feasibility of using a robot to provide mediations during a one-on-one (child-robot) interactive read-aloud is essential for the advancement of integration of robotic with educational settings. As robots become increasingly sophisticated, determining their potential in supporting children's learning experiences and identifying the factors that can enhance or hinder their effectiveness in specific contexts is crucial for optimizing their use and their effectiveness in interaction with human-beings. Uncovering these factors allow researchers and developers to refine the design and implementation of robotic educational tools, ensuring that they are more pedagogically sound and capable of addressing the unique and personalized needs of learners. Furthermore, it contributes to building a solid foundation for the integration of robots in education, helping to establish them as valuable resources in classrooms. By examining the feasibility of using robots for one-on-one interactive read-alouds, this research shed light on the potential of robotic tools in the realm of language development and literacy education, ultimately informing future research and development efforts in the field

More specific to the aim of this study, there has been conflicting research on the topic of robot tutors' effectiveness for teaching languages to developing children (e.g., Kanda et al., 2004; Moriguchi et al., 2011; Tanaka & Matsuzoe, 2012; Mazzoni & Benvenuti, 2015). For example, in a robot-mediated context of vocabulary teaching, a robot is reported to be as effective as a human instructor or less effective (e.g., Hyun et al., 2008; Moriguchi et al., 2011; see Vogt et al., 2019). The effectiveness of a robot may be related to the type of learning task (Tazhigaliyeva et al., 2016), the robot's mediation of learning (Ahmad et al., 2021; Rohlfing et al., 2022), and robot's socio-emotional mediation (Saerbeck et al., 2010). Yet, there is little research that explores these robot mediations and their effects (Almousa & Alghowinem, 2022).

To address an aspect of this gap in the literature, this study explored the feasibility of using a robot to offer instructional mediations. We focused on the context of one-and-one dialogic read-alouds, due to the necessary mediations in this learning context and the body of research that informs potentially effective mediations. The study explored the following research question:

> *What are the supports and barriers related to the feasibility of using a robot to provide mediations during a one-on-one (child-robot) interactive read-aloud?*

Theoretical Framework

To understand and capture the nuance of robot-learners' interactions, this study employs Valsiner's (1987) zone theory. This theory views the developmental context as the collaboration between three structures: Zone of Free Movement (i.e., the restriction and freedom applied in the context in terms of tools that are being used and hereafter ZFM); Zone of Promoted Action (i.e., the tools that attract children's attention and offer to mediate learners and hereafter ZPA); and Zone of Proximal Development (i.e., the emerging ability of a child which uncovered due to the provided mediations by more knowledgeable person and hereafter ZPD). The interaction of these zones and how they canalize the child's development of a particular response is presented in Figure 1.

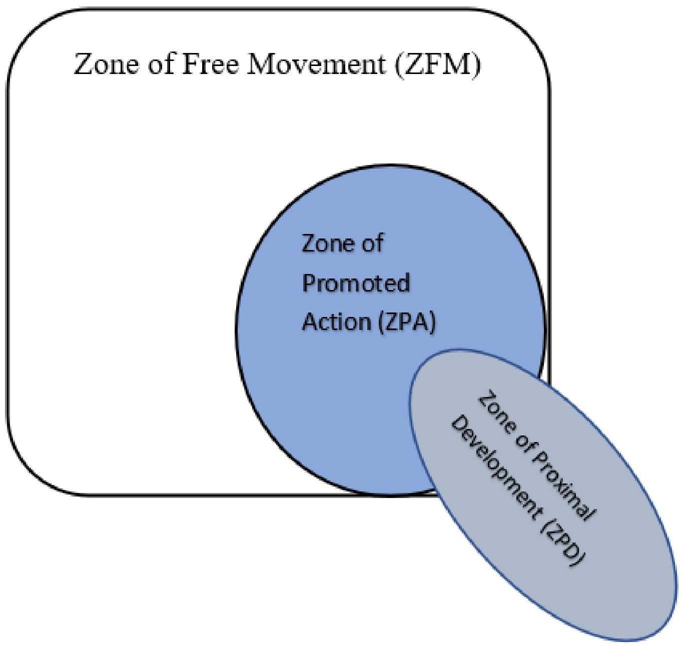


Figure 4.1

The Interconnection between Zones

The ZFM and ZPA concentrate on the contextual freedom/restrictions and instructional opportunities that may impact the growth of the learners (Valsiner, 1998). The ZFM is dynamically narrowed or widened by the instructor setting constraints on how students may engage in the read-aloud. For example, an instructor may narrow the ZFM by asking children to raise their hands when they want to answer a question. The ZFM "canalizes the child's development direction by providing a framework for cognitive activity" (Blanton et al., 2005, p. 6). Similarly, the instructor or their peers use the ZPA to urge others to concentrate on learning in a certain manner (Valsiner, 1997). For example, a teacher or child may pose a question concerning the meaning of a vocabulary word in order to draw the attention of others to that vocabulary meaning. Thus, the ZFM and ZPA provide a framework for identifying the types of mediations that occur in the read-aloud situation. This offers a framework for investigating which mediations best improve students' reading comprehension and vocabulary development by human and robot.

This theory was recently employed in two read-aloud studies, one with bilingual children whose families were refugees, and the other with children from low-SES families who lived in an underserved urban area (Bakhoda et al., 2022 and Christ et al., 2022). Both focused on the dynamism of the teacher-student and student-student interactions and the effectiveness of mediations that were provided to the learners in the read-aloud context. Likewise, in the current study, zone theory facilitated exploration of the developmental context that is shaped by the robot during read-alouds to mediate learners' engagement and responses during the read-aloud.

Literature Review

The main focus of this study is on the feasibility of the robot in presenting effective mediations to literacy learners during an interactive read-aloud. The literature review is organized to provide a vivid picture of research in each area. This is followed by the studies that experimentally employed a robot to play a role during a read-aloud presented in detail. Understanding effective mediations in teacher-student read-aloud contexts, combined with the robot's capacity for dialogic interaction, helps address the research gap identified in previous studies that focused on robot-mediated read-alouds.

Read-Aloud and Mediations

Research shows that certain teacher questions used during read-aloud interventions support children's pre- to post-test gains in listening comprehension and vocabulary knowledge (Beck et al., 2013; Coyne et al., 2009; Price & Bradley, 2016). For example, studies show that when a teacher asks inferential questions during interactive read-aloud interventions, this supports improved children's pre- to post-test gains in comprehension and vocabulary (Neugebauer & Currie-Rubin, 2009; Hindman et al., 2019). Likewise, when teachers use high-demand (e.g., predicting, analyzing, connecting) talk-turns during interactive read-aloud interventions, this supports children's improved pre- to post-test gains in vocabulary (Gómez et al., 2017). For example, Write and Gotwals (2017) found that an interactive read-aloud intervention, in which the teacher asks questions (e.g., driving and evidence-seeking) and actively engages students in explorations of a book, leads to children's greater pre- to post-test gains in vocabulary.

Teacher-student interaction is replete with management mediation that support children's engagement with comprehension *during* the read-aloud (Bakhoda et al., 2022; Christenson, 2016; Christ et al, 2022; Cabell et al., 2019; Mihai, 2021; Wright & Gotwals, 2017). Christenson (2016) found that teachers use behavioral management strategies (e.g., explaining the rules) to help children engage with the read-aloud activity. Moreover, Bakhoda and colleagues (2022) ran sequential statistical talk-turn analysis on the teacher-student's interactions during an emergent bilingual read-aloud and found that teacher's managemental (e.g., calling student's name) in earlier talk-turns linked to the students' expression of inference.

In addition, teacher-student and student-student interactions support children's reading comprehension and vocabulary development *during* the read-aloud (Bakhoda et al., 2022; Christenson, 2016; Christ et al, 2022; Cabell et al., 2019; Mihai, 2021; Wright & Gotwals, 2017). Cents-Boonstra and colleagues (2021) found that students' involvement highly increases when the instructor provides constructive support and encouragement (e.g., verifying the child's responses) (Cents-Boonstra et al., 2021). Price and colleagues (2012) and Zucker and colleagues (2010) distinguished teachers' questions as high-cognitive-demand (open questions) and low-cognitive-demand questions (closed questions), which led the children to produce high-cognitive (inferential and literal) and low-cognitive (yes/no) responses, respectively. Moreover, Bakhoda and colleagues found that inferential mediations (e.g., guiding questions) in earlier talk-turns linked to the students' expression of inference during a read-aloud interaction and clarification as a mediation in earlier talk turn directly relates to the student's later expression of developed inference. Likewise, Christ and colleagues (2022) explored the teacher-kindergartners talk-turns and found that when a teacher asks an inferential question in an earlier talk turn, it is more likely for a child to show a developed inference ability in current talk-turns.

Robot-Human Interpersonal Interaction

In educational contexts, robots can be employed to engage in interpersonal interactions or deliver support through social interaction (Breazeal et al., 2016; Donnermann et al., 2022). In interpersonal interactions, the robot plays the role of a learner who interacts with the human user to learn something (e.g., Westlund et al., 2017). When robots deliver support through social interactions, robots help the human user by supporting their learning (e.g., Schodde et al., 2017). Most studies focus on the latter (Belpaeme et al., 2018).

Robots are reported to provide learners with different types of supportive assistance in language literacy development (Rohlfing et al., 2022). In its role as a tutor, a robot can successfully direct the child, as the more knowledgeable entity (e.g., Movellan et al., 2009; Vogt et al., 2017; 2019), to help the child acquire new knowledge and language skills (Chen et al., 2020). Specifically, robots are capable of offering socioemotional support when the child is distracted and effectively improve the child's engagement with the task (Caruana et al., 2022; Chen et al., 2020). Also, robots can provide explicit prompts to assist learners with the correct use of language pronunciation (Lin et al. 2022). The prompts and assistance can take many forms: asking questions (e.g., Hsiao et al., 2015), explaining the story (e.g., Hong et al., 2016), giving corrective feedback (e.g., Alemi et al., 2014), giving instructional cues and praise (e.g., Westlund et al., 2017), introducing a game's goal and instructions (e.g., Mazzoni & Benvenuti, 2015), modeling how to play a game (e.g., Lee et al., 2011), and responding to learners' questions or comments (e.g., Tanaka & Matsuzoe, 2012).

Despite the demonstrated effectiveness of the robot in assisting a learner to perform a specific task, most robot studies focused on the outcome of the interaction with the robot rather than the process (e.g., Lio et al., 2019; Alemi & Haeri, 2020; Leeuwestein et al., 2020). For example, studies conducted by Alemi and Haeri (2020) used the experimental pretest-posttest study design to justify the effect of robots on 38 kindergarteners' speaking and vocabulary development.

Robot and Read-Aloud Context

There have been few studies that have investigated the effect of using robots for read-alouds (i.e., Shen & Li, 2018; Nakadai et al 2011; Nakadai et al 2011; Hyun et al 2008; Ramey et al., 2012). These studies reported improvement in learners' motivation, task engagement, and linguistic ability (e.g., story making, understanding, word recognition). However, they either focused on the learners' outcome through the static assessment (e.g., pre/post-tests) or gave the robot a passive role (e.g., listening to the child read or reading aloud to the child without interactions). For example, Shen and Lin (2018) used a self-report questionnaire to explore the effect of robot read-alouds (without robot-child interactions) on the motivation of the learners. They reported that the robot increased the motivation of the learners. In another example, Nakadai and colleagues (2011) used a robot to listen to a child while they read-aloud. Their focus was on the child's increased volume, which they interpreted as the manifestation of the child's higher engagement. Across this body of research, the interactive mediations that have been shown to support comprehension and vocabulary engagement during read-alouds (Lin et al., 2022, Kanero et al., 2018) have not been studied in the context of robot read-alouds. This study aims to address this limitation.

Methods

The aim of this study was to explore the supports and barriers related to the feasibility of using a robot to provide mediations during a one-on-one (child-robot) interactive read-aloud. To achieve this, a multilayered study design (Braun & Clarke, 2006; Creswell, 2014; Yin, 1984) was employed, incorporating qualitative case study methods, behavioral coding, and thematic analysis to ensure a comprehensive approach to data collection and assessment.

This design integrates multiple methods to assess the robot's effectiveness in mediating learning:

1. **Qualitative Case Study:** This method was chosen to enable an in-depth exploration of each child's interaction with the robot. Case study methodology allows for detailed observations of individual behaviors, responses to the robot's prompts, and the cognitive and emotional aspects of the interaction. Each child's session with the robot was treated as a case, allowing for rich, contextual data to be gathered through observations and follow-up interviews.

2. **Behavioral Coding:** During the read-aloud sessions, key behaviors were systematically recorded using a pre-defined coding scheme. This included metrics such as verbal engagement (answering the robot's questions), gaze direction (toward the robot or book), and physical responses (e.g., movement or dancing). The behaviors were recorded at 10-second intervals to capture a nuanced understanding of how children engaged with the robot throughout the session.

3. **Post-Interaction Interviews:** Following each reading session, children participated in semi-structured interviews to reflect on their experience with the robot. The interview responses provided insight into their emotional connection, engagement, and preferences for reading with a robot versus a human. These interviews were audio-recorded and transcribed for later analysis.

4. **Thematic Analysis:** The qualitative data from the interviews and session observations were analyzed using thematic analysis (Braun & Clarke, 2006). This approach allowed for the identification of recurring themes related to the cognitive and emotional supports and barriers experienced by the children during the robot-mediated read-aloud. Themes were categorized into areas such as cognitive scaffolding, emotional engagement, and sensory challenges.

The combination of these methods provides a robust framework for understanding both the behavioral and emotional dimensions of the child-robot interactions, ensuring that the results are aligned with the research question and can offer comprehensive insights into the feasibility of robot-mediated educational tools.

Participants

A total of 20 children, aged 3 to 6 years, participated in this study. The participants were pre-kindergarten, kindergarten, or first-grade learners, recruited from a preschool and kindergarten program affiliated with a university's early childhood education center located in the Midwestern United States. This center offers a comprehensive curriculum designed to support the development of young learners. To recruit participants, the directors of local child care centers and schools associated with the university were emailed an informational letter to share with parents. Interested parents then contacted the researchers directly to enroll their children in the study.

The group included 12 girls and 8 boys. In terms of race and ethnicity, the cohort of children was composed of 9 Caucasians, 3 Indians, 3 Arabs, 2 African Americans, 2 Asians, and 1 Hispanic. This study received approval from the Institutional Review

Board (IRB), ensuring that all ethical guidelines were strictly adhered to during recruitment, data collection, and all phases of the research study.

Table 4.1

Participant demographics for robot-mediated read-aloud study

Characteristics	**Number of Participants**
Gender	
Girls	12
Boys	8
Race/Ethnicity	
African American	2
Caucasian	9
Indian	3
Arab	3
Asian	2
Hispanic	1
Total Participants	21

Robot

Pepper is a 120cm tall robot programmed to interactively present a book to each participant. This robot has the ability to perceive the environment effectively and be involved in interaction with others. Equipped with a human-like voice, Pepper can ask questions, provide feedback, and respond to participants in real time. It also has advanced sensors, allowing it to recognize faces, interpret gestures, and adjust its behavior based on the child’s responses. Pepper has been employed for educational, medical, and companionship purposes.

Figure 4.2

Pepper

Book

The book, *This Is Not My Hat* (Klassen, 2012), was selected based on a recommendation for ages 4-8 by the Children’s Literature Comprehensive Database (CLCD), a trusted resource for educators, librarians, and researchers that provides detailed information and expert reviews on children's books. CLCD is widely regarded for its comprehensive collection of reviews and resources, drawing on the insights of professional educators, literary experts, and librarians who specialize in children's literature. The narrative is written from the unreliable perspective of a little fish who steals a hat from a larger fish and predicts that the larger fish will never find out. Of course, the larger fish does find out and beautiful illustration clues help illuminate how the large fish finds the small fish and gets his hat back. Given the combined text and illustration clues, the text provides strong support for asking the child inferential questions (e.g., Do you think he [the big fish] noticed? Why or why not?). See Table 4.3 for all inferential questions. This provides a meaningful context for the robot to mediate the child's inferencing during the interactive read-aloud.

Validity of the Preprogrammed Mediations

The preprogrammed mediations for the robot were carefully designed and aligned with well-established theoretical constructs, such as the Zone of Free Movement (ZFM) and Zone of Promoted Action (ZPA) (Valsiner, 1997). These mediations draw on extensive research from the fields of educational psychology and literacy development, ensuring their relevance and effectiveness in promoting cognitive engagement and learning. For example, the inferential questions used in this study, such as "Should he [the big fish] be worried about that?", are supported by research highlighting the importance of high-cognitive-demand questions in enhancing children's comprehension and critical thinking (Bakhoda et al., 2022; Christ et al., 2022; Zucker et al., 2010). The alignment of these mediations with established literature ensures that they are not arbitrarily chosen, but rather informed by evidence-based practices known to facilitate learning. This validation through prior studies provides confidence that the robot's mediations are effective tools for scaffolding children's understanding, engagement, and cognitive development during interactive read-alouds.

Table 4.2

The preprogrammed design for the robot

Pre-programed Mediation	Code/Category of Mediation	Theoretical Construct with which the Mediation Aligns	Citations for the research that informed the development of the mediation
	Zone of Free Movement (ZFM): "delimits the full set of possible ways" one can act (Valsiner, 1997, p. 180) and organizes the child's direction of development through its framework for activity (Blanton et al., 2005)		
Please do not touch me	Restricts action	ZFM	Researcher developed code
Please sit on the chair in front of me	Restricts action	ZFM	Researcher developed code
	Zone of Promoted Action (ZPA): Constructed by the mediator (e.g., a teacher or more knowledgeable other) as s/he tries to get the child to attend to learning in a particular way (Valsiner, 1997)		
Should he [the big fish] be worried about that? Why or why not?	Inferential question	ZPA	Bakhoda et al., (2022); Blything et al., (2020); Christ et al., (2022); Mascareño et al., (2016); Zucker et al., (2010)
Yes, that's right	Response evaluation	ZPA	Christ et al., (2022); Bakhoda et al., (2022); Cents-Boonstra et al. (2021); Jadallah et al. (2011)
What do you notice about his eye [the big fish]?	Guiding question	ZPA	Bakhoda et al., (2022); Jadallah et al. (2011)
Why is he [the big fish] looking up?	Literal question	ZPA	Blything et al., (2020); Christ et al., (2022); Deshmukh et al. (2019); Sartori et al. (2021)
Do you think he [the big fish] noticed? Why and why not?	Inferential question	ZPA	Bakhoda et al., (2022); Blything et al., (2020); Christ et al., (2022); Mascareño et al., (2016); Zucker et al., (2010)
What is the crab doing?	Literal question	ZPA	Blything et al., (2020); Christ et al., (2022); Deshmukh et al. (2019); Sartori et al. (2021)

Table 4.2 continued

Pre-programed Mediation	Code/Category of Mediation	Theoretical Construct with which the Mediation Aligns	Citations for the research that informed the development of the mediation
Where is he pointing to?	Literal question	ZPA	Blything et al., (2020); Christ et al., (2022); Deshmukh et al. (2019); Sartori et al. (2021)
How did he [the big fish] get his hat back? How do you know?	Inferential question	ZPA	Bakhoda et al., (2022); Blything et al., (2020); Christ et al., (2022); Mascareño et al., (2016); Zucker et al., (2010)
Where did the hat come from?	Inferential question	ZPA	Bakhoda et al., (2022); Blything et al., (2020); Christ et al., (2022); Mascareño et al., (2016); Zucker et al., (2010)

Data Collection Rationale

To answer the research question—*What are the supports and barriers related to the feasibility of using a robot to provide mediations during a one-on-one (child-robot) interactive read-aloud?* —it is essential to examine a range of elements that together reveal the intricate dynamics of this interaction. Observing child behavior, including engagement and non-verbal cues, offers critical insights into how effectively the robot maintains attention and creates a supportive learning environment. This is particularly significant given the well-established role of engagement in learning outcomes (Lin et al., 2022; van den Berghe et al., 2019). Additionally, analyzing children's responses to inferential questions serves to evaluate the robot's capacity to scaffold cognitive development, as research consistently highlights the importance of such questioning for literacy advancement (Zucker et al., 2010; Price et al., 2012).

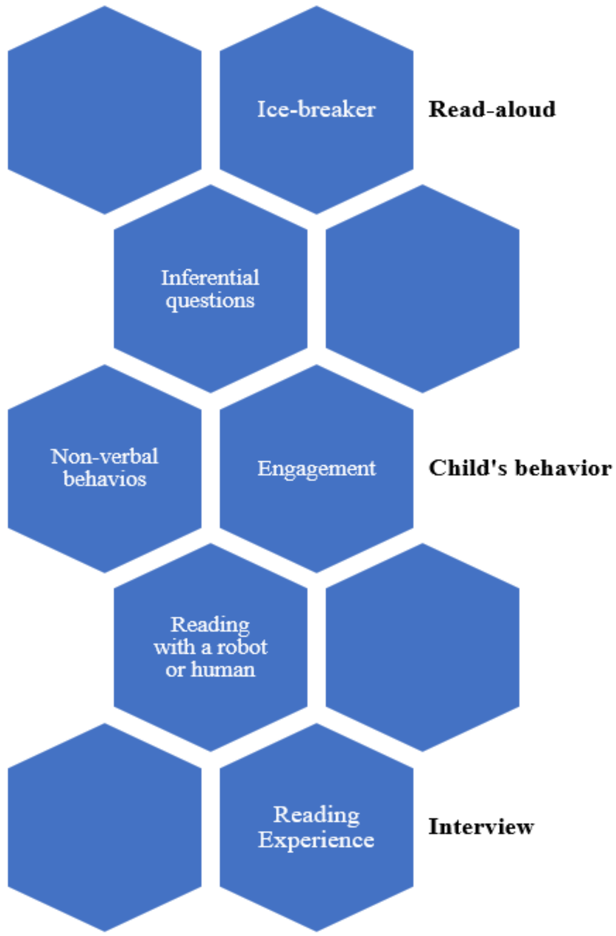


Figure 4.3

Visual representation of key analytical elements in robot-mediated read-aloud sessions

The social-emotional dimensions of the interaction are also key, with non-verbal behaviors and children’s preferences for reading with a robot versus a human offering insight into potential supports or barriers. These could include the emotional connection, which may influence learning outcomes (Rohlfing et al., 2022; Tanaka & Matsuzoe, 2012). Moreover, post-read-aloud interviews allow the children’s subjective experiences to be captured, providing a holistic view of their learning interaction, which complements the behavioral data (Almousa & Alghowinem, 2022).

By integrating these various elements, this layered analysis provides a comprehensive understanding of the factors affecting the feasibility of using robotic mediations in literacy development, addressing both cognitive and emotional aspects of the child-robot interaction (Breazeal et al., 2016; Anwar et al., 2019).

Data Collection Procedure

The data collection occurred in three steps: Ice breaker, read-aloud, and the interview.

The session began with an ice-breaker phase to build rapport between the child and the robot, Pepper. This phase included light conversation where Pepper asked the child for their name and favorite activities, followed by an invitation to dance. The ice-breaker aimed to establish a comfortable, engaging environment for the child, helping to reduce any initial apprehension. By encouraging the child to interact with both Pepper and the researcher, this phase fostered a positive connection that paved the way for the subsequent reading and question-answer interaction.

In the Read-Aloud Section, the story book, *This Is Not My Hat* by Jon Klassen, was presented on the screen at the close access to Pepper's reach. During the story, Pepper holds a pointer to highlight relevant points and illustrations on the screen, aiding the child's comprehension and engagement. At key moments in the narrative, Pepper pauses to ask three inferential questions designed to encourage critical thinking and reflection, such as, "Do you think the big fish noticed?" Based on the child's response, Pepper provides various mediations—ranging from asking follow-up questions to offering clues from the text or prompting prior knowledge. This structured interaction flow allows Pepper to guide the child through reasoning and deeper understanding. If needed, the researcher presented more mediations through Wizard of Oz, which allows the researcher to control Pepper's behavior. This enables the researcher to control Pepper's actions and responses in real-time, simulating advanced autonomy and closely monitoring child interactions.

Moreover, this technique allows the researcher to adapt Pepper's responses based on the child's behavior and answers. Pepper corrects misinformation or provides positive reinforcement, ensuring the child remains engaged and supported throughout the session. All inferential questions, mediations, paraphrased mediations are presented in table 4.3.

Table 4.3

Inferential questions, mediations, and answers

	Q1. Do you think he [the big fish] noticed? Why and why not?	Q2. Should he [the little fish] be worried about that? Why or why not?	Q3. How did he [the big fish] get his hat back? How do you know?
Paraphrase	Did the big fish notice that his hat was gone?	Do you think the big fish will find out where the little fish went?	Where did the hat on the big fish's head come from?
TC	Where is the big fish looking?	What is the crab doing?	Where is the hat now?
TC Paraphrase	Look at the big fish's eye, where is he looking?	Where is the crab pointing?	What does the big fish have on his head now? [He has the hat on his head]
BK	What is missing from his head?	What do people do when someone takes their stuff?	Who had the hat before?
BK Paraphrase	What is not on his head anymore?	Do you think the big fish wants his hat back?	Who took the hat at the beginning of the book?
Correct answer	I think he noticed because I notice when something I have is missing, and the big fish is looking up at the top of his head where his hat used to be	I think he should be worried because the big fish looks angry and the crab pointed to show him where the little fish went, so I think he may go after the little fish	I think he got his hat back because he found the little fish. The crab pointed in the direction the little fish went, and the big fish went that way and came back with his hat. He must have found him

Note: TC= Text Clue, BK= Background

In the designed protocol, the flow of the interaction between the robot (Pepper) and the child follows a structured sequence, each inferential question triggers a series of potential responses based on the child's answer, leading to mediations that help guide or correct the child's understanding. For example, in Question 1, "Do you think the big fish noticed?" The robot offers specific text and prior knowledge mediations based on the child's response. Correct answers are praised, while incomplete or incorrect answers prompt further questions or explanations. The detailed flow of the research procedure, outlining all possible mediations and responses, is provided in the supplementary appendix G for further reference. This structured approach ensures a consistent and supportive interaction aimed at enhancing comprehension and engagement.

Each robot-learner dyad's interactions were video recorded with two cameras, from front and back. This allowed capturing the participants facial expression in cloze up and their robot child interaction in long shots. The recorded videos were the main source of data analyses in this study. Finally, at the end of the session with Pepper, the researcher asked the child the following feedback questions:

- What was it like to read with Pepper?
- Was there anything helpful about reading with Pepper? Was there anything difficult about reading with Pepper?
- Do you prefer to read with Pepper or a human adult, like your teacher or parent? Why?

Broad prompts (e.g., Tell me more about that) were used to elicit more or clarifying information based on each child's responses. These interviews were also video-recorded for in-depth analysis.

Data Analysis

The data analysis process employed qualitative emergent coding and constant comparative analysis (Corbin & Strauss, 2014), which was applied across the entire data set, encompassing three key phases: the ice-breaker, the read-aloud, and the post-read-aloud interview. Both the read-aloud and interview sections were transcribed, ensuring that all verbal exchanges were accurately captured for subsequent coding. The child's behavior during the interaction with the robot was coded in 10 second time slots in order to capture all the detailed nonverbal behaviors of the child.

Additionally, key behaviors observed during the child-robot interaction sessions, such as attention, engagement, and physical movements, were systematically categorized into various engagement metrics (e.g., gaze toward the robot, gaze away, restless movement) to provide a nuanced understanding of how these interactions influenced the children's learning experiences. This analysis also focused on examining verbal engagement as an indicator of cognitive engagement and interaction success.

Two coders—one from an educational background and the other with expertise in social robotics—collaboratively coded the data. Before starting the full analysis, these individuals practiced coding together to establish a consistent understanding of the coding scheme. This initial phase allowed them to resolve any ambiguities and develop a shared framework for identifying the supports and barriers related to the feasibility of using a robot for mediations during a one-on-one (child-robot) interactive read-aloud (Appendix I). The calculated inter-rater reliability between the two codes for the children’s behavior, during reading interaction, and the interview were .79, .84, and .86, respectively.

Once they were aligned, the coders independently analyzed the entire data set, applying the emergent codes to the transcripts. Any discrepancies between their interpretations were discussed, and a consensus was reached to ensure reliability. This iterative process also incorporated quantitative metrics, such as verbal engagement percentages and gaze percentages, to evaluate the robot's effectiveness in maintaining children's focus during literacy activities. The integration of qualitative and quantitative analyses ensured a comprehensive exploration of both cognitive and emotional engagement during the sessions.

The constant comparative method ensured that insights evolved continuously, allowing for refinements to the coding structure as new patterns emerged from the data. To deepen the analysis, the effectiveness of the robot's mediations was also assessed. A scoring system was employed to evaluate how children responded to mediations, whether they required partial, full, or no mediation to arrive at correct answers. Pearson's correlation analysis was used to explore relationships between learning rates and various behavioral factors, including engagement and distractions.

Results

This section outlines the approach employed to analyze the data collected during the child-robot interaction sessions. The analysis was conducted through qualitative emergent coding and constant comparative analysis (Corbin & Strauss, 2014), allowing for the identification and categorization of key behaviors observed in the participants. These behaviors, including attention, engagement, and physical movements, were systematically coded to gain a deeper understanding of how children interacted with the robot and how these interactions influenced their learning experiences. The goal of this analysis is to explore both the supports and barriers associated with using a robot as a mediator in educational settings. By examining behavioral patterns such as verbal engagement and attention, this analysis aims to evaluate the robot's effectiveness in maintaining children's focus and fostering meaningful interaction during literacy activities. This section provides a foundation for understanding how various factors contribute to the feasibility of integrating robots in educational contexts, specifically within one-on-one learning environments.

Table 4.4

Child-Robot Interaction Behaviors

Category	Description
Distraction	The child is distracted during the interaction (e.g., playing with an object, focusing on something else).
Gaze_Toward_Robot (Gaze_Robot)	The child is looking at the robot.
Gaze_Toward_Book (Gaze_Screen)	The child is looking at the screen.
Gaze_Away (Gaze_Away)	The child is not looking at the robot or book, indicating lack of attention but still attending to the interaction.
Restless movement	The child exhibits restless body movements.
Verbally engaged	The child appropriately answers the robot's question.
Physically engaged in dancing	The child is physically engaged in dancing.
Accept dancing	The child agrees to dance.

The table highlights key engagement metrics—verbal engagement, gaze toward the robot, and restless movement—across selected participants to address the research question: What are the supports and barriers related to the feasibility of using a robot to provide mediations during a one-on-one (child-robot) interactive read-aloud?

Participants such as Kara (56% verbal engagement, 82% gaze) and Ivan (39% verbal engagement, 95% gaze) demonstrated high engagement with the robot, suggesting that the robot successfully captured and maintained their attention. The strong gaze percentages indicate that the robot effectively served as a focal point during the read-aloud, supporting the feasibility of using robots for instructional mediation. These high levels of verbal engagement suggest that the robot prompted meaningful interaction and cognitive engagement during the session.

Table 4.5

Key engagement metrics and barriers in child-robot read-aloud interactions

Participant	Verbal Engagement (%)	Gaze Toward Robot (%)	Restless Movement (%)	Key Observations
Kara	56%	82%	22%	Strong engagement (Support)
Ivan	39%	95%	36%	High engagement but some restlessness (Support/Barrier)
Grant	2%	25%	62%	Low engagement, high restlessness (Barrier)
Ethan	31%	96%	46%	High gaze and engagement, some restlessness (Support/Barrier)
Aria	21%	68%	39%	Moderate engagement, high distraction (Barrier)
Tristan	26%	32%	26%	Moderate engagement, restless (Barrier)
Gavin	14%	99%	29%	Strong gaze but low verbal engagement (Support/Barrier)
Lila	2%	46%	28%	Low verbal engagement, distracted (Barrier)

On the other hand, participants like Grant (2% verbal engagement, 25% gaze) and Aria (21% verbal engagement, 39% restless movement) presented significant barriers. Low verbal engagement, high distraction, and frequent restlessness suggest that the robot struggled to maintain attention or provide sufficient emotional and cognitive support for these children. This indicates that while robots may work well for some children, their ability to engage all learners consistently is limited and may require further enhancements in interaction strategies or adaptability to individual needs.

The data show both promising engagement in some children and significant challenges in others. High engagement and gaze levels support the robot's potential as a mediator, but frequent distractions and restlessness in others highlight the need for more adaptive interaction strategies. Thus, while feasible for some learners, further development is necessary to ensure consistent effectiveness across diverse participants.

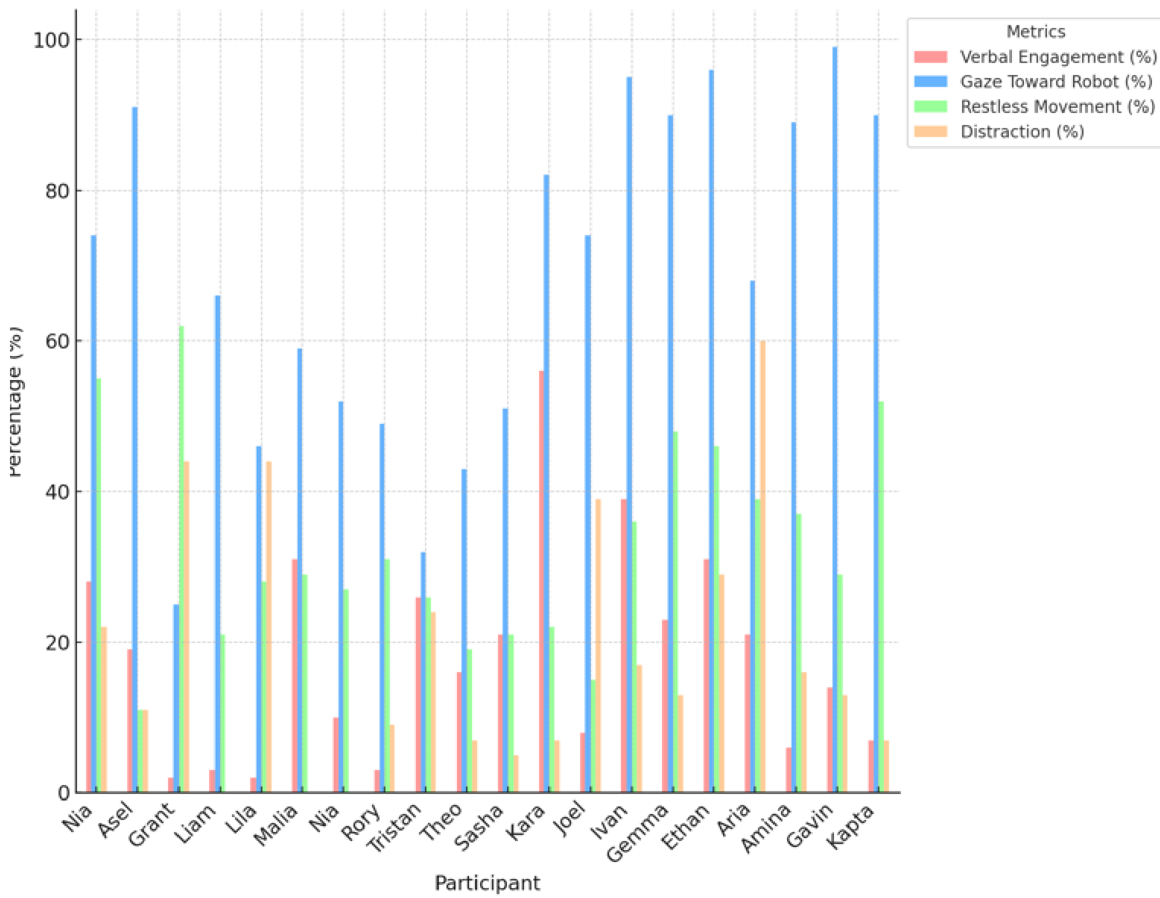


Figure 4.4

Engagement and barriers in child-robot interaction

The figure illustrates the engagement and barrier metrics for participants during a one-on-one child-robot interactive read-aloud session. Key metrics such as verbal engagement, gaze toward the robot, restless movement, and distraction percentages are presented for each participant. The data reveals varying levels of engagement, with participants like Kara and Ivan showing high verbal engagement and gaze toward the robot, while others, such as Grant and Aria, exhibited more restlessness and distraction. This suggests both supports and barriers to the feasibility of using a robot for mediation in literacy interactions. For further detailed analysis, please refer to Appendix H.

Robot Mediations Effectiveness

In 35 instances, the robot's mediations were ineffective in guiding learners to the correct answer. However, in 10 cases, learners were able to reach the correct answer after receiving all the available mediations. In 8 cases, partial mediation was sufficient, while in 7 cases, learners arrived at the correct answer independently, without requiring any mediation.

Table 4.6

Robot Mediation Outcomes in Guiding Learners to Correct Answers

Outcome	Number of Instances
Mediations ineffective	35
Correct answer after all mediations	10
Correct answer after partial mediation	8
Correct answer without mediation	7

To evaluate the effectiveness of these mediations, learners were assigned a score based on their need for assistance. If the mediations were entirely ineffective, a score of 0 was given. Learners who reached the correct answer after one mediation were assigned a score of 1, while those requiring two mediations received a score of 2. A score of 3 was given to learners who needed more than two mediations to arrive at the correct answer. This scoring system is based on the notion that children with more developed cognitive abilities required fewer mediations to reach the correct answer (Bakhoda & Shabani, 2019). An example of a typical mediation pattern and the corresponding scores is presented below.

Table 4.7

Participant Responses and Learning Rates

Participant	Q1	Q2	Q3	Learning Rate
Nichole	Inferential Question → Correct answer without rationale to the inferential question → Reason-seeking question → Correct Answer with Rationale to the inferential question → Praise/Positive Reinforcement	Inferential Question → Correct answer without rationale to the inferential question → Reason-seeking question → Correct Answer with Rationale to the inferential question → Praise/Positive Reinforcement	Inferential Question → Correct Answer with Rationale to the inferential question → Praise/Positive Reinforcement	5
Grant	Inferential Question Repetition → No response to inferential question → Inferential Question Repetition → Reason-seeking question → No response to reason-seeking question → Background Knowledge Mediation → No response to mediation → Paraphrasing the background mediation → No response to mediation → Robot provides the correct answer to the mediation → Inferential Question Repetition → Incorrect Answer without rationale to the inferential question → Reason-seeking question → No response to reason-seeking question → Robot provides the correct answer to the inferential questions	Inferential Question → Incorrect Answer without rationale to the inferential question → Reason-seeking question → Textual Clue Mediation → No response to mediation → Paraphrasing the text mediation → No response to mediation → Robot provides the correct answer to the mediation → Inferential Question Repetition → Incorrect Answer without rationale to the inferential question → Reason-seeking question → No response to reason-seeking question → Background Knowledge Mediation → No response to mediation → Paraphrasing the background mediation → No response to mediation → Robot provides the correct answer to the mediation → Inferential Question Repetition → No response to inferential question → Robot provides the correct answer to the inferential questions	Inferential Question → No response to inferential question → Paraphrasing the inferential question → No response to inferential question → Textual Clue Mediation → No response to mediation → Robot provides the correct answer to the mediation → Inferential Question Repetition → No response to inferential question → Background Knowledge Mediation → No response to mediation → Paraphrasing the background mediation → No response to inferential question → Robot provides the correct answer to the mediation → Inferential Question Repetition → No response to inferential question → Robot provides the correct answer to the inferential questions	0

To explore the relationships between the learning rate and various behavioral factors, a correlation analysis was conducted. The following steps outline the methodology used in this analysis:

The first step involved preparing the dataset by selecting the relevant columns for analysis. These included the learning rate as well as metrics related to verbal engagement, gaze behavior, and distractions. By isolating these variables, we ensured that the analysis focused on the most pertinent factors affecting learning outcomes. Next, Pearson's correlation coefficient was applied to generate a correlation matrix, which measures the strength and direction of the linear relationships between the learning rate and the behavioral factors. The correlation values range from -1 to 1, where a value of 1 represents a perfect positive correlation, -1 indicates a perfect negative correlation, and 0 suggests no correlation. This step provided a clear picture of how each behavioral factor aligns with the learning rate. To facilitate a deeper understanding of these relationships, several visualizations were created. A correlation heatmap was generated to visually depict the strength and direction of the relationships between variables. Additionally, scatter plots were used to illustrate specific relationships between the learning rate and key engagement metrics. Finally, bar plots were employed to summarize the correlation coefficients, offering a clear comparison of how different factors relate to the learning rate. By following these steps, the analysis aimed to uncover the key behavioral influences on learning rates, providing valuable insights into how verbal engagement, gaze behavior, and other factors contribute to the learning process.

Table 4.8

Correlation Coefficient Analyses

Factor	Correlation Coefficient	Relationship Description
Verbally engaged (%)	0.76	Strong positive correlation with learning rate; higher engagement leads to better learning.
Verbally engaged (#)	0.64	Strong positive correlation; frequent verbal interactions enhance learning rates.
Gaze Toward Robot (%)	0.45	Moderate positive correlation; focusing on the robot is associated with higher learning.
Gaze Toward Book (%)	0.37	Moderate positive correlation; suggests that attention to materials aids learning.
Physically engaged in dancing	0.24	Weak positive correlation; physical involvement may slightly boost learning.
Accept dancing	0.04	Very weak positive correlation; minimal impact on learning rates observed.
Gaze Away (%)	-0.02	Negligible correlation; no significant relationship with learning rate.
Gaze Away (#)	-0.17	Weak negative correlation; increased gaze away may correlate with lower learning.
Restless movement (%)	-0.22	Weak negative correlation; higher restlessness may hinder learning.
Distraction (%)	-0.23	Weak negative correlation; higher distraction correlates with lower learning rates.
Restless movement (#)	-0.35	Moderate negative correlation; suggests that restlessness adversely affects learning.
Distraction (#)	-0.39	Moderate negative correlation; higher distractions are linked to lower learning effectiveness.
Time (s)	-0.70	Strong negative correlation; longer task durations may not lead to higher learning rates.
Number of 10 sec intervals (#)	-0.70	Strong negative correlation; similar to time, this indicates potential fatigue or disengagement.

The analysis revealed significant relationships between the learning rate and several behavioral factors. The following plots illustrate these relationships:

Correlation Heatmap

The correlation heatmap visualizes the relationships between the learning rate and various factors. Positive correlations are indicated in shades of blue, while negative correlations are shown in shades of red. The heatmap shows that verbally engaged percentage (0.76) and verbally engaged count (0.64) have the strongest positive correlations with learning rate, suggesting that higher engagement leads to better learning outcomes.

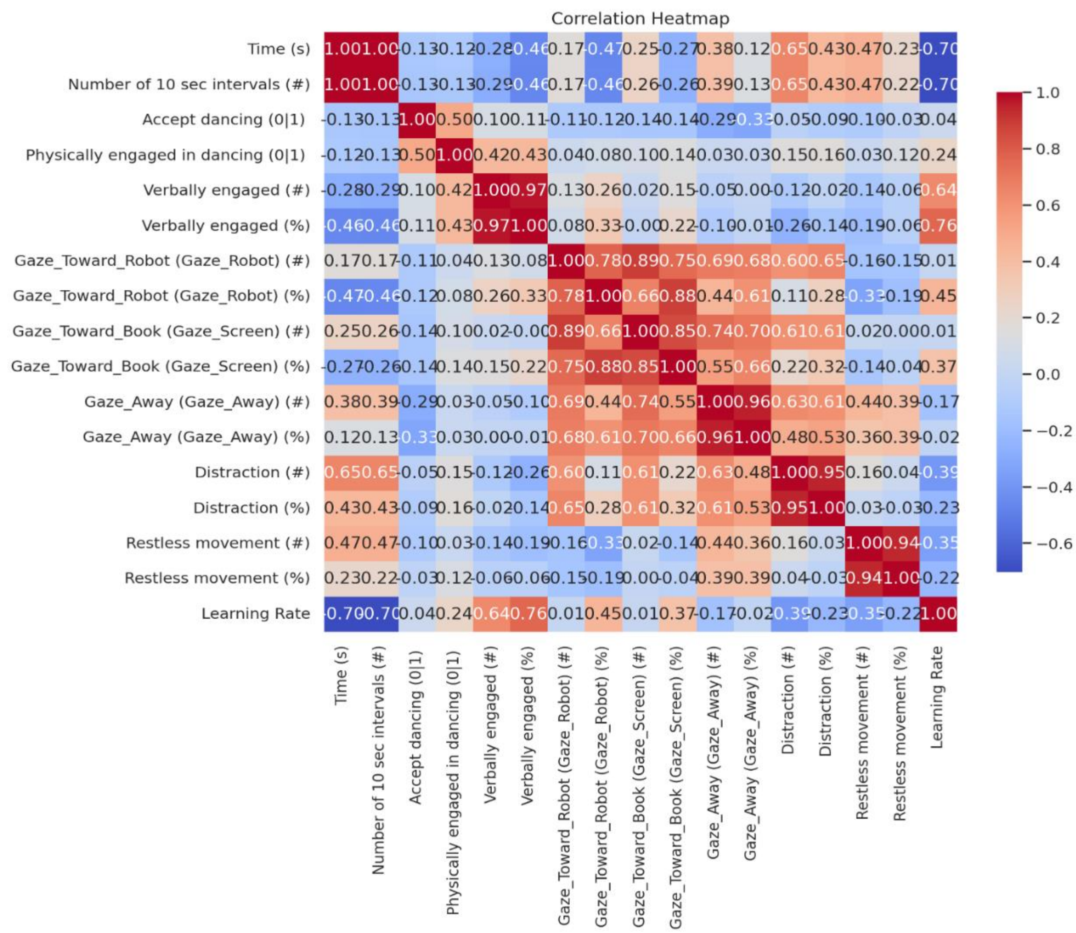


Figure 4.5

Correlation Heatmap Visualization

Scatter Plot: Learning Rate vs. Verbally Engaged (%)

This scatter plot illustrates the relationship between learning rate and verbally engaged percentage. The trend suggests that as the percentage of verbal engagement increases, so does the learning rate. This indicates that participants who interact more verbally with the task are likely to learn more effectively.

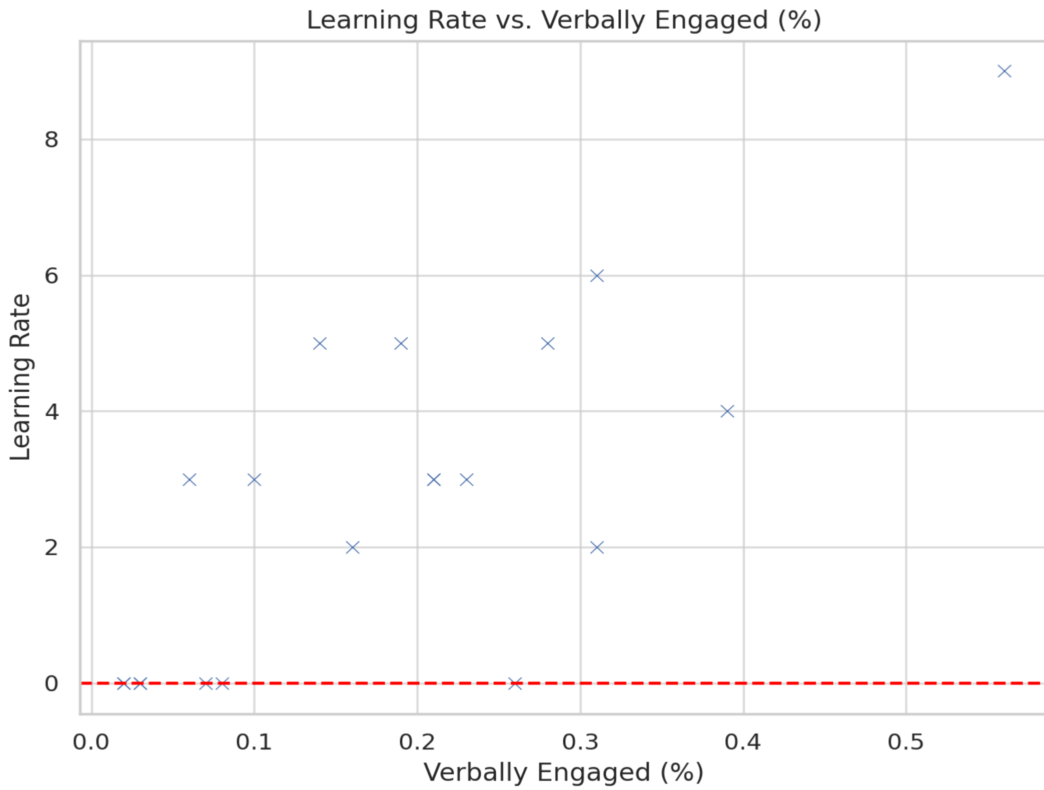


Figure 4.6

Scatter Plot Illustration

Bar Plot of Correlation Coefficients

The bar plot displays the correlation coefficients of various factors in relation to the learning rate. Factors like distraction and restless movement show negative correlations, while engagement factors show positive correlations. This supports the observation that lower distraction levels and higher engagement are associated with higher learning rates, suggesting a positive relationship between these behaviors and learning outcomes.

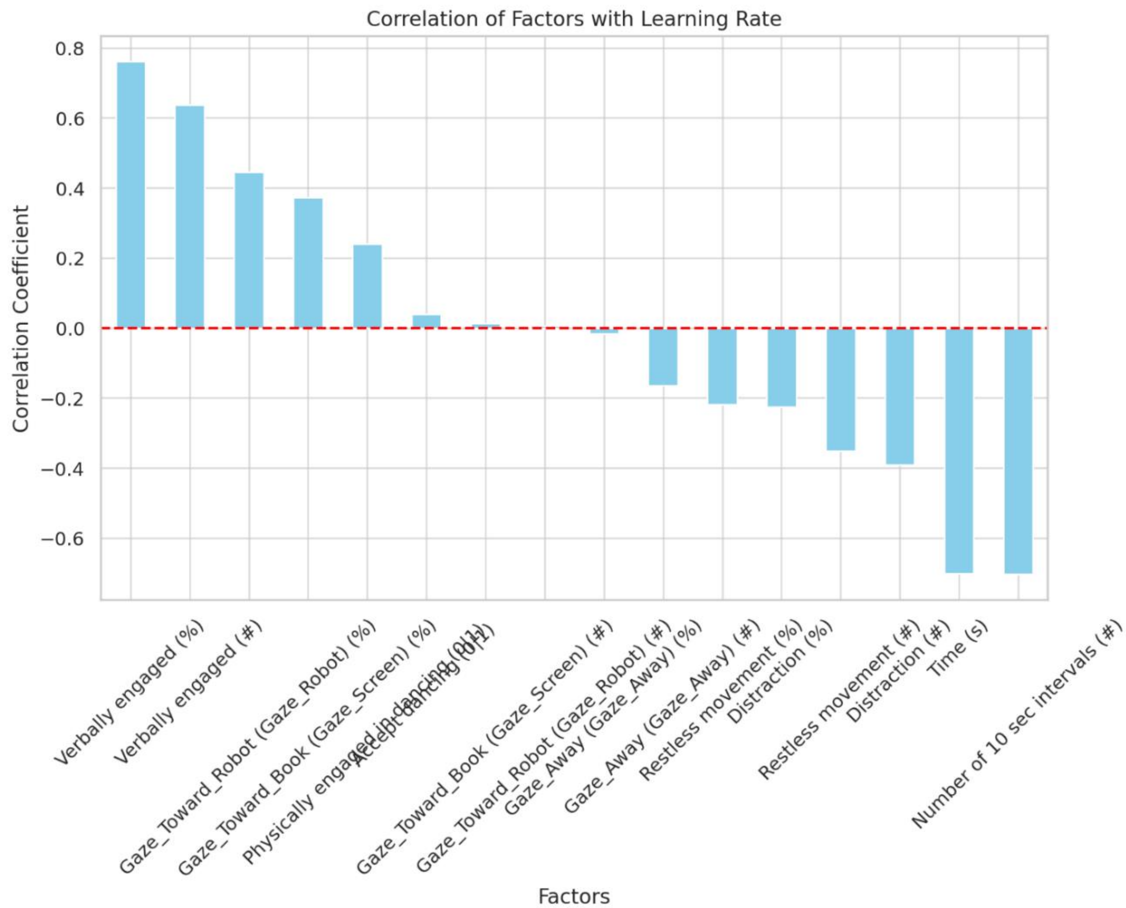


Figure 4.7

Bar Plot Visualization

The analysis indicated that behavioral factors significantly correlated with learning rates in participants. Verbal engagement showed a strong positive correlation with learning outcomes, indicating that children who verbally engaged more frequently tended to have higher learning rates. Additionally, minimizing distractions and fostering physical engagement could further support the learning process.

Barriers and Support of Using Robot in the Interview

Qualitative Analysis of Interview Data

To address the research question—What are the supports and barriers related to the feasibility of using a robot to provide mediations during a one-on-one (child-robot) interactive read-aloud?—a thematic analysis of the interview data was conducted (codes are available in Appendix J). This analysis captures children's experiences with Pepper during the interactive read-aloud sessions, shedding light on both the supports and barriers involved in utilizing robots like Pepper within educational contexts, particularly for language learning and literacy development.

Supports for Robot-Mediated Reading

Positive Attitudes Toward the Robot's Features

Many children expressed positive attitudes towards Pepper, highlighting specific features of the robot's design and functionality that enhanced their reading experience. For example, several participants enjoyed Pepper's physical appearance and interactive elements. Tristan, for instance, appreciated the robot's pointer, remarking, "I liked the pointer," while Nia mentioned Pepper's size, saying, "I like that he is huge." These comments suggest that the novel and interactive design of the robot can engage children, offering a reading experience that feels distinct from traditional human-led sessions.

Moreover, children responded favorably to Pepper's speech clarity. Nia observed that "He speaks loud," and Ansel noted, "The robot pronounces the words right." Such responses indicate that technical features like clear articulation can aid children in focusing on and comprehending the story, suggesting that robots like Pepper may serve as effective tools for scaffolding learning through their ability to provide precise auditory feedback during read-aloud sessions.

Robot's Ability to Elicit Engagement

Another prominent support was Pepper's ability to maintain engagement through interactive features like eye contact, body movements, and screen displays. Sasha commented on the enjoyment of watching the screen, while Aria appreciated the robot's encouragement, noting, "He said 'good job' when I answered questions." This combination of visual, auditory, and verbal feedback appears to play a role in sustaining children's attention and fostering an interactive learning environment. The robot's praise for correct answers and its structured questioning seem to contribute to a more dynamic experience, potentially enhancing active learning in children.

These interactive elements suggest that robots like Pepper have the potential to create an engaging and stimulating educational environment. Research supports the idea that technology-driven interactions can enhance learner engagement (van den Berghe et al., 2019), reinforcing the notion that robots may be effective tools in certain educational contexts.

Novelty and Preference for the Robot

Several children expressed a preference for reading with Pepper, which could be attributed to the novelty of interacting with a robot. Tristan stated, "I prefer Pepper," and Lila echoed this sentiment, saying, "I prefer to read with Pepper." This preference likely stems from the unique experience that a robot-mediated reading session offers, introducing children to a novel method of engagement. Aria further emphasized this novelty, remarking, “I never seen this before,” referring to Pepper’s behavior during the session.

This excitement surrounding the robot’s novelty may play a significant role in fostering early engagement, suggesting that robots can serve as an effective supplementary tool in educational settings. The combination of curiosity and technological advantages (such as visual aids) may enable robots to capture children’s interest and encourage active participation in learning activities.

Barriers to Robot-Mediated Reading

Difficulty in Understanding or Engaging with the Robot

While some children found Pepper easy to interact with, others encountered challenges. Gavin, for instance, remarked, “It was hard because of hard questions,” while Tristan struggled with understanding the story, noting, “It was difficult because the big fish was mother to the little fish.” These comments suggest that Pepper’s instructional mediation may not always be sufficient, particularly when dealing with more complex content.

Additionally, some children, like Theo and Rory, expressed uncertainty about what made the experience challenging, which may point to a lack of deeper engagement or comprehension. This indicates that while robots can mimic certain teaching behaviors, such as asking questions, they may lack the flexibility or empathy needed to provide the cognitive and emotional scaffolding required for more nuanced understanding. These findings align with existing research highlighting the limitations of pedagogical interventions involving robots (Blanchard et al., 2009).

Preference for Human Interaction: Emotional Connection

A recurring theme in the data was the children's preference for human readers, largely due to the emotional connection they experience with their parents. Liam expressed this preference by stating, "I like my mom because she cuddles with me," and Theo explained his choice by saying, "I like him [my dad]." These responses suggest that the emotional and physical presence of human readers plays a critical role in creating a supportive and comforting reading environment.

This lack of emotional engagement represents a key limitation of robot-mediated learning. Although Pepper can replicate certain aspects of human reading, such as reading aloud and asking questions, it cannot offer the emotional warmth and relational dynamics that human caregivers provide, particularly in emotionally sensitive contexts like bedtime reading. Emotional connection remains a significant barrier to the feasibility of robots fully replacing human interactions in educational settings (Ahmad et al., 2019).

Physical and Sensory Discomfort with the Robot

Some children also reported discomfort with Pepper's physical presence. Tristan mentioned, "It was difficult because it stinks," and Nia noted that the robot made "squeaky sounds," which made the interaction feel unnatural. These comments highlight another barrier—physical and sensory discomfort can detract from the learning experience and potentially cause children to disengage or feel uneasy around the robot.

These reactions suggest that, while robots offer several technical advantages, their physical presence may not always be perceived positively. Addressing these barriers is essential when designing robots for educational settings, especially for young learners who may be sensitive to sensory input or have specific expectations of a reading partner.

The interview data provides valuable insights into the supports and barriers related to the feasibility of using robots like Pepper in one-on-one read-aloud sessions. The primary supports include the robot's ability to engage children through its novel interactive features, its clear speech output, and its capacity to provide structured feedback. These aspects suggest that robots can be effective tools in structured, task-oriented educational settings.

However, several barriers emerged, including children's preference for human interaction due to emotional bonding, the robot's limitations in mediating complex reading tasks, and physical or sensory discomfort. These findings highlight that while robots can supplement educational experiences, they are unlikely to fully replace human teachers, particularly in contexts that require emotional connection and adaptive instructional strategies.

Ultimately, the feasibility of using robots like Pepper in education will depend on balancing their technical capabilities with the emotional, cognitive, and sensory needs of learners. Robots can enhance engagement and provide structured educational content, but they must be designed and implemented to complement, rather than replace, human interaction.

Discussion and Implication

This study aimed to explore the feasibility of using a robot to provide mediations during one-on-one (child-robot) interactive read-aloud sessions. The analysis revealed both supports and barriers to this emerging pedagogical tool, shedding light on the nuances of robot-mediated interactions in early literacy development. By examining engagement metrics, such as gaze direction, verbal interaction, and physical engagement, the study offers insight into the factors that either facilitate or hinder the robot's effectiveness as a literacy mediator.

The findings align with prior research on teacher-mediated read-alouds, where active engagement and inferential questioning positively impacted children's comprehension and vocabulary development (Beck et al., 2013; Coyne et al., 2009; Wright & Gotwals, 2017). Specifically, this study's results echoed the effectiveness of inferential questions during read-alouds, as demonstrated in studies by Hindman et al. (2019) and Price & Bradley (2016), where high-cognitive-demand talk-turns supported vocabulary gains. However, our findings diverge in that robot-mediated read-alouds did not consistently produce high engagement across all participants, especially in cases where emotional connection and scaffolding were lacking.

A key contrast between this study and previous literature is the role of emotional connection. While research on human-read read-alouds has highlighted the importance of emotional engagement (Christ et al., 2022; Cents-Boonstra et al., 2021), the robot in this study struggled to replicate the relational dynamics typically provided by a human instructor. Children reported a preference for reading with their parents due to the emotional and physical comfort provided, a factor that is difficult to replicate with current robotic technology. This finding aligns with the work of Ahmad et al. (2019), who noted that while robots can offer instructional support, their ability to provide the warmth and connection essential for young learners remains limited.

Additionally, while the robot was effective in some cases at maintaining attention and providing structured mediation, challenges arose in the flexibility of its interactions. Participants who encountered difficulties with the robot's questions or found its mediations confusing were less likely to engage meaningfully. This aligns with previous studies indicating that robots, while effective in providing structured feedback, lack the adaptive capacity of human instructors (Blanchard et al., 2009; Bourguet et al., 2020).

Implications for the Field

The implications of this study for educational practice and the integration of robotics in literacy development are significant. First, the results suggest that robots can be valuable supplementary tools in educational settings, particularly in structured, task-oriented contexts. For instance, robots like Pepper can effectively guide children through inferential reasoning and scaffold their understanding during read-aloud sessions. However, they should not be considered a replacement for human instructors, especially in contexts where emotional connection and individualized scaffolding are critical to learning outcomes.

Practically, this study suggests that the design of educational robots should focus on enhancing their emotional and cognitive responsiveness. To increase feasibility and effectiveness, future iterations of educational robots could benefit from more advanced adaptive feedback mechanisms that allow for personalized responses based on the learner's progress. Integrating socio-emotional cues into the robot's design could also help address the barriers related to emotional engagement, making robotic tools more suitable for young learners.

In the context of literacy education, these findings highlight the importance of balancing technological innovation with human interaction. While robots can offer consistent and structured mediation, the study underscores the ongoing need for human instructors who can provide the emotional and contextual flexibility that robots currently lack. Therefore, educational institutions seeking to implement robot-assisted learning should do so in tandem with human-led interventions, ensuring that robots are used to complement, rather than replace, human educators.

Limitation and Future Direction

This study provides valuable insights into the feasibility of using robots to mediate one-on-one interactive read-aloud sessions, but several limitations need to be acknowledged. These limitations also point towards important directions for future research.

Small and Homogeneous Sample Size: The study involved a relatively small group of participants (20 children aged 3-6 years), which limits the generalizability of the findings. Most participants shared similar demographic backgrounds, which may not represent the diversity of learners typically found in real-world educational settings. Future research should involve larger and more diverse populations that include different age groups, socioeconomic backgrounds, language proficiencies, and learning abilities. By exploring a more diverse sample, studies can better assess the robot's effectiveness across a range of learners and educational contexts.

Limited Scope of Interaction: The study focused on a single book and a specific set of inferential questions during the robot-mediated read-aloud sessions. While this provided a controlled environment for analysis, it restricts the understanding of how robots perform across different learning tasks. Future research should explore a broader range of reading materials, interaction types, and instructional goals to evaluate the robot's ability to adapt to various educational scenarios. For example, incorporating different genres, literacy tasks, and age-appropriate complexity can help assess the flexibility of robots in real-world classrooms.

Controlled Environment: The interactions in this study took place in a highly controlled setting, free from typical classroom distractions or spontaneous student behavior. Although this helped isolate the robot's mediation capabilities, it does not reflect the complexity of real-world classrooms, where students might face numerous distractions. Future studies should test robots in natural educational environments with the presence of peer interactions, background noise, and diverse learning conditions to evaluate the robot's effectiveness in more realistic settings.

Wizard-of-Oz Technique: The use of the Wizard-of-Oz technique, where the robot was partially controlled by a human operator, limits the autonomy of the robot's responses. This method, while useful for simulating advanced robotic behavior, does not fully represent the capabilities of fully autonomous robots. Future research should explore the performance of fully autonomous robots to assess how well they can independently mediate and respond to children without human intervention. This provides a more accurate understanding of their feasibility in classrooms.

Emotional Engagement and Adaptability: One of the key barriers observed in this study was the robot's inability to provide the emotional and adaptive support that human instructors naturally offer. Many children expressed a preference for human readers due to the emotional connection and physical comfort they provide. Future research should focus on developing robots with enhanced social-emotional capabilities, including facial recognition, emotional expression, and adaptive learning algorithms that can personalize interactions based on real-time feedback. This would help robots better mimic human-like interactions, addressing the emotional needs of young learners and providing more individualized instruction.

Lack of Longitudinal Data: This study examined the immediate responses of children during single read-aloud sessions, but it did not investigate long-term effects. Without longitudinal data, it is difficult to determine whether robots can sustain engagement or promote lasting learning outcomes. Future research should consider conducting longitudinal studies to track how repeated interactions with robots' impact children's literacy development over time. This would provide insights into whether robots can contribute to sustained learning gains and how children's attitudes towards robot-mediated instruction evolve. Emphasis on Cognitive Over Emotional Learning: The study primarily focused on cognitive outcomes, such as inferential question responses, while emotional and social learning was less emphasized. However, the findings suggest that emotional engagement plays a significant role in children's learning experiences. Future research should investigate hybrid models where robots complement human teachers by handling structured, cognitive tasks while human instructors focus on emotional and social learning. This collaboration could optimize both instructional and emotional scaffolding in educational settings.

CHAPTER FIVE
DISCUSSION AND FUTURE RESEARCH DIRECTIONS

Abstract

This chapter discusses the findings of the study within the context of existing literature and highlights the implications for practice, limitations, and directions for future research. This research aimed to explore the feasibility of using a robot to mediate literacy learning through one-on-one read-aloud sessions with young children, focusing on engagement, cognitive support, emotional connection, and sensory comfort.

Key Findings and Implications

Emotional Connection and Preference for Human Interaction

A significant finding of this study was the children's preference for human readers, largely due to the emotional connection they experience with parents or caregivers. This highlights a limitation in robot-mediated interactions, where the absence of human-like emotional warmth can affect a child's comfort and engagement. Future robotic designs should integrate advanced emotional recognition and adaptive social features to better emulate the relational dynamics of human interaction, potentially improving the robot's acceptance among young learners.

Cognitive Engagement and Structured Support

The study's results suggest that robots, like Pepper, can effectively scaffold cognitive tasks by providing structured support, such as asking inferential questions that encourage critical thinking. This aligns with previous studies emphasizing the role of inferential questioning in literacy development. However, the robot's limited ability to adapt its feedback based on real-time responses hindered some children’s engagement, indicating the need for more responsive AI-driven capabilities that can adjust based on the learner’s input.

Physical and Sensory Comfort

The study also uncovered physical and sensory barriers. Some children expressed discomfort with the robot’s movements and sounds, which detracted from the learning experience. Addressing these sensory elements could enhance the feasibility of robot-mediated read-alouds, especially for young learners who are particularly sensitive to their environments. This suggests a direction for future improvements in robot design focused on minimizing sensory discomfort.

Role of Longitudinal Engagement

This study’s single-session design provided insights into immediate responses, but it lacks data on the potential long-term impacts of robot-mediated learning. Longitudinal research could reveal whether repeated interactions with a robot can sustain engagement and contribute to lasting learning outcomes, thereby addressing the gap in understanding the long-term feasibility of such interventions.

Future Research Directions

Expanding Sample Diversity

This study’s sample size was relatively small and homogeneous, limiting the generalizability of the findings. Future studies should involve larger and more diverse populations across different age groups, cultural backgrounds, and learning abilities to better understand how robots can support varied learning needs across different contexts.

Exploring Autonomous Robot Capabilities

The study used the Wizard-of-Oz technique, where the robot was partially controlled by a human operator, limiting its autonomy. Further research should examine the feasibility of using fully autonomous robots to provide independent mediation without human assistance, which would offer a more realistic understanding of their educational capabilities.

Investigating Hybrid Models for Instruction

The findings suggest that robots could complement human instructors in specific educational roles, particularly for structured cognitive tasks. Future research should explore hybrid instructional models where robots focus on cognitive engagement, while human instructors address emotional and social learning. Such a model could leverage the strengths of both human and robot facilitators in educational settings.

Developing Adaptive Social-Emotional Features

Given the limitations in emotional engagement observed in this study, future robots should be equipped with features like facial recognition and adaptive learning algorithms that personalize interactions based on children’s responses. This would enable robots to meet the emotional and social needs of young learners more effectively, thereby enhancing their role as educational mediators.

Conclusion

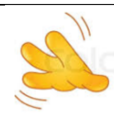
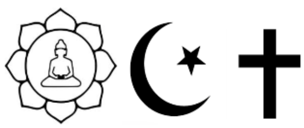
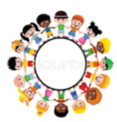
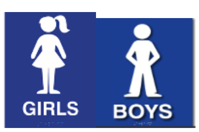
This study contributes to the emerging body of research on educational robotics by providing insights into the supports and barriers of robot-mediated literacy instruction for young learners. While robots show potential in structured cognitive engagement, significant challenges remain in addressing emotional and sensory needs. By pursuing these research directions, future studies can further illuminate how robots might be more effectively integrated into educational practices, optimizing their role as supplementary tools alongside human educators in diverse classroom settings.

APPENDIX A

FIGURE A CULTURAL RELEVANCE RATING RUBRIC

Student Name:

Check the thumbs up or thumbs down to agree or disagree with each of the following as your teacher reads it aloud.

	 Yes, this is the same as me.	 This is kind of like me.	 No, this isn't the same as me.
The main character (s) are the same race, ethnicity, or religion as me.  			
The main characters are the same age or gender as me. 			
The main characters talk like me and my family. 			
I have lived in or visited places like those in the story. 			
I have had an experience similar to one in the story.			

Total: ___/5

APPENDIX B

BOOKS USED AND CULTURAL RELEVANCE (CR) RATINGS BY STUDENTS AND TEACHER

Books Used and Cultural Relevance (CR) Ratings by Students and Teacher

Week	**1**		**2**		**3**		**4**	
Books	*My Friend Jamal* (McQuinn, 2008)		*I See the Sun in Nepal* (King, 2010)		*The Sandwich Swap* (Queen Rania, 2010)		*Lilly's Big Day* (Henkes, 2014)	
Culture(s) represented	Somali and U.S. dominant culture		Nepali		Middle Eastern and U.S.		U.S. dominant culture	
CR ratings	Student	Teacher	Student	Teacher	Student	Teacher	Student	Teacher
Bashiir	5	5	0	0.5	1	2	2	1.5
Fawzia	4.5	4.5	1	0.5	3	2.5	3.5	2
Juddha	0.5	1	2.5	3.5	0.5	2	0	1.5
Amisha	2	1	4.5	3.5	2.5	2.5	2	2

APPENDIX C

ANALYTIC DIFFICULTIES AND STATISTICAL STRATEGIES I USED TO ADDRESS THEM

Analytic Difficulties and Statistics Strategies I Used to Address Them

Analytic difficulty	**Statistical discourse analysis strategy**
Data set	
· Missing data (01??10011)	· Markov Chain Monte Carlo multiple imputation (Peugh & Enders, 2004) via LISREL (Joreskog & Sorbom, 2018)
· Inter-rater reliability	· Krippendorff's (2012) alpha
Outcome variables	
· Differences across students and lessons	· Multilevel, cross-classification analysis (Goldstein, 2011)
· Similar adjacent talk ($t_3 \sim t_4$)	· Q-statistics (Ljung & Box, 1979)
· Discrete variable (yes/no)	· Logit / Probit and odds ratios (Kennedy, 2008)
· Infrequency (< 25%)	· Logit bias estimator (King & Zeng, 2001)
· Multiple dependent variables (Y_1, $Y_{2, \ldots}$)	· Multivariate outcome multilevel analysis (Goldstein, 2011)
Explanatory variables	
· Sequences of turns of talk ($X_{t-2} \rightarrow X_{t-1} \rightarrow Y_0$)	· Vector auto-regression (VAR; Kennedy, 2008)
· Indirect, multilevel, mediation effects ($X \rightarrow M \rightarrow Y$)	· Multilevel *M-test* (MacKinnon et al., 2004)

· Cross-level interactions (Student x Turn of Talk)	· Random effects model (Goldstein, 2011)
· Many hypotheses' false positives	· Two-stage linear step-up procedure (Benjamini et al., 2006)
· Compare effect sizes ($\beta_1 > \beta_2$?)	· Lagrange multiplier tests (Bertsekas, 2014)
· Consistency of results across data sets (robustness)	· Separate multilevel, single-outcome models · Analyses of subsets of the data (Kennedy, 2008) · Original (not estimated) data

APPENDIX D

SUMMARY STATISTICS FOR MAJOR STUDENT VARIABLES

*Summary Statistics for Major Student Variables (*N *= 1,806)*

Variable	**#[a]**	**Mean**	**SD[b]**	**Min**	**Median**	**Max**
<u>ZFM</u>[c]						
Off-topic/task conversation or behavior	163	0.09		0.00	0.00	1.00
Negotiate (to engage differently than the teacher proposed)	16	0.01		0.00	0.00	1.00
<u>ZPA</u>[d]						
Agrees (with another's idea)	182	0.10		0.00	0.00	1.00
Clarifies (gives information to help others understand)	85	0.05		0.00	0.00	1.00
Extends (adding to other's idea)	9	0.01		0.00	0.00	1.00
Modeling (response)	4	0.00		0.00	0.00	1.00
Gives information (e.g., information about the text)	67	0.04		0.00	0.00	1.00
Question for CCC (connect, compare, contrast)—open	42	0.02		0.00	0.00	1.00

Question for clarification—closed	94	0.05		0.00	0.00	1.00
Question for vocabulary—open	23	0.01		0.00	0.00	1.00
Reiterates (past information/activities)	63	0.04		0.00	0.00	1.00
ZPD[e]						
Developing factual knowledge	7	0.00		0.00	0.00	1.00
ZAD[f]						
Developed factual knowledge	13	0.01		0.00	0.00	1.00
Developed opinion	49	0.03		0.00	0.00	1.00
Developed Inference	14	0.01		0.00	0.00	1.00
Developed CCC (connect, compare, contrast)	401	0.22		0.00	0.00	1.00
Developed vocabulary	49	0.03		0.00	0.00	1.00
Control Variables—WIDA—Overall score		3.40	0.46	2.90	3.35	4.00
WIDA—Listening subsection score		5.15	1.39	3.10	5.75	6.00

WIDA—Speaking subsection score	2.83	0.33	2.60	2.70	3.30
WIDA—Reading subsection score	3.30	1.37	2.20	2.85	5.30
WIDA—Writing subsection score	3.23	0.45	2.60	3.35	3.60
Control variables—talk-turns for each book across data set					
My Friend Jamal	0.36		0.00	0.00	1.00
I See the Sun in Nepal	0.24		0.00	0.00	1.00
The Sandwich	0.16		0.00	0.00	1.00
Lilly's Big Day	0.24		0.00	0.00	1.00
Control variables—overall book ratings by student (sum)	2.46	1.68	0.00	2.00	5.00
Book reflects child's race/ethnicity/religion	0.52	0.36	0.00	0.50	1.00
Book reflects child's age/gender	0.61	0.40	0.00	0.75	1.00
Book reflects child's talk	0.46	0.32	0.00	0.25	1.00
Book reflects places the child has been	0.33	0.26	0.00	0.00	1.00

Book reflects child's experiences	0.49	0.34	0.00	0.50	1.00
Talk- turns for second (vs. first) session discussing a book	0.36	0.48	0.00	0.00	1.00

[a] The number indicates instances of this student behavior in these data.

[b] Dichotomous variables do not have standard deviations.

[c] ZFM = Zone of Free Movement

[d] ZPA = Zone of Promoted Action

[e] ZPD = Zone of Proximal Development

[f] ZAD = Zone of Actual Development

APPENDIX E

SUMMARY STATISTICS FOR MAJOR TEACHER VARIABLES

*Summary Statistics for Major Teacher Variables (*N *= 1,509)*

Variable	#[a]	Mean	SD[b]	Min	Median	Max
ZFM[c]						
Off-topic/task conversation or behavior	72	0.048		0	0	1
ZPA[d]						
Agrees (with another's idea)	142	0.094		0	0	1
Clarifies (gives information to help others understand)	152	0.101		0	0	1
Extends (adding to other's idea)	17	0.011		0	0	1
Modeling (response)	8	0.005		0	0	1
Gives information (e.g., information about the text)	125	0.083		0	0	1
Question for CCC (connect, compare, contrast)—open	72	0.048		0	0	1
Question for clarification—closed	122	0.081		0	0	1
Question for vocabulary—open	63	0.042		0	0	1

Reading (the passage)	118	0.078		0	0	1
Reiterates (past information / activities)	47	0.031		0	0	1
<u>Control variables overall overall book ratings by teacher (sum)</u>		2.469	1.708	0	2	5
Race/ethnicity/religion		0.425	0.302	0	0.25	1
Age/gender		0.706	0.449	0	0.50	1
Talk		0.300	0.246	0	0	1
Places		0.675	0.433	0	0.75	1
Experiences		0.363	0.277	0	0.75	1
Second (vs. first) session discussing a book		0.310	0.463	0	0	1

[a] The number indicates instances of this teacher behavior in these data.

[b] Dichotomous variables do not have standard deviations.

[c] ZFM = Zone of Free Movement

[d] ZPA = Zone of Promoted Action

APPENDIX F

TRANSCRIPT EXAMPLE: EXPRESSION OF DEVELOPED VOCABULARY AFTER CLOSED CLARIFICATION QUESTION

Transcript Example: Expression of Developed Vocabulary After Closed Clarification Question

Line #	**Speaker**	**Speaker's transcription**	**Theoretical code**	**Talk-turn code**
B1	Khadija	Oh, sa*Baya* (changes the stress) (at the same time with Abdullahi)	ZPA	Provides information
B2	Teacher	Sa*Baya*?	ZPA	Question for clarification—closed
B3	Khadija	Sa*Bayad.*	ZPA	Reiterates
B4	Teacher	Oh, sa*Bayad*, thank you. Is that right?	ZPA	Question for clarification—closed
B5	Khadija	Yeah, sabayad. It's kind of hard pancake, but you eat it with like pasta or soup…	ZAD	Developed vocabulary
B6	Teacher	Oh, awesome…	ZPA	Agrees
B7	Khadija	…sugar, or stuff.	ZAD	Developed vocabulary

APPENDIX G

TRANSCRIPT EXAMPLE: EXPRESSION OF DEVELOPED VOCABULARY AFTER OPEN VOCABULARY QUESTION

Transcript Example: Expression of Developed Vocabulary After Open Vocabulary Question

Line #	Speaker	Speaker's transcription	Theoretical code	Talk-turn code
A1	T	What is dhal? Remember you told us like?	ZPA[a]	Question for vocabulary—open
A2	Manish	It's a soup. It's like a soup but it's not soup.	ZAD[b]	Developed vocabulary

[a] ZPA = Zone of Promoted Action

[b] ZAD = Zone of Actual Development

APPENDIX H

INITIAL INTERACTION, COMPANION GUIDANCE, CONSENT PROCESS

Initial interaction, Companion Guidance, Consent process

Initial interaction

Talk to the child to reach the door. (ask questions: Their names, what is their favorite animal)
Iman asks the child to sit on the chair in the middle of the room. Ask the child's companion to sit on the chair in the back.

Guidance for Child's Companion

Thank you so much for accompanying your student to participate. To ensure the integrity of our study and to maintain the natural interaction between the child and our robot, please only provide emotional support, but not support related to the questions that the robot will ask the child. Thanks!

Assent form

Iman reads the assent form top to down

Hi, my name is *Iman Bakhoda* and I am a *student at this university.*

I am working on a project about *how a robot can talk with children about an interesting book*.

I am asking if you want to help because *you are in [choose the correct grade: prekindergarten, kindergarten, or first-grade] and you can listen to the book and talk to the robot*.

Your mom or dad said it's ok for you to help me with the project, but you can say no. It's up to you.

If you help me with this project, I will ask you to *sit in front of a robot and listen to the story he reads. He will ask you some questions about the story and talk with you about it.*

It's okay to say "No" if you don't want to be in the study. If you say "Yes" you can change your mind and stop any time and no one will be upset.

Do you have any questions? Do you want to think about it?

Would you like to help me with this project?

Yes ____ (Mark here if s/he agrees to participate.)

Write child's name here if s/he says "yes." ______________________

Researcher/Research Associate Initials IB

Rapport-building interaction

Robot is stand-by (asleep) here. Click to wake up and talk to Iman

Phase 1: Pepper Initiates Conversation with Iman

- [In the Room]Iman and the child are already in the room.Pepper: "*Hello Iman! It's great to see you. Who have you brought with you today?*"
- Iman: "*Hi Pepper! I'm here with a young friend who would like to meet you and hear a story*."

Phase 2: Interaction Shifts to the Child

- [Hello_Child]Pepper (to the child): "Hello there! I'm Pepper, and I love making new friends. What's your name?"
- Child: Responds with their name.
- [Hello to child] Pepper: "*It's so nice to meet you.*

Phase 3: Pepper Asks Questions

1. [Hello_Child_Fun]Pepper: "What do you like to do for fun?"
    - *Child responds.*
    - [Hello_Child_Fun_Respond]Pepper: "That does sound fun!."
2. Pepper: "I love dancing. Would you like to dance with me? "
    - *The child agrees to dance.*
        i. [Intro_Dance]Pepper: [if child responds "yes"] "Fantastic! Let's invite Iman too. Iman, would you join us in a dance?" If the child is sitting on his chair, Iman: "Do you want to get up and dance with us?"
        ii. Iman: "Yes!"
    - *The child said no to dance*
        i. Pepper: [if child responds "no"] " Okay, Iman will you dance with me?"

ii. Iman: (to Pepper) “Sure!” (to child) “You can join us if you change your mind.” (ask two times if the child does not want to dance)

Transition to Reading

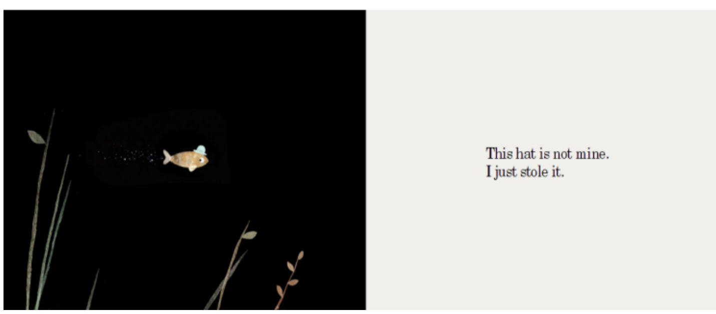
- ○ [Transition to Reading] After the dance, everyone starts to settle down. Pepper: "That was such fun, thank you for dancing with me! Now, let's settle down. You can sit on the blue chair. Now I’m going to read you a story and we will talk about it”.
- [Iman leaving the room] Iman says: I’ll be back when Pepper finishes the story.
- Pepper: “Iman, see you when the story is done!"

Read-aloud section

Pepper:

--------I have a fun and exciting story to share with you today. It's called 'This Is Not My Hat' by Jon Klassen. In this underwater adventure, a tiny fish takes something that doesn't belong to him. Do you want to find out what happens next? Let's dive into the story! Make sure you're sitting comfortably on your chair so that you can see all the pictures and hear the story.

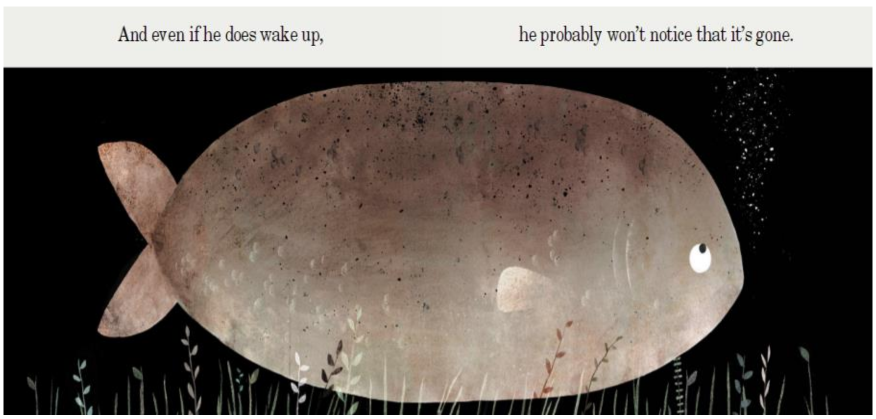
Pepper reads



Pepper continues

Pepper continues

Pepper continues



FLOW
Q1: Do you think the big fish noticed? Go to R1A, R1B, R1C, R1D, R1E, or R1F based on response

R1A: Correct with rationale "Good job" Continue reading

R1B: Possibly correct, but without rationale Ask "Why" Go to R1A, R1C, R1D, R1E, or R1F based on response
(second time) provide a correct answer to Q1 Continue reading

R1C: Partially correct – uses text clues compliment text clue use prior knowledge mediation [What is missing from his head?]
→ child provided appropriate response (i.e., coheres with the text clues, accurate knowledge about the world, and sound reasoning) → Go to Q1
→ child is unable to provide appropriate response → Tell the child the answer→ Go to Q1

(second time) provide a correct question answer to Q1 Continue reading

R1D: Partially correct–uses prior knowledge clues□compliment prior knowledge use □ text mediation [Where is the big fish looking?]

→ child provided appropriate appropriate response (i.e., coheres with the text clues, accurate knowledge about the world, and sound reasoning) → Go to Q1

→ child is unable to provide appropriate response → Tell the child the answer → Go to Q1

(second time)□ provide a correct question answer to Q1 □ Continue reading

R1E: Incorrect without expressing misinformation OR I Don't Know

(first time)□ text mediation[Where is the big fish looking?] □ Go to Q1

(second time) □ prior knowledge mediation[What is missing from his head?]□ Go to Q1

(third time)□ provide a correct answer to Q1 □ Continue reading

R1F: Expresses misinformation □ correct misinformation using text to speech □ Go to Q1

(second time—same misinformation)□ provide a correct answer to Q1 □ Continue reading

(subsequent times—different misinformation)□ correct misinformation □ Go to Q1

<u>RULES RELATED TO ADMINISTERING FLOW AND CHILD INTERACTIONS WHILE READING</u>

If a **child does not respond** to a question□rephrase the question using text to speech to ask again.

If a child still does not respond after rephrasing the question□ provide the response

□If the response provided is for a mediation question (text/PK clues)□ ask Q1

□If the response is for Q1□ continue reading

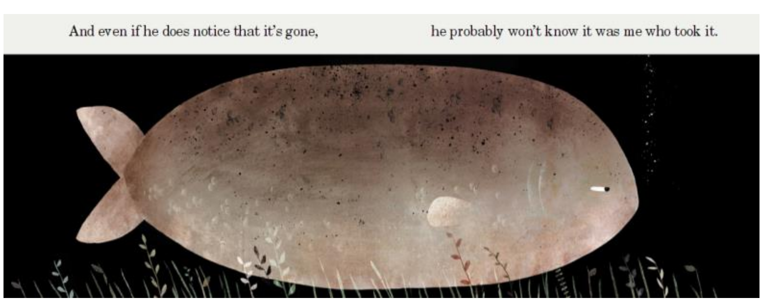
If at any time a child needs a **behavioral prompt**, use the appropriate one (sit, don't touch robot, etc.) □ continue reading OR mediational flow

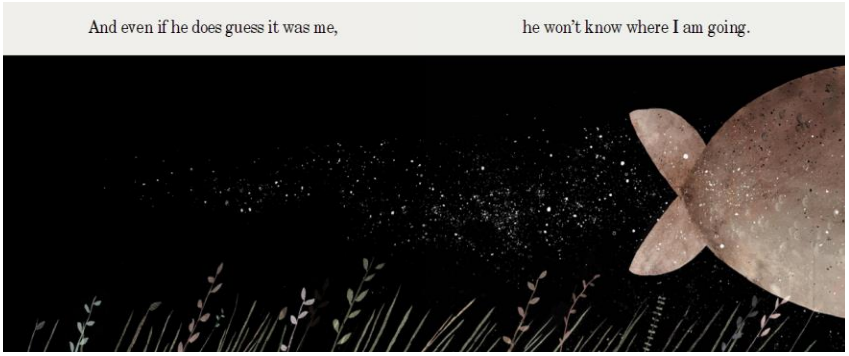
If at any time the child produces a **spontaneous accurate comment** about the book (not in response to a flow question), provide an encouraging response (e.g., pre-program something like, "Good noticing!" that will address many comments) □ continue reading

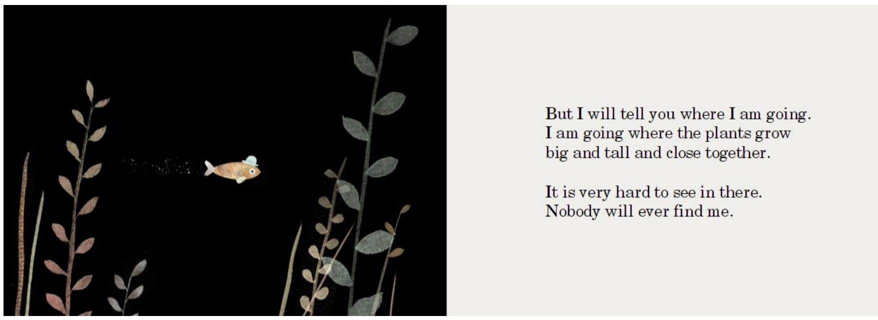
If at any time the child produces a **spontaneous inaccurate comment** about the book (not in response to a flow question)□ correct misinformation using text to speech □ continue reading

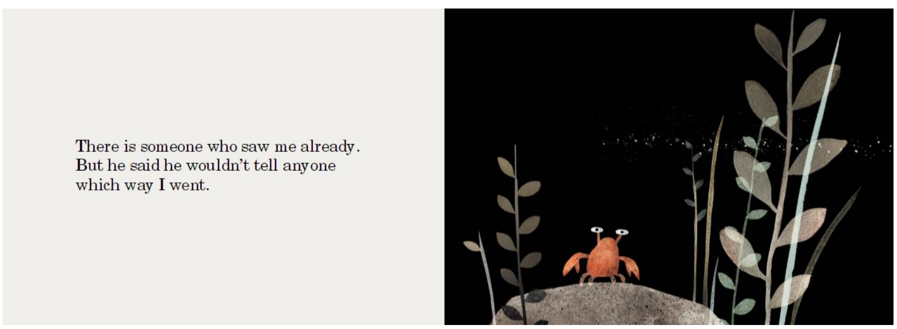
If at any time **predetermined mediations do not align well with the child's response or behavior**, use speech to text instead.

Pepper continues

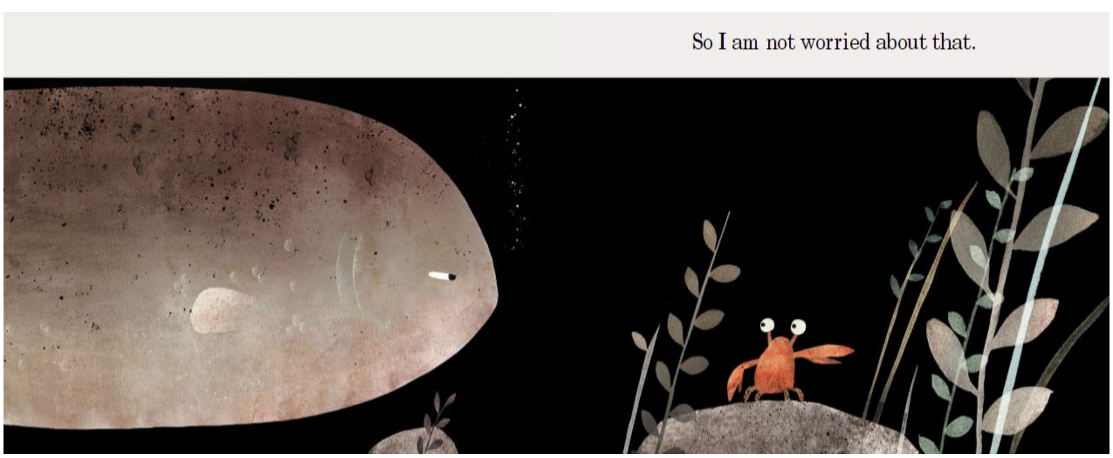








Pepper continues



FLOW
Q2: Should he [the little fish] be worried about that? Go to R1A, R1B, R1C, R1D, R1E, or R1F based on response

R1A: Correct with rationale "Good job" Continue reading

R1B: Possibly correct, but without rationale Ask "Why" Go to R1A, R1C, R1D, R1E, or R1F based on response

(second time) provide a correct answer to Q2 Continue reading

R1C: Partially correct – uses text clues compliment text clue use prior knowledge mediation[What do people do when someone takes their stuff?]

→ child provided appropriate response (i.e., coheres with the text clues, accurate knowledge about the world, and sound reasoning) → Go to Q2

→ child is unable to provide appropriate response → Tell the child the answer→ Go to Q2

(second time-b) provide the answer to Q2 Continue reading

R1D: Partially correct–uses prior knowledge cluescompliment prior knowledge use text mediation [What is the crab doing?]

→ child provided appropriate appropriate response (i.e., coheres with the text clues, accurate knowledge about the world, and sound reasoning) → Go to Q2

→ child is unable to provide appropriate response → Tell the child the answer → Go to Q2

(second time-b) provide the answer to Q2 Continue reading

R1E: Incorrect without expressing misinformation OR I Don't Know

(first time) text mediation [What is the crab doing?] Go to Q2

(second time) prior knowledge mediation [What do people do when someone takes their stuff?] Go to Q2

(third time) provide a correct answer to Q2 Continue reading

R1F: Expresses misinformation correct misinformation using text to speech Go to Q2

(second time—same misinformation) provide a correct answer to Q2 Continue reading

(subsequent times—different misinformation) correct misinformation Go to Q2

RULES RELATED TO ADMINISTERING FLOW AND CHILD INTERACTIONS WHILE READING

If a **child does not respond** to a questionrephrase the question using text to speech to ask again.

If a child still does not respond after rephrasing the question provide the response

If the response provided is for a mediation question (text/PK clues) ask Q2

If the response is for Q2 continue reading

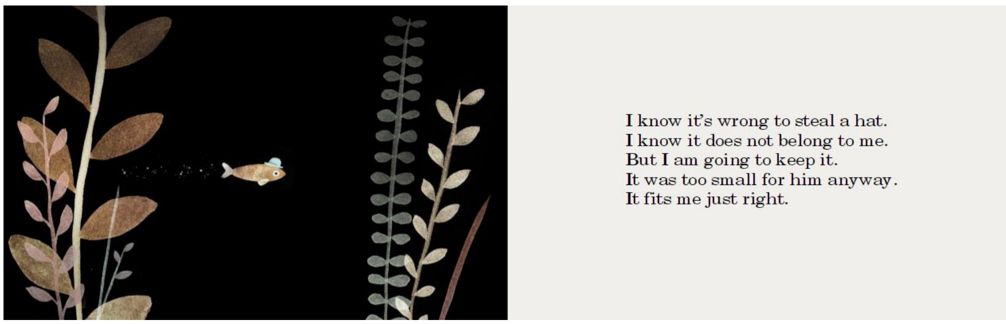
If at any time a child needs a **behavioral prompt**, use the appropriate one (sit, don't touch robot, etc.) continue reading OR mediational flow

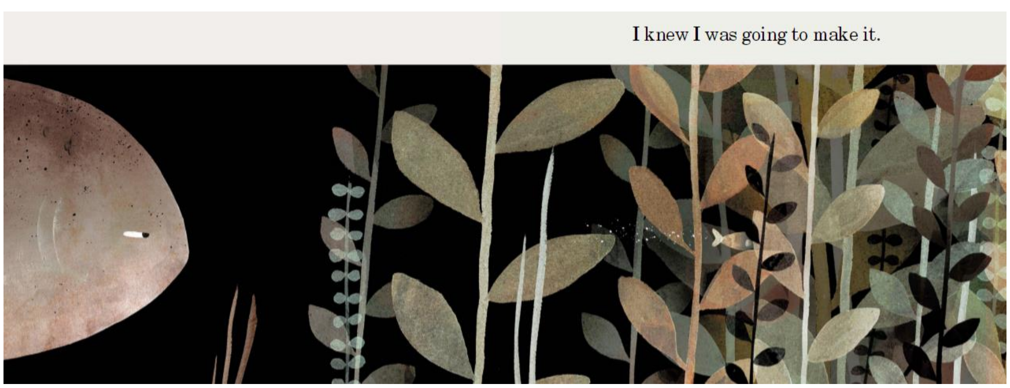
If at any time the child produces a **spontaneous accurate comment** about the book (not in response to a flow question), provide an encouraging response (e.g., pre-program something like, "Good noticing!" that will address many comments) continue reading

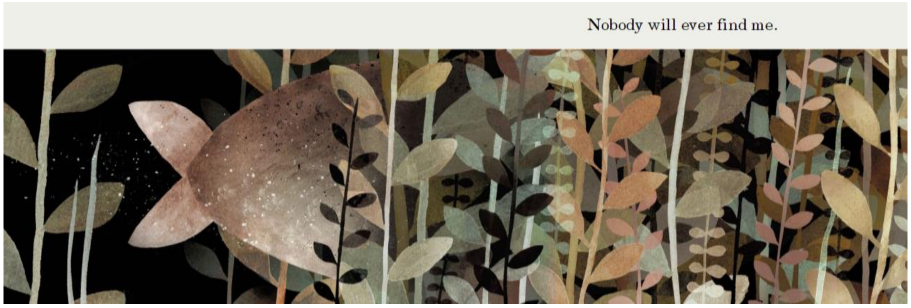
If at any time the child produces a **spontaneous inaccurate comment** about the book (not in response to a flow question)→ correct misinformation using text to speech → continue reading

If at any time **predetermined mediations do not align well with the child's response or behavior**, use speech to text instead.

Pepper continues







FLOW

Q3: How did he [the big fish] get his hat back? □ Go to R1A, R1B, R1C, R1D, R1E, or R1F based on response

R1A: Correct with rationale □ "Good job" □ Continue reading

R1B: Possibly correct, but without rationale Ask “How do you know?” Go to R1A, R1C, R1D, R1E, or R1F based on response

(second time) provide a correct answer to Q3 Continue reading

R1C: Partially correct – uses text clues compliment text clue use prior knowledge mediation [Who had the hat before?]

→ child provided appropriate response (i.e., coheres with the text clues, accurate knowledge about the world, and

sound reasoning) → Go to Q3

→ child is unable to provide appropriate response → Tell the child the answer→ Go to Q3

(second time-b) provide the answer to Q3 Continue reading

R1D: Partially correct–uses prior knowledge cluescompliment prior knowledge use text mediation [Where is the hat now?]

→ child provided appropriate appropriate response (i.e., coheres with the text clues, accurate knowledge about the

world, and sound reasoning) → Go to Q3

→ child is unable to provide appropriate response → Tell the child the answer → Go to Q3

(second time-b) provide the answer to Q3 Continue reading

R1E: Incorrect without expressing misinformation OR I Don't Know

(first time) text mediation [Where is the hat now?] Go to Q3

(second time) prior knowledge mediation [Who had the hat before?] Go to Q3

(third time) provide a correct answer to Q3 Continue reading

R1F: Expresses misinformation correct misinformation using text to speech Go to Q3

(second time—same misinformation) provide a correct answer to Q3 Continue reading

(subsequent times—different misinformation) correct misinformation Go to Q3

<u>RULES RELATED TO ADMINISTERING FLOW AND CHILD INTERACTIONS WHILE READING</u>

If a **child does not respond** to a questionrephrase the question using text to speech to ask again.

If a child still does not respond after rephrasing the question provide the response

If the response provided is for a mediation question (text/PK clues) ask Q3

If the response is for Q3 continue reading

If at any time a child needs a **behavioral prompt**, use the appropriate one (sit, don't touch robot, etc.) continue reading OR mediational flow

If at any time the child produces a **spontaneous accurate comment** about the book (not in response to a flow question), provide an encouraging response (e.g., pre-program something like, “Good noticing!” that will address many comments) continue reading

If at any time the child produces a **spontaneous inaccurate comment** about the book (not in response to a flow question) correct misinformation using text to speech continue reading

If at any time **predetermined mediations do not align well with the child's response or behavior**, use speech to text instead.

Pepper continues

Closing:

Thank you for spending this time with me today. I had a great time reading and chatting with you. I hope to see you again soon!

Interview Section

1. **Researcher Enters the Room**

----------Action: Enter the room calmly with a friendly demeanor, and pull a chair up near where the child is sitting so you are face to face.

-----------Statement: "Hello! I saw you just finished reading with Pepper. I have a few questions about what it was like."

2. **Interview Questions**

-------------Action: Maintain a warm, interested tone to encourage the child's openness.

-------------Question 1:: "What was it like reading with Pepper?" To elicit more information you can ask “tell me more about it”

-------------Action: Nod and show active listening as the child responds. Ask follow up questions to gain more details.

Question 2: : "Was it easy or difficult to answer the questions with Pepper?" (after response) Why? Ask follow up questions to gain more details. To elicit more information you can ask “tell me more about it”

------------Question 3 "I'm curious, do you prefer to read with Pepper or with a person, like your teacher or one of your parents? (after initial response) Why?" Ask follow up questions to gain more details. To elicit more information you can ask “tell me more about it”

3. **Concluding the Interview**

------------Statement: "Thank you so much for sharing your thoughts with me. You've been very helpful! I’ll walk you back to your room now"

------------Action: Walk child back to classroom.

Appendix I

ENGAGEMENT METRICS AND BARRIERS IN CHILD-ROBOT READ-ALOUD INTERACTIONS

Engagement Metrics and Barriers in Child-Robot Read-Aloud Interactions

Participant	Accept Dancing	Verbal Engagement (%)	Gaze Toward Robot (%)	Gaze Toward Book (%)	Restless Movement (%)	Distraction (%)	Key Observations (Supports/Barriers)
Nia	Yes	28%	74%	55%	55%	22%	High engagement with gaze and robot focus (Support); Restless movement observed (Barrier)
Asel	Yes	19%	91%	72%	11%	11%	Strong gaze toward robot (Support); Minimal restlessness (Support)
Grant	No	2%	25%	27%	62%	44%	Low verbal engagement and gaze; High restlessness (Barrier)
Liam	Yes	3%	66%	34%	21%	0%	Moderate gaze toward robot (Support); Low verbal engagement (Barrier)
Lila	Yes	2%	46%	38%	28%	44%	Balanced engagement but high distraction (Barrier)
Malia	Yes	31%	59%	21%	29%	0%	High verbal engagement (Support); No distractions (Support)
Nia	No	10%	52%	42%	27%	0%	Moderate gaze and verbal engagement (Support)
Rory	Yes	3%	49%	31%	31%	9%	Low verbal engagement (Barrier); Moderate gaze (Support)
Tristan	Yes	26%	32%	13%	26%	24%	Moderate verbal engagement (Support); Restless movement (Barrier)
Theo	Yes	16%	43%	14%	19%	7%	Moderate verbal and gaze engagement (Support)
Sasha	Yes	21%	51%	22%	21%	5%	Moderate engagement and low distraction (Support)
Kara	Yes	56%	82%	68%	22%	7%	Very high verbal engagement and gaze toward robot (Strong Support)
Joel	No	8%	74%	45%	15%	39%	High gaze but low verbal engagement; High distraction (Barrier)
Ivan	No	39%	95%	60%	36%	17%	Strong gaze and verbal engagement (Support); Some restlessness (Barrier)
Gemma	Yes	23%	90%	65%	48%	13%	High gaze and moderate verbal engagement (Support)
Ethan	Yes	31%	96%	61%	46%	29%	Very strong gaze and moderate verbal engagement (Support); Restlessness (Barrier)
Aria	Yes	21%	68%	48%	39%	60%	Moderate engagement but very high distraction (Barrier)
Amina	Yes	6%	89%	64%	37%	16%	High gaze and moderate engagement (Support)

Gavin	No	14%	99%	61%	29%	13%	Very high gaze (Support); Moderate restlessness (Barrier)
Kapta	Yes	7%	90%	77%	52%	7%	Strong gaze but low verbal engagement (Support); High restlessness (Barrier)

Appendix J

CATEGORIZED CODES FOR CHILD-ROBOT INTERACTION STUDY

Categorized Codes for Child-Robot Interaction Study

Category	Sub-category	Codes	Definition
ZPA	Mediation	Textual Clue Mediation	The robot provides clues from the text to support comprehension.
	Mediation	Background Knowledge Mediation	The robot prompts the child to use prior knowledge to answer questions.
	Mediation	Unscripted Mediation	Impromptu mediations that were not part of the pre-designed interaction plan.
	Mediation	Praise/Positive Reinforcement	The robot praises the child for correct answers or participation.
	Mediation	Inferential Question Repetition	The robot repeats questions to re-engage the child after no response or incorrect answers.
	Mediation	Paraphrasing the inferential question	The robot rephrases an inferential question to make it easier to understand.
	Mediation	Paraphrasing the text mediation	The robot rephrases clues from the text to help with comprehension.
	Mediation	Paraphrasing the background mediation	The robot rephrases questions or mediations related to prior knowledge.
	Mediation	Reason-seeking question	The robot asks a 'why' question to encourage deeper thinking.
ZPD	Answer and Response	Correct Answer with Rationale to the inferential question	The child provides a correct answer with an explanation or rationale.
	Answer and Response	Correct answer without rationale to the inferential question	The child gives the correct answer but does not explain why.
	Answer and Response	Incorrect Answer without rationale to the inferential question	The child provides an incorrect answer without an explanation.
	Answer and Response	Incorrect Answer with incorrect rationale to the inferential question	The child gives an incorrect answer along with an incorrect explanation.
	Answer and Response	No response to inferential question	The child does not provide any response to the question.
	Answer and Response	No response to reason-seeking question	The child does not respond to 'why' questions.
	Answer and Response	Partially correct answer using the text clue	The child gives a partially correct answer based on text clues.
	Answer and Response	Incorrect Answer to the mediation	The child responds incorrectly to the mediation provided by the robot.
	Answer and Response	Correct answer to the mediation	The child provides a correct answer to the mediation.
	Answer and Response	No response to mediation	The child does not respond to the robot’s mediation.
	Answer and Response	Partially correct answer using background clues	The child gives a partially correct answer using prior knowledge.
	Answer and Response	Child confirms they do not know the answer	The child admits they do not know the answer.

	Answer and Response	Child confirms they guessed the correct answer	The child acknowledges they guessed the correct answer.
	Answer and Response	Unclear response	The child's response is unclear or ambiguous.
ZFM	Behavioral Management	Behavioral management	The robot manages or redirects the child's behavior during the interaction.
	Behavioral Management	Off-topic talk	The child engages in conversation unrelated to the task or story.
	Behavioral Management	Redirecting child's attention	The robot redirects the child's attention to the task or story.
	Behavioral Management	Child self-talk	The child talks to themselves during the interaction.
	Behavioral Management	Child-initiated interaction	The child starts an interaction or conversation with the robot without prompt.
	Emotional and Social Supports	Emotional Reaction to Robot	The child shows an emotional response (positive or negative) to the robot.
	Technical and Interactional Issues	Technical Issue	Any instance where the robot's behavior impedes the interaction.

Appendix K

INTERVIEW CODING

Interview Coding

Code	Definition	Example
Positive Reading Experience	The child reflects positively on the reading experience with the robot	"It was good reading with Pepper" (Sasha)
Negative Reading Experience	The child reflects negatively on the reading experience with the robot	" Because the big fish was mother to the little fish " (Tristan)
Similarity to Human Reading	The child identifies similarities between reading with the robot and with a parent or teacher	"Reading the book is the same" (Aria)
Different from Human Reading	The child identifies differences between reading with the robot and with a human	"Pepper reads on screen, but my mom reads from the book" (Ethan)
Preference for Robot	The child expresses a preference for interacting with the robot over a human (parent/teacher)	"I like reading with Pepper" (Lila)
Preference for Human	The child expresses a preference for reading with a parent or teacher	"I like my mom because she cuddles with me" (Liam)
Positive attitude toward the robot-dancing	The child enjoys dancing with the robot, finding it engaging	"I like the dancing" (Aria)
Negative Reading Experience-physical appearance of the Robot	The child reflects negatively on the robot’s physical appearance	"It was difficult because it stinks" (Tristan)
Positive attitude toward the robot-voice	The child appreciates the clarity or quality of the robot’s voice	"He speaks loud" (Nia)
Emotional connection with human	The child prefers human readers due to emotional bonding or connection	"My parents read to me before bed" (Rory)

REFERENCES

Ahmad, M. I., Mubin, O., Shahid, S., & Orlando, J. (2019). Robot's adaptive emotional feedback sustains children's social engagement and promotes their vocabulary learning: A long-term child–robot interaction study. *Adaptive Behavior, 27*(4), 243–266. https://doi.org/10.1177/1059712319844182

Alemi, M., & Haeri, N. S. (2020). Robot-assisted instruction of L2 pragmatics: Effects on young EFL learners' speech act performance. *Language Learning & Technology, 24*(2), 86. http://eric.ed.gov/ERICWebPortal/detail?accno=EJ1263089

Alemi, M., Meghdari, A., & Ghazisaedy, M. (2014). Employing humanoid robots for teaching English language in Iranian junior high-schools. *International Journal of Humanoid Robotics, 11*(03), 1–25. https://doi.org/10.1142/S0219843614500224

Almousa, O., & Alghowinem, S. (2022). Conceptualization and development of an autonomous and personalized early literacy content and robot tutor behavior for preschool children. *User Modeling and User-Adapted Interaction.*

Anwar, S., Bascou, N. A., Meneske, M., & Kardgar, A. (2019). A systematic review of studies on educational robotics. *Journal of Pre-College Engineering Education Research, 9*(2), 19. https://doi.org/10.7771/2157-9288.1223

Ascenzi-Moreno, L. (2018). Translanguaging and responsive assessment adaptations: Emergent bilingual readers through the lens of possibility. *Language Arts, 95*(6), 355–369.

Bakhoda, I., Christ, T., Chiu, M. M., Cho, H., & Liu, Y. (2022). Teacher and emergent bilingual student read-aloud mediations. *Journal of Literacy Research, 54*(4), 509–541. https://doi.org/10.1177/1086296X221140859

Beck, I., McKeown, M., & Kucan, L. (2013). *Bringing words to life.* Guilford.

Belpaeme, T., Kennedy, J., Ramachandran, A., Scassellati, B., & Tanaka, F. (2018). Social robots for education: A review. *American Association for the Advancement of Science (AAAS).* https://doi.org/10.1126/scirobotics.aat5954

Bennison, A. (2020). Using zone theory to understand teacher identity as an embedder-of-numeracy: An analytical framework. *Asia-Pacific Journal of Teacher Education*, *50*(2), 171–186. https://doi.org/10.1080/1359866X.2020.1828821

Blackwell, C. K., Wartella, E., Lauricella, A. R., & Robb, M. (2015). Technology in the lives of educators and early childhood programs: Trends in access, use, and professional development from 2012 to 2014. *Center on Media and Human Development at Northwestern University.*

Blanchard, E. G., Volfson, B., Hong, Y. J., & Lajoie, S. P. (2009). Affective artificial intelligence in education: From detection to adaptation. *Frontiers in Artificial Intelligence and Applications, 200*, 81–88. https://doi.org/10.3233/978-1-60750-028-5-81

Blewitt, P., Rump, K. M., Shealy, S. E., & Cook, S. A. (2009). Shared book reading: When and how questions affect young children’s word learning. *Journal of Educational Psychology*, *101*(2), 294–304. https://doi.org/10.1037/a0013844

Blanton, M., Westbrook, S., & Carter, G. (2005). Using Valsiner’s zone theory to interpret teaching practices in mathematics and science classrooms. *Journal of Mathematics Teacher Education, 8*(1), 5–33.

https://doi.org/10.1007/s10857-005-0456-1

Bourguet, M., Jin, Y., Shi, Y., Chen, Y., Rincon-Ardila, L., & Venture, G. (2020). Social robots that can sense and improve student engagement. Paper presented at 2020 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE), Takamatsu, Japan, 127–134. https://doi.org/10.1109/TALE48869.2020.9368438

Breazeal, C., Harris, P. L., DeSteno, D., Kory Westlund, J. M., Dickens, L., & Jeong, S. (2016). Young children treat robots as informants. *Topics in Cognitive Science, 8*(2), 1–11. https://doi.org/10.1111/tops.12192

Brown, S. (2016). Young learners' transactions with interactive digital texts using Ereaders. *Journal of Research in Childhood Education, 30*, 42–56.

Cabell, S. Q., Zucker, T. A., DeCoster, J., Melo, C., Forston, L., & Hamre, B. (2019). Prekindergarten interactive book reading quality and children's language and literacy development: Classroom organization as a moderator. *Early Education and Development, 30*(1), 1–18. https://doi.org/10.1080/10409289.2018.1514845

Charlton, C., Rasbash, J., Browne, W. J., Healy, M., & Cameron, B. (2020). *MLwiN Version 3.05.* Centre for Multilevel Modelling, University of Bristol.

Chen, H., Park, H. W., & Breazeal, C. (2020). Teaching and learning with children: Impact of reciprocal peer learning with a social robot on children's learning and emotive engagement. *Computers and Education, 150.* https://doi.org/10.1016/j.compedu.2020.103836

Chevalier, M., Giang, C., Piatti, A., & Mondada, F. (2020). Fostering computational thinking through educational robotics: A model for creative computational problem solving. *International Journal of STEM Education, 7*(1), 1–18. https://doi.org/10.1186/s40594-020-00238-z

Christ, T., Bakhoda, I., Chiu, M. M., Wang, X. C., Schindel, A., & Liu, Y. (2022). Mediating learning in the zones of development: Role of teacher and kindergartner talk-turns during read-aloud discussions. *Journal of Research in Childhood Education.* https://doi.org/10.1080/02568543.2022.2146816

Christ, T., Chiu, M. M., & Wang, X. C. (2013). Preschoolers' engagement with reading behaviors: A statistical discourse analysis of peer buddy-reading interactions. *Journal of Research in Reading, 37*, 375–408.

Christ, T., Chiu, M. M., Rider, S., Kitson, D., Hanser, K., McConnell, E., Dipzinski, R., & Mayernik, H. (2018). Cultural relevance and informal reading inventory performance: African-American primary and middle school students. *Literacy Research and Instruction, 57*(2), 117–134. https://doi.org/10.1080/19388071.2018.1424274

Christ, T., Wang, X. C., & Chiu, M. M. (2015). Emergent readers' social interaction styles and their comprehension processes during buddy reading. *Literacy Research and Instruction, 54*, 45–66.

Christenson, L. A. (2016). Class interactive reading aloud (CIRA): A holistic lens on interactive reading aloud sessions in kindergarten. *Educational Research and Reviews, 11*(23), 2138–2145. https://doi.org/10.5897/ERR2016.2874

Chiu, M. M., & Lehmann-Willenbrock, N. (2016). Statistical discourse analysis:

Modeling sequences of individual actions during group interactions across time. *Group Dynamics: Theory, Research, and Practice*, *20*(3), 242–258. https://doi.org/10.1037/gdn0000048

Cho, H., & Christ, T. (2021). How two emergent bilingual students from refugee families make inferences with more and less culturally relevant texts during read-alouds. *TESOL Quarterly.* https://doi.org/10.1002/tesq.3094

Cho, H., Christ, T., & Liu, Y. (2022). Recognizing emergent bilingual parent–child dyads' funds of identity through their discussions about culturally relevant text. *Journal of Language, Identity & Education, 29*(6), 1–16. https://doi.org/10.1080/15348458.2021.2004893

Cohen, J., West, S. G., Aiken, L., & Cohen, P. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences.* Lawrence Erlbaum.

Corbin, J., & Strauss, A. (2014). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (4th ed.). Sage.

Currie, E. (2013). Consciousness, solidarity and hope as prevention and rehabilitation. *International Journal for Crime, Justice and Social Democracy, 2*(2), 3–11. https://doi.org/10.5204/ijcjsd.v2i2.114

Daniel, S. M., Martin-Beltrán, M., Peercy, M. M., & Silverman, R. (2016). Moving beyond yes or no: Shifting from over-scaffolding to contingent scaffolding in literacy instruction with emergent bilingual students. *TESOL Journal, 7*(2), 393–420. https://doi.org/10.1002/tesj.213

Deshmukh, R. S., Zucker, T. A., Tambyraja, S. R., Pentimonti, J. M., Bowles, R. P., &

Justice, L. M. (2019). Teachers' use of questions during shared book reading: Relations to child responses. *Early Childhood Research Quarterly, 49,* 59–68. https://doi.org/10.1016/j.ecresq.2019.05.006

DiGiacomo, D. K. (2020). Supporting interests and sharing power: Insights from a Scottish youth program. *Journal of Youth Development, 15*(5), 68–92. https://doi.org/10.5195/jyd.2020.869

Ebe, A. E. (2010). Culturally relevant texts and reading assessment for English language learners. *Reading Horizons, 50*(3), 193–210.

Erdemir, E., & Brutt-Griffler, J. (2020). Vocabulary development through peer interactions in early childhood: A case study of an emergent bilingual child in preschool. *International Journal of Bilingual Education and Bilingualism, 25*(3), 834–865. https://doi.org/10.1080/13670050.2020.1722058

García, O. (2009). *Bilingual education in the 21st century: A global perspective.* Wiley-Blackwell.

Giroir, S., Grimaldo, L. R., Vaughn, S., & Roberts, G. (2015). Interactive read-alouds for English learners in the elementary grades. *The Reading Teacher, 68*(8), 639–648. https://doi.org/10.1002/trtr.1354

Goldstein, H. (2011). *Multilevel statistical models* (4th ed.). Wiley.

Gómez, L., Vasilyeva, M., & Dulaney, A. (2017). Preschooler teachers' read-aloud practices in Chile as predictors of children's vocabulary. *Journal of Applied Developmental Psychology, 52,* 149–158. https://doi.org/10.1016/j.appdev.2017.07.005

Goos, M., & Bennison, A. (2019). A zone theory approach to analyzing identity formation in mathematics education. *ZDM Mathematics Education, 51*(3), 405–418. https://doi.org/10.1007/s11858-018-1011-8

Henkes, K. (2014). *Lilly's big day.* Greenwillow Books.

Hindman, A. H., Wasik, B. A., & Bradley, D. E. (2019). How classroom conversations unfold: Exploring teacher–child exchanges during shared book reading. *Early Education and Development, 30*(4), 478–495. https://doi.org/10.1080/10409289.2018.1556009

Javorsky, K., & Trainin, G. (2014). Teaching young readers to navigate a digital story when rules keep changing. *The Reading Teacher, 67*(8), 606–618.

Kennedy, P. (2008). *Guide to econometrics.* Wiley-Blackwell.

King, D. (2010). *I see the sun in Nepal* (J. Inglese, Illus.). Satya House Publications.

Konstantopoulos, S. (2008). The power of the test in three-level cluster randomized designs. *Journal of Research on Educational Effectiveness, 1*, 66–88. https://doi.org/10.1080/19345740701692522

Krippendorff, K. (2012). Commentary: A dissenting view on so-called paradoxes of reliability coefficients. In C. T. Salmon (Ed.), *Communication yearbook 36* (pp. 481–499). Routledge.

Ladson-Billings, G. (1994). *The dreamkeepers: Successful teachers of African American students.* Jossey-Bass.

Lenhart, C., Bouwma-Gearhart, J., Villanueva Alarcón, I., Youmans, K., & Nadelson, L. (2020). Engineering faculty members' perceptions of university makerspaces:

Potential affordances for curriculum, instructional practices, and student learning. *International Journal of Engineering Education, 36*, 1–12.

Lohfink, G. S., & Loya, J. (2010). The nature of Mexican-American third graders' responses to culturally-relevant picture books. *Bilingual Research Journal, 33*(3), 346–363. https://doi.org/10.1080/15235882.2010.529346

Lightfoot, C. (1988). The social construction of cognitive conflict: A place for affect. In J. Valsiner (Ed.), *Child development within culturally structured environments.* Ablex.

Marsh, J. (2016). The digital literacy skills and competencies of children of pre-school age. *Media Education Studies and Research, 7*(2), 197–214.

Marsh, J., Plowman, L., Yamada-Rice, D., Bishop, J. C., Lahmar, J., Scott, F., Davenport, A., Davis, S., French, K., Piras, M., et al. (2015). *Exploring Play and Creativity in Pre-Schoolers' Use of Apps: Final Project Report.* University of Sheffield.

Martin-Beltrán, M., Daniel, S., Peercy, M., & Silverman, R. (2017). Developing a zone of relevance: Emergent bilinguals' use of social, linguistic, and cognitive support in peer-led literacy discussions. *International Multilingual Research Journal, 11*(3), 152–166. https://doi.org/10.1080/19313152.2017.1330061

Mascareño, M., Deunk, M. I., Snow, C. E., & Bosker, R. J. (2017). Read-alouds in kindergarten classrooms: A moment-by-moment approach to analyzing teacher-child interactions. *European Early Childhood Education Research Journal, 25*(1), 136–152. https://doi.org/10.1080/1350293X.2016.1266226

Mascareño, M., Snow, C. E., Deunk, M. I., & Bosker, R. J. (2016). Language complexity during read-alouds and kindergartners' vocabulary and symbolic understanding. *Journal of Applied Developmental Psychology*, *44*, 39–51. https://doi.org/10.1016/j.appdev.2016.02.001

McQuinn, A. (2008). *My friend Jamal* (B. Frey, Illus.). Annick Press.

Mihai, A. (2021). Teacher-child interactions that target vocabulary development in two preschool classrooms: A conversation analytic approach. *International Journal of Early Childhood, 53*(3), 279–296. https://doi.org/10.1007/s13158-021-00296-6

Neumann, M. M., & Neumann, D. L. (2014). Touch screen tablets and emergent literacy. *Early Childhood Education Journal, 42*, 231–239. https://doi.org/10.1007/s10643-013-0608-3

Pantaleo, S. (2007). Interthinking: Young children using language to think collectively during interactive read-alouds. *Early Childhood Education Journal, 34*(6), 439–447. https://doi.org/10.1007/s10643-007-0154-y

Paris, D., & Alim, H. S. (2017). *Culturally sustaining pedagogies: Teaching and learning for justice in a changing world.* Teachers College Press.

Philp, J., Adams, R., & Iwashita, N. (2014). *Peer interaction and second language learning.* Taylor and Francis.

Plowman, L., & McPake, J. (2013). Seven myths about young children and technology. *Childhood Education, 89*(1), 27–33.

Plowman, L., McPake, J., & Stephen, C. (2010). The technologization of childhood? Young children and technology in the home. *Children and Society, 24*(1), 63–74.

Price, L. H., Bradley, B. A., & Smith, J. M. (2012). A comparison of preschool teachers' talk during storybook and information book read-alouds. *Early Childhood Research Quarterly, 27*(3), 426–440. https://doi.org/10.1016/j.ecresq.2012.02.003

Queen Rania of Jordan, & DiPucchio, K. (2010). *The sandwich swap* (T. Tusa, Illus.). Little, Brown Books for Young Readers.

Ramey, A., Gorostiza, J. F., & Salichs, M. A. (2012). A social robot as an aloud reader. In *Proceedings of the seventh annual ACM/IEEE international conference on Human-Robot Interaction (HRI '12)* (pp. 213–214). Association for Computing Machinery. https://doi.org/10.1145/2157689.2157761

Rideout, V. (2017). *The common-sense census: Media use by kids age zero to eight.* Common Sense Media. https://www.commonsensemedia.org/research/the-common-sense-census-media-use-by-kids-age-zero-to-eight

Shamir, A. (2009). Processes and outcomes of joint activity with e-books for promoting kindergarteners' emergent literacy. *Educational Media International*, *46*(1), 81–96. https://doi.org/10.1007/s10643-013-0589-2

Shamir, A., & Korat, O. (2007). Developing an educational e-book for fostering kindergarten children's emergent literacy. *Computers in the Schools*, *24*(1–2), 125–143.

Shamir, A., Korat, O., & Barbi, N. (2008). The effects of CD-ROM storybook reading on low SES kindergarteners' emergent literacy as a function of learning context. *Computers & Education, 51*(1), 354–367.

Shuler, C. (2012). *iLearnII; An analysis of the education category of the iTunes App Store*. Joan Ganz Cooney Center at Sesame Workshop.

Simpson, A., Walsh, M., & Rowsell, J. (2013). The digital reading path: Researching modes and multidirectionality with iPads. *Literacy*, *47*(3), 123–130.

Smeets, D., & Bus, A. (2014). The interactive animated e-book as a word learning device for kindergartners. *Applied Psycholinguistics*, *22*(1), 1–22.

Stephen, C., Stevenson, O., & Adey, C. (2013). Young children engaging with technologies at home: The influence of family context. *Journal of Early Childhood Research*, *11*(2), 149–164. https://doi.org/10.1177/1476718X12466215

Valsiner, J. (1987). *Culture and the development of children's actions: A cultural-historical theory of developmental psychology*. John Wiley & Sons.

van den Berghe, R., Verhagen, J., Oudgenoeg-Paz, O., van der Ven, S., & Leseman, P. (2019). Social robots for language learning: A review. *Review of Educational Research*, *89*(2), 259–295. https://doi.org/10.3102/0034654318821286

Verhallen, M. J. A. J., & Bus, A. G. (2010). Low-income immigrant pupils learning vocabulary through digital picture storybooks. *Journal of Educational Psychology*, *102*(1), 54–61. https://doi.org/10.1037/a0017133

Vogt, P., van den Berghe, R., de Haas, M., Hoffman, L., Kanero, J., Mamus, E., Montanier, J. M., Oranç, C., Oudgenoeg-Paz, O., & García, D. H. (2019). Second language tutoring using social robots: A large-scale study. In *Proceedings of the 2019 14th ACM/IEEE International Conference on Human-Robot Interaction*

(HRI) (pp. 497–505). https://doi.org/10.1109/HRI.2019.8673077

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Harvard University Press.

Wang, X. C., Christ, T., Chiu, M. M., & Strekalova-Hughes, E. (2019). Exploring the relationship between kindergarteners' buddy reading and individual comprehension of interactive App Books. *AERA Open, 5*(3), 233285841986934. https://doi.org/10.1177/2332858419869343

WIDA. (2016). *Can do descriptors: Key uses edition, Grades 2–3.* https://wida.wisc.edu/sites/default/files/resource/CanDo-KeyUses-Gr-2-3.pdf

Wong, M. Y. (2015). A qualitative examination of teacher-student power-sharing in Chinese classrooms: A study in Hong Kong. *Frontiers of Education in China, 10*(2), 251–273. https://doi.org/10.1007/BF03397065

Worthy, J., Durán, L., Hikida, H., Pruitt, A., & Peterson, K. (2013). Spaces for dynamic bilingualism in read-aloud discussions: Developing and strengthening bilingual and academic skills. *Bilingual Research Journal, 36*(3), 311–328. https://doi.org/10.1080/15235882.2013.845622

Wright, T. S., & Gotwals, A. W. (2017). Supporting kindergartners' science talk in the context of an integrated science and disciplinary literacy curriculum. *The Elementary School Journal, 117*, 513–537. https://doi.org/10.1086/690273

Xu, Y., Yau, J. C., & Reich, S. M. (2020). Press, swipe, and read: Do interactive features facilitate engagement and learning with e-books? *Journal of Computer Assisted*

Learning, *37*(1), 212–225. https://doi.org/10.1111/jcal.12480

Yin, R. K. (1984). *Case study research: Design and methods.* Sage.

Zucker, T. A., Justice, L. M., Piasta, S. B., & Kaderavek, J. N. (2010). Preschool teachers' literal and inferential questions and children's responses during whole-class shared reading. *Early Childhood Research Quarterly*, *25*(1), 65–83. https://doi.org/10.1016/j.ecresq.2009.07.001