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Affective Relations *to* Mathematics in Swedish Early Childhood Education

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Abstract

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This thesis examines how affective relations to mathematics emerge, become visible, and are sustained in Swedish early childhood education (preschool and preschool class). Integrating psychological, physiological, and interactional perspectives, it explores how children's orientations toward mathematics are shaped through teachers' affective dispositions, children's real-time engagement, and the multimodal practices of everyday preschool interaction. Three empirical studies address two overarching questions: How teachers and children co-construct affective relations to mathematics, and What different methodological approaches contribute to understanding these relations. Study I used a municipal survey of 357 educators, employing an adapted Math Anxiety Scale for Teachers of Preschool. A two-factor structure (general vs. teaching-related anxiety) was confirmed. Results showed that certified preschool teachers with higher math anxiety reported significantly lower frequency of math teaching and math-related talk—particularly in structured situations. This association did not appear for caregivers, revealing a profession-specific pathway through which teachers' affective orientations may shape children's opportunities to encounter mathematics. Study II combined pupillometry, child-friendly affect ratings, and visuospatial working memory measures with preschool class children (mean age 5.67) and one parent each. Task difficulty reliably increased pupil dilation during problem processing, but anticipatory activation before math tasks was minimal. No associations emerged between children's affect ratings and physiological measures, nor between children's and parents' math anxiety. These findings suggest that physiological components typically associated with math anxiety are not yet consolidated at this age. Study III analyzed nearly six hours of video-recorded everyday mathematics activities in a preschool using multimodal conversation analysis. Teachers' responses to children's affective stances—through prosody, gaze, body orientation, gesture, and material action—organized participation in counting, problem-solving, and emergent math play. Response practices accomplished re#engagement, repair, explanation, and moral work, demonstrating that affect is central—not peripheral—to the organization of early mathematics activities. Across studies, affective relations to mathematics appear relational, situated, and developmentally emergent. The thesis shows the value of mixed methods for capturing both intrapersonal and interactional dimensions of affect. Practically, it highlights the need to support teachers' own affective orientations to mathematics and to design early math environments that combine cognitive challenge with interactional practices that recognize and build on children's affective engagement.

Keywords: Affect; Emotion; Math anxiety; Early childhood mathematics; Preschool education; Förskola; Affective stance; Psychological constructionism; Constructed emotion; Cognitive and emotional engagement; Pupillometry; Eye-tracking; Visuospatial working memory; Multimodal interaction analysis; EMCA; Video ethnography; Teacher affect; Pedagogical practices; Mixed methods; Interdisciplinarity.

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To the Supreme voices of enjoying learning, mi abuela ∞
and my eternal 4th graders.

List of Papers

This thesis is based on the following papers, which are referred to in the text by their Roman numerals.

I. Galeano, L., Fawcett, C., Forssman, L., & Gredebäck, G. (2024). Early Childhood Educators' Math Anxiety and Its Relation to Their Pedagogic Actions in Swedish Preschools. *Journal of Cognition and Development*, *25*(1), 100–126.

II. Galeano, L., & Gredebäck, G. (2024). Exploring the Impact of Math Anxiety and Task Difficulty on Pupil Dilation in Adults and Young Children. *Cognitive science*, *48*(9), e13493.

III. Galeano, L., & Norén, N. (preliminary manuscript). *The role of affective work in Swedish preschool mathematics*

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Contents

Chapter 1. Introduction

Mathematics permeates nearly every aspect of modern life, from daily decision-making to the demands of the global job market. Expectations for individuals' mathematical skills vary depending on the policy document or societal framework considered, such as international assessments or national educational guidelines. In Sweden, these expectations are rooted also in the values and guidelines outlined in the preschool curriculum *Läroplan för förskolan* (Lpfö 18, latest version revised in 2018), which emphasizes both the need for child-centered, play-based approaches and the importance of fostering mathematical skills. Lpfö 18 tasks preschool teachers with providing opportunities for children to explore and describe their world through activities that align with their curiosity and interests (pp. 9–10) and introducing mathematical concepts such as space, time, form, numbers, and patterns (p. 15). This reflects a societal priority to cultivate a lifelong desire to learn and to equip young children with essential mathematical skills (Lpfö 18; Skolverket, 2018). Motivated by these educational aims, this thesis investigates early affective relations to mathematics in Swedish early childhood education.

Under its guidelines, Lpfö 18 specifies that children should be supported in their overall development of motor, social, cognitive and emotional skills (pp. 15–16). However, research on attitudes and emotions related to mathematics has historically focused on older children and adults, and the literature on early childhood remains limited and sometimes conflicting (Dowker et al., 2012). Since most empirical work samples children at school entry or older (e.g., Dowker et al., 2019), many questions remain about whether negative attitudes and mathematics anxiety are already present in preschool (ages ≈ 3–6). Clarity is also lacking regarding their antecedents (e.g., parental versus other contextual influences such as attending preschools) and about the most appropriate measurement approaches for capturing these phenomena in very young children. This uncertainty poses both a theoretical and a methodological challenge. Understanding how affective relations to mathematics emerge before formal schooling requires developmentally sensitive methods.

To address these gaps, this thesis project used complementary methodologies, including self-reports, temporally sensitive physiological indexing, and multimodal interaction analysis. The construct *math anxiety* served as the starting point, given its documented associations with performance and achievement, as well as its potential role in children's early socialization into mathematics. Yet the scope of the project gradually widened: from preschool teachers' and preschool class children's own affective relations to mathematics, to the interactional practices that shape these relations in everyday preschool activities. In this progression, each study became both an answer and a point of departure, with new layers of inquiry revealing further aspects of how early affective relations to mathematics take form. This approach aimed to balance attention given to the intrapersonal and interpersonal processes that shape affective relations toward mathematics.

While I started from the construct math anxiety, I recognize that prior research has problematized the conceptual boundaries between attitudes and emotions (e.g., Dowker et al., 2019, p. 212). Rather than resolving how those overlaps are handled in this thesis now, I return to them in the theoretical underpinnings (chapter 3) where I draw on Hannula's metatheory (2012) and Barrett's psychological constructionist account of emotion (2017; 2025) to clarify how these conceptual dimensions connect to the studies' empirical design.

1.1 Affective Relations, Teaching and Learning Math

This interdisciplinary research project centres on early affective (emotional) relations to mathematics. In this thesis, the terms *affective* and *emotional* are used interchangeably. Early childhood mathematics education research commonly focuses on the opportunities and conditions available for learning (Björklund et al, 2020). This section explains how the empirical studies in this thesis fit into that body of work and how they contribute to our understanding of affective relations, alongside teaching and learning mathematics in Swedish preschools.

Within this research context, the construct math anxiety is particularly relevant. Math anxiety refers to the discomfort that individuals experience when confronted with mathematical tasks or situations. Richardson and Suinn's definition[1]: "mathematics anxiety involves feelings of tension and anxiety (apprehension) that *interfere* with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972, p. 551, emphasis added) provided the conceptual lens for framing initial questions in this thesis. This definition was used as a point of departure to ask to what extent, how, and when such

[1] At the time of writing, this work had been cited over 400 times in the American Psychological Asociation PsycNet only, indicating its sustained influence in the field.

interference might occur in Swedish preschools. Studies I and II addressed these questions by operationalizing the construct through questionnaires and temporally sensitive physiological measures. Study III, extended the inquiry to the interactional organization of mathematical activity, examining how affective stances and practices are displayed and managed in everyday preschool settings. Together these studies move from investigating potential interference toward exploring the broader relational and situated processes that contour early experiences with mathematics. Throughout the thesis, the term *affective relations* refer to the evolving patterns of emotional orientations, stances, and interactional behaviors of children and teachers toward mathematics. *Engagement* denotes behavioral involvement with math tasks and activities.

Affective relations to mathematics do not emerge in isolation, they are continuously shaped by the pedagogical structures and social interactions that define preschool life (Zöggeler-Burkhardt et al., 2023; Bronfenbrenner & Morris, 2006). Teachers' emotional orientations toward mathematics, their ways of organizing learning activities, and the curricular structures that guide those activities all shape how children come to experience mathematics (Hannula, 2020; Vogt et al., 2021). Understanding how affective relations take form therefore also requires attention to the teaching practices and curricular intentions that frame them. While affective relations include individual emotional orientations toward mathematics, in this thesis they are fundamentally understood as also emerging within and through social interactions and institutional structures.

Accordingly, this research project approaches early affective relations to mathematics from complementary perspectives. It examines how such relations develop in young children both in the context of everyday preschool teaching and learning, and in preschool class children's engagement with structured mathematical tasks in a controlled environment. Similar to studies investigating how mental processes such as working memory or attention influence mathematical performance, this project explores how affective factors shape early mathematical engagement. At the same time, drawing on research that views emotion as a social and interactional phenomenon, it investigates how affective stances guide children's engagement in mathematical activities. The three empirical studies employ different methods to address intrapersonal and interpersonal processes; together, providing a multi-layered picture of how emotional and pedagogical processes are intertwined in the early childhood education context.

In study I, the frequency of pedagogical actions, and how teachers' own affective relations to mathematics shapes the learning environment of preschool age children is explored. This study is aligned with the emphasis within didactics of mathematics education[2] on the teacher's role in creating learning opportunities and fostering a positive relational environment for learning mathematics. Study II is conducted in relation to cognitive science research on mathematical problem-solving and informs the interest in how children exert attention and cognitive effort when processing math tasks. According to prior research, math anxiety likely affects the aforementioned processes, as anxiety might interfere with attention and working memory in problem-solving. Using research instruments to explore how anxiety might influence cognitive effort during problem-solving in young children, this study taps into the same kinds of mechanisms that cognitive science has investigated, such as attention/inhibition and cognitive load. Yet, we do so with the purpose of collecting local group level data that allows us to better characterize the participant population in our studies. The methods deployed in study II are novel in their use with this population's age and societal context. Study III goes beyond intrapersonal processes to also investigate the social and emotional dynamics between teachers and students in math-related activities taking place at the preschools. Study III is conducted in relation to dialogical theories of communication and social interaction in educational contexts, and adds information regarding how affective stances are handled during math-related activities in the early years.

The relevance of the overall research project stems from the indication that affective relations (e.g., math anxiety) start taking shape early in life, which has direct implications for the quality of children's early math-related experiences in preschool, beyond its posterior measurable impact on math performance. Thus, the focus of this research is on increasing the knowledge about early affective relations to mathematics, and the role teachers play in creating socio-emotional environments in preschools that are significant for the development of emotional relations towards math. Besides the potential connection between math anxiety and performance outcomes in the future, concern for the quality of young children's affective experiences with mathematics lies at the heart of this research project.

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2 In this thesis, the term 'didactics of mathematics' refers to the study of teaching and learning mathematics, including the relational dynamics between teacher, child, and content.

1.2 Overarching Aims and Research Questions

The primary aim of this project was to further the knowledge on preschool and preschool class children's *affective relations* to mathematics particularly in connection to teachers' self-assessed math anxiety, preschool class children's engagement with math tasks, and everyday math-related activities in the preschool. The secondary aim was to explore how to investigate affective relations from different theoretical and methodological points of view. To this end, instruments were developed and methodologies were employed to frame affect as an emergent emotional experience shaped by individuals *within* their socio-cultural environments.

In pursuit of these aims, the following research questions were addressed:

- How do teachers and children (co-)construct affective relations to mathematics in early childhood education?

- What do different research methodologies contribute in characterizing affective relations to mathematics in early childhood education?

These research questions were explored within three sub studies, focusing on (i) preschool teachers' self-assessments of math anxiety, (ii) preschool class children's physiological, psychological and behavioral engagement with structured math tasks, and (iii) affective practices in everyday math-related activities in the preschool. To capture intrapersonal and interpersonal processes shaping early affective relations to mathematics, each sub-study tested and employed tailored instruments, including surveys, lab-based pupillometry, and video-ethnographic interaction analysis.

A comprehensive framework enabled the integration of findings across these different levels of inquiry: the impact of math anxiety on teachers' own relation to mathematics and teaching practices; children's exertion of attention and cognitive effort during mathematical tasks; and the intricacies of affective stances and practices in the social organization of activities during early math-related teacher-student interactions. Viewing emotional experiences as situated and context-dependent instances (Barret, 2017; Hoemann et al., 2019) aligns in some respects with affect as an interactional achievement, as highlighted in the close analysis of sequentially organized actions in social interaction (Heritage, 1984; Schegloff, 1992; Sidnell, 2015). In a wider sense, this approach contributed to increasing knowledge on teachers' role in the creation of supportive socio-emotional environments during math-related activities in preschools.

1.3 Outline of the Thesis

Chapter 1 introduces the research problem and defined the object of study: early affective relations to mathematics in Swedish early childhood education. It explains the relevance of this focus, sets out the aims and research questions, and gives a very brief overview of the studies included in the thesis. Chapter 2 situates the empirical work in the broader landscape of early childhood mathematics education in Sweden. It begins by examining international performance trends and affective factors such as mathematics anxiety, then traces the historical, curricular, and pedagogical developments that shape how mathematics is taught and experienced in Swedish preschools.

Chapter 3 elaborates the theoretical framework guiding the design and analysis in the thesis. Chapter 4 highlights previous research most directly relevant to Studies I–III, complementing the broader background provided in Chapter 2. This layered approach avoids redundancy while ensuring that the relevant literatures are addressed at appropriate levels of detail. Chapter 5 presents the methodology in each study. This chapter includes a description of the empirical material, ethical considerations and methods of analysis. It concludes with a meta-level reflection on design and conceptual positioning of each study. Chapter 6 summarizes the results of the studies individually, and the discussion (Chapter 7) integrates them to display the empirical, theoretical, methodological contributions, and the practical implications of the thesis as a whole. Finally, Chapter 8 consists of a summary of the thesis in Swedish.

Chapter 2. Background

To understand how affective relations to mathematics take form in Swedish early childhood education, it is necessary to situate the thesis within the broader educational and societal context. This includes examining international performance trends, historical legacies in teacher education, national curriculum goals, and the pedagogical practices that shape early childhood mathematics education in Sweden. The following background outlines these layers, beginning with Sweden's participation in international assessments and the role of affective factors in shaping performance.

2.1 The Big Picture: Sweden in Context

The importance placed on instilling strong mathematical skills at the national level in Sweden becomes more apparent when analyzed through the lens of its participation in international studies like TIMMS (Trends in International Mathematics and Science Study) and PISA (Programme for International Student Assessment). TIMMS is conducted every 4^{th} year since 1995, and students attending grade 8 (the year they turn 14 years old) in Sweden have been participating since 1995 (1999, 2003, 2007, 2011, 2015, 2019, 2023), while those attending grade 4 (the year they turn 10 years old) were integrated in 2007. PISA tracks the performance of 15-year-olds in mathematics, reading, and science across participating countries. PISA is conducted every 3^{rd} year, and Sweden has participated in the PISA studies since its beginnings in the year 2000 (2003, 2006, 2009, 2012, 2015, 2018, 2022: delayed due to the COVID pandemic). In the 2003, 2012, and 2022 study cycles, the focus was specifically on mathematics, providing valuable insights into *trends* in both mathematical achievement and some factors influencing students' performance.

In PISA 2003, Sweden achieved an average math score of 509, which placed it significantly above the OECD average of 500 (Skolverket, 2004, p. 54). Sweden's math score declined to 478 in PISA 2012, reflecting a significant drop in performance over the previous decade (Skolverket, 2013, p. 50) and in relation to the OECD average for that year. Sweden's score then improved in the subsequent PISA cycles, rising to 502 by 2018, surpassing the

OECD average once again (OECD, 2019). However, the most recent PISA 2022 results indicate a reversal of these gains, with Swedish students' math performance declining to 482, a level closer to the historical low recorded in 2012 (OECD, 2023a). Although Swedish students currently perform above the OECD average of 472, these trends signpost ongoing challenges in maintaining consistent mathematical performance. The fluctuations in Sweden's math scores over time suggest a need for deeper understanding of the factors contributing to these shifts.

One important factor examined in PISA is math anxiety, measured through a composite index capturing students' self-reported worry, nervousness, and tension when engaging with mathematics (OECD, 2023b). Figure 1 shows that Sweden's PISA math scores (blue) and the OECD average (orange) have fluctuated significantly between 2003 and 2022, with students in Sweden falling back to levels close to the historical low. Over the same period, Swedish students' math anxiety scores increased (from –0.49 to –0.07), coinciding in time with both declines in performance and its fluctuation over time (Skolverket, 2004, p. 77; Skolverket, 2013, p. 79; Skolverket, 2023, p. 47). This pattern is *consistent with* a potential association between rising anxiety and *fluctuating* performance rates in Sweden. However, causality cannot be inferred from these aggregated trends which would require future targeted longitudinal analysis.

Figure 1. *Sweden's PISA: Math Performance, OECD average, and Math Anxiety*

In the PISA reports, math anxiety—the feeling of tension and apprehension when confronted with math—has been widely identified as a key factor associated with mathematics performance, both in Sweden (Skolverket, 2023, p. 47) and globally (OECD, 2023b). Box I.2.1 in the OECD report (OECD, 2023b, p. 58) shows a general trend whereby students with higher mathematical performance experience less anxiety related to the subject. This pattern, first identified in the PISA 2012 report, continues to be observed in PISA 2022 across all participating education systems (OECD, 2023b, p. 58), reinforcing the negative association (inverse relation) between math anxiety and math performance reported globally (Barroso et al., 2021; Foley et al., 2017; Hembree, 1990; Namkung et al., 2019).

OECD analyses indicate that even in education systems with relatively strong performance, substantial variation in students' math anxiety persists (OECD, 2023b). This indicates that despite Sweden's relatively strong performance compared with the OECD average, substantial variation in math anxiety persists among students. Furthermore, the trend reported over the years when mathematics was a focus in PISA shows an increase in math anxiety scores: from -0.49 in 2003 (Skolverket, 2004, p. 77), to -0.35 in 2012 (Skolverket, 2013, p. 79), and to -0.07 in 2022 (OECD, 2023b, p. 58). In the meantime, the extensive literature on math anxiety suggests that addressing it early is crucial, as its effects extend beyond academic performance to essential life skills and career choices (Eidlin-Levy et al., 2023; Caviola et al., 2022).

One of the most recent and comprehensive studies utilizing data from TIMSS 10- and 14-year-olds and PISA 15-year-olds suggests that in Sweden, as students progress through school, the impact of individual math anxiety on achievement becomes stronger, peaking at age 14, and then slightly decreasing by age 15. Contextual anxiety (i.e., classroom or school-level anxiety) appears to impact younger students' math achievement more, particularly in TIMSS Grade 4, and its influence diminishes as students age, which indicates that classroom and broader education environments matter significantly for younger students (Lau et al., 2022).

It is important to note that TIMSS does not include a math-anxiety scale directly comparable to PISA's composite index. Instead, Lau et al. (2022) rely on the single TIMSS item *Mathematics makes me nervous* to approximate individual anxiety, and they construct contextual (education-environment) anxiety measures by averaging student responses within the sampled unit—that is, classrooms in TIMSS and schools in PISA. Finally, they estimate three-level models (L1 = student; L2 = education environment — classroom for TIMSS, school for PISA; L3 = country) to separate individual from contextual effects. Because the underlying items differ (single-item TIMSS vs. five-item PISA index), the individual and contextual effects are comparable in form but not identical in measurement.

Research has also traced the development of math anxiety throughout the school years, but much less is known about how these affective relations originate in early childhood education and preschool contexts. Through metanalyses, both increasing (Namkung et al., 2019) and decreasing (Barroso et al., 2021) trends for math anxiety have been reported in the primary school years. Reviews of this literature emphasize that the scarcity of studies with young children, the lack of multimethod approaches, and the absence of complex longitudinal models limit our ability to explain when and how math anxiety develops (Eden et al., 2013). These knowledge gaps reinforce the need for early-focused, multi-method investigations that trace how affective relations to mathematics take shape over time. Putting the discrepancy of these trend results aside, the fluctuation in overall average math anxiety levels reported across school years stresses the role and importance of early education in shaping both individual opportunities and broader societal outcomes.

Although international assessments document rising math anxiety in Sweden and the literature links anxiety to performance (Carey et al., 2016), this should not be interpreted as a direct causal relationship. Multiple interacting factors such as individual differences, prior achievement, classroom climate, teacher practices, and also insufficient mathematics ability have been shown to contribute to math anxiety (Maloney & Beilock, 2012; Dowker et al., 2016). Recent systematic reviews and meta-analysis of intervention studies reinforce this complexity. Sammallahti et al. (2023) report moderate reductions in math anxiety (Hedges' $g = -0.467$) and concurrent improvements in math performance ($g = 0.502$), particularly when interventions incorporate cognitive support (focused on participants' learning strategies) and emotion regulation (e.g., relaxation and expressive writing) strategies. Liu et al. (2025) extend this picture by reporting that interventions combining mathematics-skill instruction with anxiety-reduction components produced the largest pooled reductions in reported math anxiety (combined interventions: Hedges' $g = -1.09$), compared with anxiety-only interventions ($g = -0.71$) and skills-only programs ($g = -0.37$). These pooled estimates are averages across diverse studies (and show substantial between-study heterogeneity), and moderator analyses indicate that effectiveness depends on participant and program characteristics. For example, anxiety-focused interventions seem to be especially effective for participants with very high baseline anxiety. Liu et al. (2025) also note that insufficient mathematics ability may be one contributing factor to math anxiety, and reductions in anxiety do not always produce immediate performance gains, indicating a complex, bidirectional relationship between ability and anxiety. Together, Sammallahti et al. (2023) and Liu et al. (2025) show that combining emotional dimensions with skill development yields greater benefits, as reducing anxiety alone does not always lead to immediate performance gains.

These findings also suggest that policy and curriculum aims that combine the development of mathematical skills with practices that attend to students' emotional experience of mathematics are promising. This type of approach, which is aligned with Sweden's preschool curriculum Lpfö 18's (Skolverket, 2018) dual focus in emotional and math skills development may be helping address achievement goals while also mitigating the development and impact of math anxiety in children's educational paths. However, little is known about how affective relations to mathematics unfold in preschool settings (Dowker et al., 2012), and how teachers' own affect influences these early trajectories (Mammarella et al., 2019; Kirkland & Hunt, 2024). The focus of this thesis is therefore to explore how individual factors, such as personal anxiety towards mathematics, influence students' experiences with mathematics, while also considering the broader contexts within which this negative affect may develop. Furthering the knowledge on affective relations to mathematics is relevant not only for improving student outcomes, but also for shaping the formation and practices of educators. On this final point, Palmer (2020, p. 34, my transl.) argues that "the teacher profession is special in the sense that all pre-service teachers also have their own prior experience of the school world." This phrase leads us to explore the national historical and policy context that frames preschool mathematics education in Sweden.

2.2 Historical and Gendered Legacies

To understand contemporary affective relations to mathematics in Swedish preschools, it is necessary to consider the longer historical and gendered legacies that have shaped how mathematics has been perceived, taught, and valued. According to Larsson (2024), the English concept of infant schools (småbarnsskolor) was introduced to Sweden in the 1830s. This was followed by the first Swedish nurseries (barnkrubbor) opened in the 1850s inspired by the French model which focused on childcare for working mothers in industrial settings. Towards the end of the 19^{th} Century, a third form of preschool emerged, *kindergartens* (barnträdgårdar). Kindergartens were based on Friedrich Fröbel's ideas, emphasizing the role of play for children's development **(**Larsson, 2024**).**

Palmer (2020) highlights the influence of Descartes' dualistic model, which grew strong in the 19th century (p. 39). The model posited a series of vertical separations—public vs. private, systematic vs. unpredictable, independent vs. dependent, and rational vs. emotional—establishing a hierarchy in which opposing qualities were seen as fundamentally distinct. Alongside these vertical dichotomies, the model also linked certain qualities horizontally, most notably associating rationality with masculinity and emotion with femininity, reinforcing both the separation between mental domains and gendered hierarchies (Palmer, 2020, p. 39–40). This framework was subsequently used to argue that mathematics was primarily a masculine and rational domain, justifying the exclusion of women from mathematics-intensive education and professions (Palmer, 2020, p. 40).

Historically, mathematics has been framed as a male-dominated domain, a narrative that has perpetuated stereotypes about who can excel in the subject. "When mathematics emerged as an academic discipline in the 18th century, only men with an official professional life were included in the circle that had the opportunity to engage in mathematics" (Palmer, 2020, p. 39, my transl.). Clear examples of this can be traced back to the curriculum of public schools in Sweden. For example, girls were not allowed to learn geometry until 1889, when it became an optional subject area until 1919 (Normalplan, 1878, p. 63; Normalplan, 1889, p. 29; Normalplan, 1900, p. 34). It was only then that girls and boys had the same mathematics curriculum in school. This influence is also evident in how researchers made gender-differentiated claims in Sweden. For instance, regarding more advanced mathematics, even by 1939 it was stated—without any reservations—that woman in particular have difficulties with mathematics (Wallin & Grimlund, 1939, p. 9). These examples make it clear that a particularly gender-differentiated way of thinking about mathematics persisted well into the 20th century in Swedish schools.

Despite progress in gender equality within general education, the legacy of gender-differentiated perceptions of mathematics appears to have influenced teacher education programs into the 21st century. In Sweden, preschool education programs are still characterized by female overrepresentation. Notably, until 2005, teacher education programs were arranged in a way that made it possible for student teachers to complete their training opting out from mathematics courses (Palmer, 2020, p. 14; Utbildningsdepartementet, 2001). As Palmer (2020) notes, this was partly because preschool pedagogy at the time emphasized care, play, and holistic development rather than subject-specific knowledge. In compulsory-school teacher education, prior to the 2001 reform (Prop. 2000/01:60; Utbildningsdepartementet, 2001), students could specialize in Swedish and Social Sciences instead of Mathematics and Natural Sciences and therefore took little or no mathematics courses, reflecting broader assumptions about who would be responsible for mathematics teaching in schools. The changes introduced by this bill were implemented gradually and came into full effect in 2005. Although the structures differed between preschool and compulsory-school programs, and for different reasons, both illustrate how mathematics was unevenly prioritized across teacher education during this period. Rather than indicating a lack of competence among preschool teacher students themselves, these historical arrangements point to institutional and curricular traditions that may have indirectly reinforced gendered notions of mathematics as a challenging or less accessible subject for certain individuals. Such structures form an important background for understanding how teachers' affective relations to mathematics may be framed long before entering the preschool profession.

Palmer also refers to others and her own research (e.g., Aydin & Costu, 2016; Gresham, 2007; Palmer, 2009, 2010), showing that students training to become teachers of young children experience greater aversion to mathematics than other teacher students (Palmer, 2020, p. 14). This observation is reinforced by both classic (Hembree, 1990) and more recent studies (Jenßen, 2021) on math anxiety among early childhood educators, which illustrates the persistency of math anxiety in this group. Moreover, the gendered lens is a common approach in studies examining the individual effect of math anxiety on achievement and it is linked to a possible intergenerational effect, which may affect female students more strongly (Beilock et al., 2010). Various affective factors (e.g., Sumpter & Sollerman, 2022) including math anxiety, have been reported as stronger among female students (Hill et al., 2016; Hyde et al., 1990). This tendency is observed globally and in Sweden, where recent research shows that girls report higher levels of math anxiety than boys already by grade 4, that is, the year they turn 10 years old (Finell et al., 2024).

This gender difference reflects not only social and cultural biases but also motivational and affective differences that often begin in early childhood (Li et al., 2021; Anders & Rossbach, 2015). The plausible causes behind this early start become more evident for example, when high math-anxious adults narrate negative experiences with mathematics, linking them to their own elementary mathematics teachers and early experiences with math content (Hunt & Maloney, 2022; John, Nelson, Klenczar & Robnett, 2020; Shamoon, 2014). In Sweden, where gender differences in affective variables toward mathematics are documented among school-age children (Finell et al., 2024), and where pre-service early childhood teachers report aversion to mathematics (Shamoon, 2014; Palmer, 2009), it becomes essential to explore how early affective experiences shape their short- and long-term educational trajectories.

Early affective relations are relevant to children's immediate engagement with mathematics but also to their longer-term educational and professional trajectories. More boys than girls continue to pursue educational and professional careers in Science, Technology, Engineering and Mathematics (STEM) fields worldwide (Wang & Degol, 2016), and this gender gap may be partially explained by affective factors related to mathematics (e.g., Ahmed, 2018), particularly the higher prevalence of math anxiety among females. Meta-analytic evidence from TIMSS and PISA show that while gender differences in mathematics achievement are generally small, differences in affective factors (such as valuing math, motivation, self-concept, self-efficacy, and math anxiety) are substantially larger in countries with greater gender equity, including Sweden (Else-Quest et al., 2010). Recent research adds more nuance since affective gaps persist (Ghasemi & Burley, 2019), and achievement gaps in mathematics and science can also become more pronounced in more egalitarian and prosperous countries, especially in early grades (Oberleiter, Golle, & Scherer, 2023). According to a report from the Swedish National Agency for Education (Håkansson, 2024), in the 2022/2023 school year, more than 80% of students in the technical program were boys, with the percentage rising to nearly 90% for the fourth technical year. This gender disparity is further compounded by Swedish students' lower interest in mathematics and natural sciences, particularly compared to the international average. This trend is especially pronounced among girls, who remain underrepresented in STEM fields (Håkansson, 2024, my transl.).

This situation in Sweden reflects what some scholars refer to as the gender-equality paradox, where high levels of gender equality coincide with large gender gaps in STEM participation (Stoet & Geary, 2018). The paradox suggests that, in countries with greater gender equality, the gender gap in STEM might actually be wider, a counterintuitive finding. However, recent research has questioned the validity of this paradox, arguing that it may be an artifact of how cultural clusters and data quality are accounted for in global comparisons (Berggren & Bergh, 2025). This raises important questions about how we measure and interpret gender equality, STEM engagement, and whether Sweden's case is truly paradoxical or more reflective of deeper cultural dynamics.

In addition, Swedish-specific evidence highlights the role of early educational mechanisms. Gender differences in performance, confidence, competitiveness, and aspirations emerge already in compulsory and upper secondary school, shaping later STEM choices (Lénárd, 2025). Since the paradox is often used to explain away Sweden's gender imbalance in STEM, Berggren and Bergh's critique allows us to consider that other factors such as cultural, institutional, and educational aspects might be more important drivers of STEM participation choices (2025). Taken together with Lénárd's findings, this suggests that beyond national-level equality, factors such as classroom composition, motivational beliefs, and individual aspirations may play a stronger role in explaining gendered pathways in mathematics and STEM in Sweden.

To fully understand the factors shaping mathematical engagement, it is important to examine affective influences that vary among different groups

(Wang et al., 2015). The persistent gender disparities in STEM also highlight the importance of educational contexts as for instance, interactions in the preschools may contribute to shaping early affective relations towards math. Moreover, these findings must be interpreted considering the broader context, as the evolution of the Swedish preschool sector reflects significant societal, political, and educational shifts over several decades (Larsson, 2024). This, in turn, influences teacher preparation and the educational environments.

2.3 Expansion and Institutionalization of Preschool Education

In the 1960s, childcare was primarily viewed as a support system for working mothers, but economic growth and increasing female workforce participation led to a growing need for expanded childcare options. The 1970s marked a turning point with *Barnstugeutredningen*, a comprehensive investigation that emphasized the educational importance of early childhood care. By the 1980s, municipal day-care centers became the dominant form of childcare, culminating in the 1985 passage of the *Preschool for all children* bill, which solidified preschool as a public service (Larsson, 2024).

Larsson and Palmer agree that the 20th century saw a paradigm shift, with preschool increasingly viewed as essential for child development (Larsson, 2024; Palmer 2020). In 1998, the Swedish preschool received its own curriculum, with responsibility transferred to the Swedish National Agency for Education. This trend toward public preschool continued into the 2000s with the introduction of the childcare guarantee in the year 2000, ensuring a place for every child. Despite the only temporary reintroduction of the Carer's Allowance (Vårdnadsbidraget) between 2008 and 2014, preschool participation surged, with over 80% of children attending preschools. By the 2010s, the majority of Swedish children were in preschool, and by 2024, Sweden's preschool enrolment was 86% for ages 1-5, a rate among the highest in Europe (Larsson, 2024).

The latest version of the Swedish preschool curriculum (Lpfö18) regards everyone who works in the preschools as an important role model of behavior and talk that affects children's understanding and development of their own points of view. It states that preschool teachers are in charge of initiating and facilitating the activities that take place in the preschools, with the preschool curriculum as their starting point. Though, it is also stated that children's curiosity and own interests should be given importance at the moment of determining how a particular set of skills will be developed (Lpfö18, p. 7). From these guidelines derives the local notion that in Sweden, teachers must promote children's overall development and learning, as well as a life-long desire to learn.

More specifically, regarding mathematical skills learning, the curriculum states that the preschool should allow children to use "mathematics to investigate and describe their environment, and solve everyday problems that could be raised by themselves or others" (Lpfö18, p. 14). Hence, the activities promoted by teachers must allow students to develop an "understanding of space, time and form, and the basic properties of sets, patterns, quantities, order, numbers, measurement and change, and to reason mathematically about this" (Lpfö18, p. 14). Furthermore, teachers are expected to use math content as a foundation to foster children's ability to "discern, express, investigate and use mathematical concepts and their interrelationships" (Lpfö18, p. 14). These curriculum guidelines frame teachers as reflective practitioners who must make pedagogical decisions balancing children's interests, developmental needs, and mathematical learning goals.

The preschool curriculum highlights children's ability to "learn through play, social interaction, exploration and creation, but also by observing, conversing and reflecting" (Lpfö18, p. 11), thereby promoting varied methods that stimulate children's drive to learn. It also emphasizes the importance of continual challenge across diverse environments (e.g., indoors and outdoors) and the benefits children gain from the freedom to engage in play with peers, combining their own ideas and imagination with the materials and situations they encounter in preschool. In sum, the latest Swedish preschool curriculum sets out math-related learning goals for early childhood education (Lpfö18, p. 14) and aligns with local research highlighting the importance of an early start in developing mathematical skills. Studies in Sweden show that children begin acquiring mathematical abilities at a young age (e.g., Björklund, 2010; Reis, 2011), and these early experiences play a crucial role in later mathematics learning and school performance (e.g., Clements & Sarama, 2013; 2014; 2020).

Beyond individual academic success, fostering early mathematical engagement also has broader societal implications. It contributes to Sweden's ambition of sustaining a competitive, knowledge-based society, partly by encouraging more women to pursue mathematics-intensive education and professions that remain male-dominated (Palmer, 2020, p. 15). The long-standing underrepresentation of women in mathematics, together with the late inclusion of mathematics in preschool teacher programs, reflects enduring educational and curricular choices that continue to influence how in-service preschool teachers engage with mathematics today. Yet, curriculum implementation and teacher preparation are also mediated through local leadership and enactment. These issues are further explored in the following section.

2.4 Curriculum Enactment and Leadership

Curriculum enactment in Swedish preschools depends on both teacher agency and leadership strategies. Leadership in this context concern preschool principals but also how preschool teachers exercise leadership within working teams, particularly when negotiating responsibilities with childminders (in this thesis text: caregivers). Both Hildén et al. (2021) and Sundström (2025) highlight tensions around role distribution and professional authority that are central to curriculum enactment.

In 2010, preschools were integrated into the school system, making teaching a formal requirement (*Swedish Educational Act*, SFS 2010:800). Following inspections of 82 preschools in 2016, the Swedish Schools Inspectorate (SSI) concluded that the concept of teaching was largely absent in preschool descriptions and urged a teaching process aligned with curriculum goals (as cited in Hildén et al., 2021; Swedish Schools Inspectorate, 2016). Hildén et al. explained that SSI defined teaching as *"preschool teachers' conscious support of children's goal-oriented learning and development"* (Hildén et al., 2021, p. 2) and noted that the inspection prompted widespread national and local development processes to foreground more planned instruction. They further reported that many preschool teachers and managers associate teaching with compulsory-school, content-driven instruction and fear this shift threatens the play-based, child-centered approach (Hildén et al., 2021).

Sundström's (2025) study provides an in-depth look at how preschool principals interpret and enact the latest Early Childhood Education and Care (ECEC) curriculum. Through observations of group discussions and interviews with sixteen principals involved in a municipal implementation project, Sundström show both the opportunities and challenges of balancing traditional play-based approaches with an increased emphasis on structured teaching. Their research reveals that while principals generally view the new curriculum, and particularly the emphasis on teaching, as a positive development that could elevate the status of preschool education, they also recognize significant challenges. These challenges arise from the need to reconcile the new policy demands with long-established practices centred on play and care.

Among these challenges is managing staff resistance. As "structural aspects of context include professional relationships and power dynamics within preschools, with historical patterns of work distribution" (Sundström, 2025, p. 2), rebranding traditional play and care practices as teaching requires more frequent use of the term with their staff, development of their curricular knowledge, and their roles in relation to children (Sundström, 2025, p. 7). According to Sundström (2025), practice shifts are required in terms of adapting professional roles and reconciling curriculum demands with existing work structures. Principals also reported concern about these changes leading to resistance with "childminders expressing insecurity, and teachers feeling overwhelmed" (Sundström, 2025, p. 8). The authors also stated that while municipal support, such as the structured modules and collegial discussions (as part of the study's implementation project) are appreciated for fostering shared understanding, challenges related to timing, flexibility, and the practical rebalancing of staff responsibilities persist.

Hildén et al. (2021) investigated how Swedish preschool teachers collectively manage teaching as a new part of their professional mission. Their study shows initial tensions emerged between curriculum goals and child-centered pedagogy, and between teacher responsibility and team traditions. However, over time, teachers achieved agency through sustained collegial discussions, reframing teaching as playful yet goal-aware. This transformation was anchored in professional core values, such as sensitivity to children's needs, commitment to pedagogical practices for the greater good of children, and teamwork, which served as buffers against perceived threats to preschool traditions. These findings propose that repeated dialogue is necessary to reducing insecurity and fostering shared understandings, suggesting that leadership must create conditions for such professional conversations.

Sundström's (2025) study makes visible the back-and-forth between policy directives and local practices, demonstrating that successful curriculum enactment depends not only on clear policy communication but also on supportive, context-sensitive implementation strategies that acknowledge the cultural, structural, and material realities of preschool settings (Sundström, 2025). Among the few principals who were more critical of the Implementation Project modules' content, some questioned the timing of specific content presentation and pointed out that discussions on specific topics would be more appropriate and systematically tackled "if needed" and "when appropriate" for each preschool unit (Sundström, 2025, p. 9). Also, "more flexible forms of support, in the form of a bank of available materials" were requested (Sundström, 2025, p. 9). Hence, it is important to note that while principals expressed the need for greater autonomy to define when to discuss specific curricular areas, they also asked for the generation and provision of concrete materials and stressed the benefits of being part of a coherent macro-level structure that "increase[s] equivalence across the municipality," ultimately "strengthening the ECEC quality" (Sundström, 2025, p. 10).

These insights contribute to understanding the evolving role of preschool teachers and the integration of teaching and learning in early childhood education in Sweden. The tensions identified by Hildén et al. (2021) and the structural challenges highlighted by Sundström (2025) help explain variations in practice and inform the interpretation of this thesis' findings. The following section presents local research that show such shifts as expressed in play-based mathematics education where more formal mathematics instruction situations have just begun to become part of the children's routines.

2.5 The Integration of (Teaching) and Learning into Play

Early childhood mathematics education in Sweden represents a dynamic interplay between theory, practice, and policy (Hildén et al., 2021; Sundström, 2025). The preschool curriculum emphasizes a play-based, child-centred approach that aims to cultivate positive, long-lasting attitudes toward learning, including fostering mathematical skills (Lpfö18). The integration of these goals in practice is crucial given that early experiences with math can influence later performance and engagement. Empirical studies in Swedish preschools illustrate both the potential and the challenges inherent in this approach. Three key themes emerged from a review of key empirical studies on early childhood mathematics education in Sweden: teaching-through-play, discrepancies between curriculum goals and practice, and mathematizing during play and in interaction with teachers. By examining these findings, this section connects the role of teachers in fostering mathematical reasoning with the broader discussion on affective factors in mathematics education.

Pramling Samuelsson and Johansson (2006) discuss a paradigmatic shift in early childhood education, emerging in the late 1990s and early 2000s, which changed the perspective on the relation between play and learning in early childhood education. According to these authors, traditionally, play and learning were seen as separate. Play was considered a child's natural way of exploring the world, whereas learning was structured and guided by the teacher. This separation meant that play was valued as an independent activity, free from adult interference, while *real* learning was associated with specific educational activities (Pramling Samuelsson & Johansson, 2006). However, this perspective has evolved, and the new view suggests that play and learning are not separate but intertwined. Play is now recognized as a vital part of the learning process, contributing to cognitive, social, emotional, and creative development. Learning is no longer seen as something that only happens in isolated, teacher-led moments but as a process deeply embedded in children's everyday activities, including play.

Previously, teachers were expected to support play without interfering in its free and creative nature. Learning, in contrast, was structured and goal-oriented, often led by the teacher in specific activities. In the new integrated perspective, teachers are responsible for fostering play while also embedding learning opportunities within it. This requires a delicate balance. Teachers should guide and enrich play without dominating or restricting it (Pramling Samuelsson & Johansson, 2006). Studies in Swedish preschools show the importance of teaching-through-play and allowing free play as strategies to support mathematical learning. For instance, Björklund et al. (2018) analysed teacher-child interactions in preschools to understand how mathematical concepts are introduced and developed through play. Their findings revealed that preschool teachers employ various strategies to confirm, encourage, support, and challenge children's mathematical thinking. Three of the four identified teacher actions—providing strategies, situating known concepts, and challenging concept meaning—allowed play to continue even as teachers intentionally guided children toward mathematical learning. Thus, they demonstrated how preschool teachers support mathematical reasoning by embedding subtle guidance within children's play, extending their ideas without overwhelming the spontaneity of play.

Similarly, Johansson et al. (2012) examined mathematical activities in Swedish preschools, categorizing them using Bishop's (1986) six types of mathematical activities: counting, locating, measuring, designing, playing, and explaining. Their study found that preschool activities often integrate children's interests while fostering mathematical reasoning. Beyond general play-based learning, these researchers have also categorized different ways in which mathematical activities emerge during preschool interactions. Children's interactions with teachers were classified as either instrumental, where mathematical reasoning occurred alongside another goal, or pedagogical, where play was directly guided towards mathematical exploration. This classification highlights the flexible ways in which mathematics emerges during play, how teachers facilitate such moments and the role of teachers in shaping these interactions. Sumpter and Hedefalk (2015) demonstrated that preschoolers (1–5 years) engage in collective mathematical reasoning during free outdoor play. Across three episodes, they showed how the children used mathematical products and procedures to challenge and support arguments. The children also recruited concrete materials (e.g., rocks, structures found in the playground, and their own body heights) to illustrate claims, and mobilize social constructs (including jokes) to sustain participation and drive the collective reasoning forward. Two of these outdoor episodes showed that mathematical reasoning can emerge without explicit adult guidance, suggesting that curricular ambitions to diversify mathematical content can be advanced from child-initiated, playful contexts.

The paradigm shift that Pramling Samuelsson and Johansson (2006) discussed is reflected in research but also in educational policies, such as Sweden's preschool curriculum, which emphasizes the integration of play and learning since its introduction in 1998 —the first curriculum specifically for preschool. Additionally, learning is increasingly viewed as a social and cultural process rather than just an individual cognitive achievement. Children's lived experiences, social interactions, and cultural contexts play a crucial role in their development. This shift moves away from rigid developmental stages and toward an understanding that children learn and develop simultaneously through interaction with their environment and peers (Pramling Samuelsson & Johansson, 2006). It therefore challenges educators to rethink traditional teaching methods and adopt a more flexible, child-centered approach that recognizes play as a fundamental way of learning. It also raises important questions about how to balance structured learning objectives with the inherently spontaneous and creative nature of play.

Despite the curriculum's emphasis on integrating mathematics into early learning and the promising practices cited above (Björklund et al., 2018; Johansson et al., 2012), research also reveals gaps between curriculum ideals and everyday pedagogical practices. For example, Björklund and Barendregt (2016) surveyed 147 preschool teachers and found that while teachers frequently planned and encouraged mathematical reasoning during play, they less often utilized the environment to explore spatial and pattern-based mathematical concepts other than numbers and number sequencing. This gap suggests a need for deeper reflection on the diversity of mathematical content and strategies for embedding it into everyday activities.

On the other hand, Gejard and Melander (2018) explored how children engage in mathematizing—defined in their study as the process of participating in mathematical discourse—during play. Focusing on spatiality, shape, and symmetry, their study analyzed children's video-recorded interactions with magnetic construction sets, revealing how mathematical reasoning naturally emerged through verbal and embodied interactions. Their findings argued for the potential richness of spontaneous mathematical interactions during play and called for further research on how such moments can be leveraged to support geometrical thinking considering the importance of balancing structured guidance with opportunities for open-ended exploration (Gejard & Melander, 2018).

A more recent study by Björklund and Palmér (2024) provides further insight into how mathematics can be meaningfully integrated into play. Unlike the earlier conceptualization offered by Gejard and Melander (2018), Björklund and Palmér defined mathematizing as a process that emerges only when a *true problem*, or an authentic challenge that is relevant from the child's perspective, is present within the play activity. Their qualitative analysis of video recorded data including five preschool teachers revealed that when mathematical tasks were added without a clear connection to the ongoing play, the mathematics and play often proceeded as parallel activities. In contrast, their observations from other activities demonstrated that when teachers actively participated in the play and posed *contextually grounded* questions that address genuine, real-world problems, then the mathematics content became an essential tool for problem solving (Björklund and Palmér, 2024). This integration not only supported the development of mathematical reasoning but also challenged the traditional dichotomy between play and structured learning. By emphasizing the necessity of authentic problems and responsive teacher interactions, the study suggested that the effectiveness of play-responsive teaching hinges on embedding mathematics in a way that is both meaningful and necessary for the play narrative.

Taken together these studies illustrate potentials and some challenges of early childhood mathematics education in Sweden, which is characterized by a curriculum that strives to integrate play and learning. However, fully realizing its potential requires addressing the persistent gaps between theory and practice (e.g., Björklund & Barendregt, 2016). In many occasions, it has been shown that preschool teachers in Sweden successfully integrate mathematics into play. However, gaps remain in fully leveraging the curriculum's emphasis on diverse mathematical concepts. Furthermore, the role of the teacher in this context is to navigate the integration of play and learning in preschool. Teachers, whose professional preparation and own historical experiences (as discussed in Section 2.2) inevitably shape their classroom strategies, must navigate these challenges carefully. They are expected to support children's play without disrupting it, fostering a balance between allowing free, joyful play and guiding learning in line with long-term educational goals (Pramling Samuelsson & Johansson, 2006).

This delicate balancing act has been exemplified in local research with toddlers too (Palmér & Björklund, 2024a; 2024b; 2023; Björklund & Palmér, 2022). For example, Palmér and Björklund (2023) demonstrated that everyday activities can be subtly but deliberately re-designed to support early numeracy by allowing toddlers to discern essential numerical concepts (e.g., cardinality, ordinality, and part-whole relations) without detracting from the playful nature of the activity. By carefully aligning the activity's context with targeted numerical content through multiple modes of representation, teachers can create meaningful learning moments that naturally emerge from the children's experiences. This approach demonstrates how teachers can balance children's interests with learning goals, bridging spontaneous play and structured teaching without compromising either.

In essence, while play has traditionally been seen as a natural and important part of children's development, Swedish preschool teachers are now faced with the challenge of incorporating learning into this play without undermining its value as an autonomous and carefree activity. The preschool teacher's responsibility lies in helping children engage in both spontaneous play and structured learning experiences, ultimately fostering both mathematical competence and positive attitudes towards learning from an early age. However, the emotional aspects of these playful interactions (such as enthusiasm and engagement) are often implicit in the literature and not explicitly explored as constructs. This suggests a gap in research regarding the emotional dimensions of early mathematics education, a gap that warrants further exploration. Moreover, what it means for an activity to become meaningful for the children has been problematized, categorized and analyzed through different lenses. And a clear focus on teachers' contribution to interaction with the children, shows that teachers are key actors in fostering the early development of mathematical skills. Yet, while previous research has targeted the breadth and reach of teachers' enactment of the preschool curriculum and researcher's identification of mathematical content gaps, less attention has been paid to the role of affect in teacher-student interactions.

Understanding how affective factors such as enthusiasm and emotional engagement play a part in mathematical reasoning and participation, particularly in the integration of children's interests with teachers' pedagogical goals, remains a critical area for investigation. The historical and cultural legacies of expectations in the Swedish context, call for theoretical and methodological approaches that take teacher's and children's affect seriously, both as individual orientations and as part of broader didactic relations. This orientation provides the contextual background for this thesis' focus on how children's affective relations to mathematics emerge in Swedish early childhood education. This interdisciplinary research project centres on the early development of affective relations to mathematics under a theoretical framework that incorporates affective practices in teacher–child interactions as essential. Linguistic Anthropology, EMCA, and Barrett's theory of constructed emotion (see Chapter 3) offer valuable conceptual and methodological tools for analyzing how emotional experiences are constructed in everyday preschool activities.

By examining the relational aspects of emotion, where the physiological, cognitive, and social dimensions of emotional experiences intersect, these frameworks support the study of how emotions shape early mathematical engagement and meaning making.

Chapter 3. Theoretical Underpinnings

Emotions are not peripheral but central to mathematics learning (Heyd-Metzuyanim, 2011; Hannula, 2005, 2006; McLeod, 1992). Math anxiety literature, which exemplifies how emotional experiences shape learners' engagement and performance, illustrates that affect plays a fundamental role in educational contexts (Luttenberger et al., 2018; Vukovic et al., 2013; Hembree, 1990). Preschool settings demand responsive and intentional involvement from the teachers, whose role in Sweden is described by Pramling et al. (2019) as a balanced orchestration of care and teaching practices that respect and nurture children's interests, foster values desired in a democratic society, promote joy for the learning process in general, and most recently and specifically: the development of curricular areas such as mathematics (Lpfö 18). Yet, how can these ambitious and comprehensive goals become realized in everyday preschool interactions?

In this chapter I will argue that a nuanced intra- and inter-personal theoretical account of emotions as *constructed* is crucial for understanding affective relations to mathematics, addressing math anxiety, and its plausible negative impact on the early development of mathematical knowledge and skills. Section 3.1 presents math anxiety theories and their educational significance; 3.2–3 reviews developmental and psychological theories on emotional development; 3.4–6 turns to theories of affect/emotion in mathematics-education; 3.7–8 presents psychological constructionist theories of emotion within neuroscience (centred around the ideas of Lisa Feldman Barrett); 3.9 brings in a dialogical theoretical account of affect as stance within linguistic anthropology (LA) and multimodal ethnomethodological conversation analysis (EMCA); and 3.10 concludes by identifying similarities between these last two theoretical traditions, to establish the project's theoretical framework.

The field of mathematics-related affect is conceptually diverse, encompassing attitudes, beliefs, emotions, motivation, and values (Hannula, 2012). To organize this complexity, Hannula proposes a three-dimensional metatheory: (a) cognitive, motivational, and emotional aspects of affect; (b) affective states versus traits; and (c) the physiological/psychological/social nature of affect. The resulting 18-cell matrix functions as a heuristic to map phenomena, theories, and methods to study affect (see Figure 2).

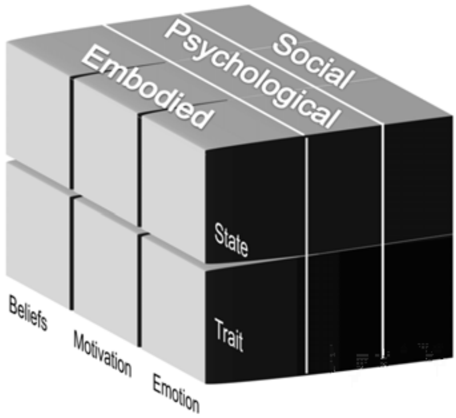

Figure 2. *Three-dimensional matrix of mathematics-related affect (adapted from Hannula, 2012, p. 144).*

The dimensions function as orthogonal axes (distinct, unrelated) for organizing research approaches (Hannula, 2012, p. 143). However, Hannula notes that in practice, research often spans multiple cells, combining cognitive, motivational, and emotional aspects or mixing state and trait perspectives (Hannula, 2012, p. 155). In this sense, the framework accommodates overlap and connections across categories, without implying that the cells themselves formally interact.

There is debate about whether mathematics anxiety should be classified as an attitude or an emotion (see Dowker et al., 2019). Some researchers argue that anxiety—being predominantly emotional—is conceptually distinct from evaluative attitudes, while others point out that many attitude models (for example Breckler's ABC model) incorporate affective and cognitive components, making it reasonable to treat mathematics anxiety as a form of attitude with multidimensional foundations (e.g., Ma & Kishor, 1997; Breckler, 1984 as cited in Dowker et al., 2019). In this thesis I adopt a pragmatic position: *mathematics anxiety* is treated as a multidimensional construct. For example, in Studies I and II, adults' general mathematics anxiety was measured using a 7-item scale adapted from Ganley et al. (2019), which captures self-reported affective (somatic), cognitive (worry/thought), and social-evaluative dimensions of math anxiety. The decision to use a multidimensional measure of mathematics anxiety is consistent with the thesis's theoretical framework, which conceptualizes emotions as constructed phenomena integrating physiological, cognitive, and social dimensions (Barrett, 2017).

I ground the thesis in the psychological constructionist account of emotion developed by Barrett, and in a social constructionist approach to situated emotion (Linguistic Anthropology or LA, and ethnomethodological conversation analysis or EMCA). Chapter 3 (sections 3.8—10) provides a detailed rationale for complementing Barrett's constructionist account of emotion with a social interactional, multimodal perspective (LA/EMCA), clarifying how these frameworks inform the design and interpretation of the empirical studies contained in this thesis.

As the matrix's third dimension (see Figure 2) accommodates the *physiological/embodied, psychological, and social nature of affect*, Hannula's framework is compatible with the Theory of Constructed Emotion (Barrett, 2017), which emphasizes how bodily signals, conceptual knowledge, and contextual/social information jointly shape affective phenomena. Barrett (2017) dissolves a strict cognition–emotion boundary by treating emotions as constructed, situated predictions that integrate interoceptive/physiological signals with prior conceptual knowledge; making physiological arousal and cognitive *worry* mutually constitutive rather than separate domains. Hannula's citation of Meyer and Turner — "emotion theories may handle cognition as part of emotion" — further clarifies this point (Hannula, 2012, p. 144).

LA/EMCA complements this perspective by treating emotion as part of accomplished, embodied and observable social practices in interaction and processes of joint meaning making. Taken together, these frameworks justify (a) measuring cognitive, physiological, and social dimensions of affective relations to mathematics (Studies I and II), and (b) using multimodal interaction analysis in Study III to trace how teachers' and children's emotion-related practices co-construct mathematical engagement and meaning-making in situ.

3.1 Math Anxiety Theories and Their Educational Significance

The math anxiety research field contains numerous studies examining the statistical negative relation between math anxiety and math performance or achievement. This section introduces math anxiety theories as a starting point to justify why affect matters in mathematics education. Meta-analyses across age and grade levels have revealed a persistent small-to-moderate negative correlation between students' math anxiety and math performance (Hembree, 1990; Ma, 1999; Namkung, Peng, & Lin, 2019; Zhang et al., 2019; Barroso et al., 2021). Studies exploring the factors underlying this relation have given rise to three main theories in the field: the Deficit Theory, the Debilitating Anxiety Model (also called the Cognitive Interference Model), and the Reciprocal Theory. From a didactics of mathematics education perspective, these theoretical models provide insights into the psychological mechanisms of math anxiety and also offer guidance for how educators can structure early learning experiences to prevent or mitigate anxiety.

The Deficit theory (Tobias, 1986) claims that poor math performance leads students to accumulate negative memories that cause higher math anxiety in the future. In contrast, the Debilitating Anxiety or Cognitive Interference model, proposes that high levels of anxiety interfere by thoughts of worry that take up working memory resources at the time of solving math problems (Ashcraft & Kirk, 2001; Ashcraft & Krause, 2007; Krinzinger, et al., 2009). Alternatively, it also proposes that the interference mechanism might be global avoidance (Aschcraft & Faust, 1994), i.e., the tendency to avoid engagement with math related situations altogether. Finally, the assessment of conflicting empirical findings for each of these explanatory accounts serves as evidence for a reciprocal causal relation between math anxiety and math performance. In other words, it is proposed that these mechanisms interact: anxiety can impair performance, while repeated poor performance (sometimes rooted in basic numerical deficits) can heighten anxiety, creating a vicious cycle. Social factors, such as exposure to anxious teachers, may further reinforce this pattern (Carey et al., 2016; Maloney & Beilock, 2012; Dowker et al., 2016).

In parallel, Processing Efficiency Theory (Eysenck & Calvo, 1992) and Attentional Control Theory (ACT; Eysenck et al., 2007) attempt to explain the negative impact of anxiety on cognitive performance by highlighting its effects on executive functions beyond working memory, including inhibition and shifting, both of which are necessary for solving mathematical problems. ACT distinguishes between performance effectiveness (the quality of performance) and processing efficiency (performance effectiveness relative to the cognitive effort invested), suggesting that anxiety impairs processing efficiency more than performance effectiveness. According to ACT, anxiety disrupts the functioning of the central executive, resulting in poorer inhibition and shifting abilities and increased susceptibility to distraction during cognitive tasks.

Building on this body of work, Lau et al. (2024) extend the existing theories by proposing an Avoidance Theory of math anxiety, which they position within the broader literature on general anxiety and specific anxieties. This theory conceptualizes math avoidance not simply as a direct consequence of poor performance or anxiety-driven cognitive interference, but also as a broader tendency (conscious or unconscious) to maladaptively avoid math-related situations. Math avoidance, in this framework, is understood as a behavior that arises in response to anxiety and leads to patterns of disengagement, both in academic and everyday contexts. The authors substantiate this view by examining avoidance from both behavioral and biological perspectives, suggesting that avoidance behaviors may manifest as subtle choices to evade math tasks altogether or as cognitive withdrawal during tasks, enriching our understanding of how avoidance tendencies contribute to the cyclical relationship between math anxiety and underperformance.

All theories of math anxiety and avoidance have significant implications for education, particularly in early childhood, where children's initial experiences with math can start shaping their long-term attitudes and abilities. Math anxiety, traditionally studied in older learners, is now documented in children as young as 4–7 years (Petronzi et al., 2019a; Lu et al., 2021). Longitudinal studies indicate that early math motivation and anxiety interact to predict achievement in early primary school (Gashaj et al., 2023; Ramirez et al., 2013, 2015). Beyond anxiety, implicit and explicit attitudes toward mathematics influence achievement and self-concept (Cvencek et al., 2021). Further, both research (e.g., Lyons & Beilock, 2012; Szczygieł & Pieronkiewicz, 2021; Lau et al., 2022) and theoretical models suggest that the educational context offers an opportunity to intervene before these relational patterns solidify. For example, the Deficit Theory suggests that early negative experiences with math may lead to future anxiety. This highlights the importance of early preventive measures in preschool settings, where educators have the chance to shape positive experiences with math before anxiety takes root.

The Cognitive Interference Model, which posits that anxiety disrupts working memory during math tasks, emphasizes the need for educational strategies that reduce unnecessary cognitive load. In classroom practice, this could mean breaking down tasks into manageable steps (Sweller, 1988), offering clear and consistent instructions, and fostering a low-pressure environment where children feel safe to explore, make mistakes and ask for help (Beilock & Maloney, 2015; Wang et al., 2025). Thus, educators can help children allocate their mental resources to solving problems, rather than worrying about them.

Moreover, ACT suggests that anxiety impairs cognitive functions such as inhibition and shifting. In education, this means that teachers can support students' executive function development by offering opportunities for flexible thinking. For instance, through varied problem-solving tasks and encouragement of a growth mindset (Dweck, 2006, 2019). It is important to recognize that some students may experience difficulty shifting their attention or inhibiting distractions when under anxiety, and educators can reduce pressure by providing structured but flexible problem-solving environments (Ramirez et al., 2018b). Research-wise, it would also become more relevant to directly test the efficiency of interventions aimed at improving executive functions, such as inhibition and attention shifting, and their potential to mitigate the negative effects of anxiety on math performance with the expansion of empirical evidence supporting this model (e.g., Skagerlund et al., 2024).

Finally, Avoidance Theory adds an additional layer to our understanding of how children engage or fail to engage with mathematics. In an educational setting, early signs of avoidance, such as reluctance to participate in math activities or subtle disengagement, should be recognized and addressed. Early intervention can prevent these avoidance behaviors from becoming regular practice. Teachers play a crucial role here, as the emotional and pedagogical climate they contribute to create can either exacerbate or alleviate future math anxiety. Additionally, the different explanatory models of math anxiety converge on the recommendation of early intervention to support positive mathematical experiences and prevent the development of maladaptive anxiety patterns. Yet they have been developed primarily with older children and adults in mind and less is known about how affective relations to mathematics begin to take shape in the preschool years, and how such relations are expressed beyond performance outcomes.

The studies presented in this thesis contextualize these theoretical perspectives by examining factors that might influence early math experiences in preschool settings. Study I focused on educators' affective orientations, while Study II explores preschool class children's cognitive, physiological, and behavioral engagement with mathematical tasks. Together, these two studies emphasize the importance of considering teacher and child factors when applying math anxiety theories to educational contexts. However, while the explanatory models revised above offer well-established explanations of the mechanisms linking anxiety and mathematics performance and remain influential in the field, they are not sufficient for the purposes of this thesis. This is because they conceptualize affect primarily as an internal psychological phenomenon, whereas this thesis seeks to understand affect as relational, socially situated, and multimodally enacted in preschool interactions. Therefore, these theories serve as a starting point that justifies why affect matters in this context, but the analytical framework of the thesis extends beyond them to constructionist and interactional perspectives on affect introduced in Sections 3.7–3.10.

3.2 A Broad Review of Perspectives on Emotional Development

The emotional development of individuals is influenced by biological, environmental, and social factors. There are many traditional and several other more contemporary conceptions of emotion within diverse perspectives in psychology and neighboring fields such as cognitive science. But essentially, three key theoretical perspectives to emotional development can be found within developmental psychology textbooks: the genetic maturational, the learning, and the functionalist views. Unsurprisingly, these views correspond to the broader evolutionary/nativist, behavioristic/conditioning-reinforcement, and socio-cultural accounts used to approach, and explain human behavior, including emotions and learning processes.

Why developmental psychology? The preschool years, roughly ages 1 to 5 in Sweden, constitute a uniquely rapid period of neural, cognitive-emotional growth, during which foundational skills in self-regulation, social understanding, and affective engagement take shape (Shonkoff & Phillips, 2000). Children who experience hardships or missed opportunities for positive affective encounters during these years might carry those vulnerabilities into later schooling and beyond. Developmental psychology is the subfield of psychology that focuses precisely on these age-related trajectories and the underlying processes unfolding in early childhood. Moreover, developmental psychology has long underpinned the Nordic play-responsive preschool model (Pramling et al., 2019). Cutter-Mackenzie et al. (2014) remind us that, following Rousseau's image of the *naturally evolving child* and Piaget's emphasis on unassisted exploration, developmental psychology "became the 'research evidence base for protecting children's opportunity to learn and develop through the provision of traditionally valued play-based experience" (see Cutter-Mackenzie et al., 2014, p. 16). This formulation is also discussed in Pramling et al. (2019) in relation to the Nordic play-responsive preschool model.

Although later critiques gave rise to post-developmental, socio-cultural and sociology of childhood perspectives (Cutter-Mackenzie et al., 2014, p. 17), developmental psychology has been a part of the play-centered pedagogy in Swedish pre-schools. See, for example, Pramling Samuelsson and Asplund Carlsson's (2008) notion of *developmental pedagogy*. Their research, grounded in Gothenburg phenomenographic work (Marton & Booth, 1997; Pramling, 1988), as well as the subsequent communicative-didactic turn (Englund, 2007), locate the *something*/*what* of learning in children's play interactions, emphasizing teacher–child dialogue over mere transmission (Pramling et al., 2019, p. 4; Pramling Samuelsson & Asplund Carlsson, 2008). In other words, developmental psychology focuses its studies mostly within the age range of our participants, and it has supported the origin of the play-responsive didactics framework that shapes Swedish preschool practice today. I will therefore continue this section by briefly describing the three key perspectives to emotional development within developmental psychology and the most common critique that they have received so far.

3.3 Four Historical Lenses on Emotional Development

The genetic maturational account, which is aligned with the nativist and evolutionary views, emphasizes that emotions are biologically wired, with individual differences in how children act being foregrounded and universality emphasized. This view is supported mostly by the studies conducted with twins (e.g., Plomin et al., 1997; Rutter, 2006) demonstrating similarities in the development of emotional expression. Further evidence comes from cross-cultural research demonstrating universal recognition of basic emotional expressions (Ekman & Friesen, 1971; Ekman, 1992a; Izard, 1971, 1987, 1994, 2004). This perspective has been criticized for neglecting environmental and social influences, as there is today a vast amount of research showing that, for example, parental emotional responses also shape their offspring's emotional development (Gottman et al., 1996, 1997; Denham et al., 2007).

The learning account, similar to behaviorism, emphasizes the importance of experience and conditioning, such as infants smiling more if encouraged to do so by their parents. Studies have established that positive reinforcement of infant smiles encourages more frequent repetition of this behavior/emotional response, suggesting that infants learn emotional display rules very early (Bandura, 1989; Denham et al., 2007). This supports the theory that emotions can be shaped by experiences, which then provides support for the behavioristic model. Critics of this account argue that the theory does not consider the universality of so-called *primary emotions* with happiness and fear being reported often as appearing very early in life; which suggests there is *something* innate about human emotional responses, and that this may date back to when these responses were necessary for survival purposes. Akin to the Darwinian-evolutionary perspective at the time of *The Expression of the Emotions in Man and Animals* (Darwin, 1872), these ideas were later taken up and further developed by Tomkins (1962), Ekman and colleagues (Ekman & Friesen, 1971), and Panksepp (1998), each of whom emphasized innate emotional systems that are also shaped by experience.

A counter perspective addresses the limitations stated above by integrating the genetic and learning frameworks and arguing that emotions serve as adaptive functions, and that they help us to understand social environments. In other words, the functionalist account proposes that emotions serve the accomplishment of goals by supporting goal-related behavior. Historically, from Aristotle and Plato to Darwin, Descartes to Ekman (Duncan & Barrett, 2007;

Ekman, 1992a), cognitive science has often treated emotions as biologically predetermined, discrete responses to external stimuli. Early models, such as those implied by basic (or what Barrett refers to as the *classic view of emotion*; Barrett, 2006a, 2006b; Gendron & Barrett, 2009) emotion theories and even aspects of Paul Ekman's work, posited that emotions were fixed physiological reactions with universal expressive features (such as facial movements: Ekman, 1992b, 1993). Several research groups have followed up on this view perpetuating the notion of emotions being biologically wired; containing physiological fingerprints; and tightly connected to *discrete and recognizable* behavioral patterns or forms of emotional expressions (Damasio, 1996; Panksepp, 1982, 1998). Most notably, neuroscientist Jaak Panksepp argued in empirical work that core emotional systems are evolutionarily ancient and rooted in subcortical neural circuits shared by mammals (Panksepp, 2005; Davis & Montag, 2019).

Similarly, early theoretical work by Mandler (1980, 1989) and McLeod and Adams (1989) contributed to a view in which emotional experience was seen as the product of automatic cognitive and physiological responses. By the 1980s, Mandler and McLeod began shifting toward adopting appraisal models, with the gap between what is treated as emotional and what is treated as cognitive functions widening. The appraisal model posits that there is an interpretative step in emotional processes, which involves a more cognitive evaluation of the physiological (i.e., "emotional") aspects of emotional experiences (Clore & Ortony, 2008). In both the biologically determined and appraisal frameworks, emotions (per se) are largely separated from cognitive processes, suggesting that affect/emotion had little to do with — or at best barely influence — the complex interactions involved in, for example, learning and meaning-making.

Meta-analytic work by Barrett and colleagues (e.g., Lindquist et al., 2012; Siegel et al., 2018) has challenged this so-called classic view of emotion. Lindquist et al. (2012) reviewed neuroimaging studies and found no consistent evidence that discrete emotions, such as anger, fear, or happiness, are associated with specific, localized brain regions. Further, Siegel et al. (2018) analyzed 202 studies of autonomic nervous system responses during emotional experiences, and found no consistent physiological patterns unique to particular emotions, with high variability both *within* and *across* emotion categories. Together, these findings suggest that emotions are not discrete, biologically hardwired entities with fixed neural or physiological signatures. This evidence calls into question the universality and biological modularity assumed by classic basic emotion and functionalist models.

3.3.1 Primary vs. Secondary Emotions (Taxonomy and Limits)

A common strategy within developmental psychology has been to define emotions as "subjective reactions to the environment that are usually experienced cognitively as either pleasant or unpleasant, generally accompanied by physiological arousal, and often expressed in some visible form or behavior" (Leman et al., 2019, p. 167) and to distinguish between so-called primary (or *basic*) emotions and secondary (or *self-conscious*) emotions. Primary emotions (e.g., joy, fear, anger, sadness, surprise, and disgust) are often described as evolutionarily ancient, universally expressed, and present from infancy onward (Ekman, 1992a; 1992b; Izard, 1993, 1994). They are thought to arise automatically in response to situations such as being startled, experiencing loss, or encountering a caregiver's face, and to require minimal cognitive processing. In contrast, secondary emotions (such as embarrassment, shame, guilt, pride, and envy) are described as typically developing later in childhood as self-awareness and social understanding mature. They depend on a child's growing ability to represent others' perspectives, internalize social norms, and appraise one's own behavior against external standards (Lazarus, 1991; Tangney & Fischer, 1995; Lewis, 2000; 2008; 2016).

There is no agreement in the literature regarding the specificity and length of the primary and secondary emotions' lists. Some sources add the category *interest* to the primary emotions list (e.g., Lewis 2000; 2016) and some of the sources for the secondary emotions listed above exclude envy. The words interest and envy are mentioned here as my deliberate attempt to exemplify how minor twitches to these lists can go unnoticed unless explicit comparisons are brought to the forefront of the discussions about these categories' boundaries. More relevant to the present thesis are questions that challenge the taxonomy: is for example frustration a secondary emotion? If so, is it secondary because it follows flawed attempts that cause anger and perhaps a pinch of fear? Or is it primary because there is no requirement for self-consciousness in its elaboration? And what about anxiety? Is anxiety a primary emotion in the sense of its universality or is it a secondary emotion that only some people experience? Is the experience of anxiety itself universal as distress, or should the clinical cut-off point for anxiety disorders be used to define the limits of this term's definition? These questions illustrate the taxonomy's arbitrariness.

While this primary/secondary taxonomy is useful in helping researchers chart typical developmental timelines and - in theory - design age-appropriate affective measures, it also glosses over the continuous, context-sensitive, and relational nature of emotional experiences (Barrett, 2017). In particular, it risks re-erecting the very intrapersonal/interpersonal dualisms that more contemporary, psychological *constructionist* models seek to dissolve.

Nevertheless, because many existing measures of early childhood affect (e.g., parental reports, observational coding schemes) are built around these categories, it became relevant to introduce them here as an organizational scaffold, while remaining mindful of their limits, before turning to more relational and situated approaches to emotion in Sections 3.7—10.

3.4 Contemporary Theoretical Debates About the Nature of Emotions and Emotional Development

Most contemporary theories recognize an interplay between individual characteristics and environmental influences in emotional development. While few scholars today endorse extreme positions in simplistic ways, debates persist about the relative weight and importance of these aspects. This section synthesizes three contemporary influential perspectives that illustrate different ways of conceptualizing this interplay.

Lench et al. (2011) distinguish between two major approaches to studying emotions. Discrete emotion theories (Ekman, 1992a; Izard et al., 1998; Lerner & Keltner, 2001; Rottenberg et al., 2007) view emotions like anger, fear, and joy as natural kinds. Emotions are distinct, evolved programs that organize physiological, behavioral, and cognitive responses for survival (for example, fear prompts escape, anger mobilizes resources). Dimensional models reduce emotions to core affective dimensions such as valence (pleasant–unpleasant) and arousal (high–low activation), arguing that differences among emotions can often be explained by combinations of these dimensions (Lench et al., 2011, p. 835). However, Lindquist et al. (2013) and Gendron and Barrett (2009) clarify that dimensional models do not claim that valence and arousal alone explain all differences. Instead, these are necessary but insufficient (Gendron and Barrett, 2009, p.318); additional meaning-making processes such as appraisals, attribution, or conceptualization are needed for discrete emotions to emerge (Lindquist et al., 2013, p. 258).

Appraisal theories (e.g., Clore & Ortony, 2008) propose that discrete emotions arise when individuals evaluate events in relation to goals and beliefs. Core affect provides a raw feeling state, but only after cognitive appraisal (for example, judging goal congruence) do specific emotions like anger or joy emerge. In contrast, Barrett's theory of constructed emotion (2006a, 2017) frames emotions as dynamic, context-sensitive constructions. Core affective sensations gain meaning through situated conceptualizations drawing on prior experience, language, and cultural knowledge (Barrett, 2006a, pp. 29–33). Unlike appraisal models, Barrett argues that conceptualization and affect are intertwined from the outset. That is, emotions are not triggered by labelling a pre-existing feeling but are products of meaning-making processes operating in context (Barrett, et al., 2025). Gendron and Barrett (2009) note that psychological constructionist models share with appraisal theories the idea that emotion involves making meaning, but they emphasize variability: two instances of fear can look and feel very different yet belong to the same category. Barrett (2009b) explicitly states that this variability is a central feature of emotional life (p. 1290).

Michael Lewis offers an alternative view. Lewis's functionalist perspective (2000; 2014; 2016) treats emotions as innate action patterns designed by evolution to coordinate adaptive responses. These patterns are universal but flexible—like language, they have an innate structure that adapts to culture and experience, allowing plasticity without abandoning the idea of evolved programs. Lewis acknowledges individual differences (temperament, environment, socialization) but emphasizes universality over variability. Psychological constructionist approaches (Barrett, 2006; 2009a; 2009b) assume emotions are psychological compounds built from basic ingredients (e.g., core affect + conceptual knowledge) that are not specific to emotion. They aim to explain the heterogeneity in emotional experience and address empirical findings that fail to support natural kind assumptions, such as the lack of consistent physiological signatures for specific emotions (Lindquist et al., 2013; Hoemann et al., 2019). For example, physiological responses do not consistently differentiate emotion categories, and instances of an emotion vary widely in psychological and physical features (Hoemann et al., 2019, p. 1833).

Why does this matter for math education research? If emotions were universal innate programs, we might expect similar *reactions* (such as anxiety) in all students facing math challenges, yet this is not the case. Nor is there a uniform decrease in the performance of all math-anxious groups (Ashcraft & Kirk, 2001; Chang & Beilock, 2016; Mammarella et al., 2015; Wang et al., 2015). When emotions are understood as constructed and variable, cultural background, language, and prior experiences are foregrounded in our understanding of how math-related emotions emerge. Barrett's emphasis on variability provides a useful lens for investigating why students' emotional relations to mathematics differ so widely, and why context matters. These considerations align with the epistemological and ontological assumptions underpinning this thesis, which in turn informed the methodological approach and shaped the design of each study. To further justify the choice of Barrett's theoretical perspective, the following section will provide a brief overview of how affect has been conceptualized within mathematics education research.

3.5 What Is Affect (Emotion) in Mathematics Education Research?

Numerous theoretical approaches have been used to explore affect in mathematics education, particularly as its significance in teaching and learning mathematics has become more widely recognized. A notable example is the 2004 mathematics education research forum, which brought together diverse theoretical traditions and later published a Special Issue featuring six analyses of a case study known as Frank (Zan et al., 2006). The editors of this issue emphasized the need to increase cohesion between diverse theoretical perspectives, and note that modern perspectives often distinguished reasoning from affect "Affect has long been treated as separate from mathematical thinking; reasoning was assumed to require suppression of emotion" (Walkerdine, 1988, as cited in Zan et al., 2006, p. 2).

This tendency to separate reasoning from affect reflects the long-standing dualistic view of mind and body, articulated by Descartes, where cognition was elevated as rational and emotion treated as secondary or disruptive (Descartes, 1641/1985; see also Chapter 2, pp. 22 and 45 above). The inseparability of affect and intellect was already a central concern in Vygotsky's work, long before contemporary neuroscientific accounts such as Damasio's *Descartes' Error* (1994). Vygotsky argued that treating thought and emotion as independent processes was a major weakness of traditional psychology, emphasizing instead that they form two sides of a unified consciousness (Vygotsky, 1986/1934; Vygotsky, 1998). As Roth and Walshaw (2015) explain, Vygotsky proposed a unit of analysis that captures the dynamic interplay between affective and intellectual processes, rejecting the Cartesian dichotomy and advocating for a dialectical approach that preserves the complexity of human activity.

In mathematics education, the term *affect* is framed as an umbrella concept, encompassing two major areas that emerged in the 1960s and 1970s: mathematics anxiety and attitudes toward mathematics (Zan et al., 2006). The same editors further pointed out the need to clarify the theoretical foundations underlying mathematical problem-solving research (Zan et al., 2006). Particularly those based on McLeod and Adams' (1989) work, which drew on George Mandler's theory of emotion and which Zan et al. (2006) describe as representing a pivotal moment in mathematics education, in which the role of affect gained increasing relevance and importance.

Mandler aimed to "develop a psychological theory that defined the processes and mechanisms responsible for emotional experiences and behavior" (Mandler, 1980, p. 219). By the late 1980s, he had advanced a cognitive-constructivist approach to emotions, which viewed emotional experience and behavior as the outcomes of cognitive analyses and physiological (autonomic nervous system) *responses* (Mandler, 1989, p. 4). This already contrasted with the more classic view, which considered emotions as discrete patterns of behavior, experience, and neural activity. Further, Mandler's framework supports the interconnectedness of emotions and cognition, offering a psychological foundation for understanding how emotional experiences can influence learning processes (Mandler, 1989). This brief overview of Mandler's developments is a response to Zan et al.'s (2006) call for a deeper understanding of the theoretical perspectives applied to affect in mathematical problem-solving, and it also reinforces the importance of studying affect in this context. Moreover, in this thesis, I understand the shift from a classic view of emotions to a more nuanced perspective as echoing the broader paradigm shifts in emotion research reviewed in section 3.4. Reflecting on that shift is crucial for distinguishing how theoretical frameworks can be employed differently to analyze affect in mathematics education.

The work of neuroscientist Antonio Damasio (1996) is also cited in Zan et al., (2006) to point out his contributions to mathematics education researchers' efforts to develop more robust theoretical frameworks and a wider range of methodological tools (p. 116). According to the editors, those advancements were essential for refining the understanding of affect in mathematical thinking (e.g., Schlöglmann, 2002). Zan et al. (2006) highlighted two key ideas from Damasio's (1996) work. First, that emotions involve physiological *reactions*. Second, that emotions can influence attention and memory bias, acting as *triggers* for action tendencies.

The special issue goes on to present the six theoretical approaches to affect in the shape of analyzes of the case of *Frank* (Zan et al., 2006). One of these approaches is Hannula's conceptualization of motivation, particularly its potential to direct behavior and other aspects concerning motivation regulation. Hannula (2006) defines motivation as "a potential to direct behavior through the mechanisms that control emotion. As a potential, motivation cannot be directly observed. It is observable only as it manifests itself in affect and cognition, for example as beliefs, values and emotional reactions. This potential is structured through needs and goals" (Hannula, 2006, p. 3), a framing that foregrounds affective mechanisms at the heart of goal-directed action. This definition emphasizes that motivation is inherently affective: it arises from the interplay of goals, needs, and emotional *responses*. Building on this, motivation regulation can be understood to involve at least three processes: (1) goals derived from psychological needs such as autonomy, competence, and belonging (see also: Ryan & Deci, 2000), (2) beliefs about goal accessibility, and (3) automatic emotional reactions that influence goal pursuit (see Hannula, 2006, for a discussion of these links in the context of mathematics education).

Zan et al.'s (2006) special issue illustrates the evolving landscape of affect research in mathematics education, highlighting how different theoretical frameworks can shape the types of research questions pursued by each research group. Here, I will not revisit them, as my primary focus is to examine their influence on the research questions pursued within the field. Instead, I will provide an overview of the growing trend of interdisciplinary exchanges among mathematics education and neuroscience. Then, I will present Schlöglmann's interpretation of Damasio's ideas, which offers valuable insights into the intersection of neuroscience and research on affect in mathematics education. Subsequently, I will highlight differences between Damasio's (1996) and Barrett's (2006a, 2017, 2025) models to explain the influence of theory for the type of research questions addressed in this thesis project.

3.6 Neuroscience Perspectives in Mathematics Education Research

A systematic review by Leikin et al. (2025) reveals the rapid expansion of research combining neuroscience and mathematics education in the last twenty years. This research field overwhelmingly targets arithmetics and problem-solving, while higher mathematics learning and equation solving remain under-researched. Moreover, few of these studies appear in mathematics education journals, indicating a gap between neuroscience and math-education communities. At the same time, the predominance of brain-imaging and eye-movement methodologies used in this field highlight the feasibility of using portable neurocognitive measures with young learners. For instance, Leikin et al. (2025) suggest that techniques such as pupillometry and lightweight EEG could be adapted to the preschool setting, enabling real-time measurement of children's physiological responses during early mathematics activities. However, these tools are still relatively underused with toddlers specifically, and preschoolers in general (Leikin et al., 2025).

In a comprehensive handbook overview, Pizzie (2022) frames math anxiety as a prime example of how emotional and cognitive processes intertwine in educational contexts. Synthesizing decades of research, the chapter explains that math anxiety is grounded in the relation between anxiety and working-memory processing. Anxiety may disrupt inhibitory control or over-load working memory, and thus reduces processing efficiency on numerical tasks. Yet, beyond the subjective distress, and physiological sensations, math anxiety is also associated with measurable deficits in fundamental numerical skills such as magnitude perception, counting, and simple arithmetic which show

how an affective state can cascade into cognitive and performance outcomes. These patterns have been linked to the recruitment of underlying neural networks (e.g., Pizzie & Kraemer, 2017), such as amygdala and prefrontal circuits, emphasizing the importance of early detection of math anxiety tendencies, even in preschool populations. Pizzie's synthesis supports the central proposition of this thesis: that early emotional experiences with mathematics constitute a powerful entry point for understanding the co-development of math-related cognition and affect in preschoolers.

Skepticism about the value of neuroscience for education has long accompanied its rise. Bruer (1997, 2008) famously warned that linking brain science directly to classroom practice was a 'bridge too far', a point reinforced by Bowers (2016), who questioned the efficacy of neuroimaging findings for informing teaching. Turner (2011, 2014) further critiqued the field's 'one-way street', showing how behavioral studies rather than brain scans have driven effective interventions. De Smedt et al. (2010) and Leikin et al. (2018) responded by arguing that cognitive neuroscience can act as a magnifying glass on processes already identified by mathematics education researchers, provided we acknowledge differences in goals, methods, and measures between the two fields. Ansari et al. (2011) noted that expecting cognitive neuroscience research to have a direct and immediate impact on classroom practice is unrealistic. Turner (2014) further emphasized that differences in timescales and focus between neuroscience and education limit the direct classroom relevance of brain research, reinforcing the need for a two-way dialogue in which teachers' insights guide research as much as neuroscientific findings inform educational theory. Together, these authors call for a genuinely reciprocal two-way dialogue, in which neuroscientists and educators mutually interrogate methods and findings and co-construct research agendas that are both scientifically rigorous and educationally meaningful.

Outside the scope of isolated studies that apply methodologies more conventional in neuroscience than education researchers' approaches, self-identified educational neuroscientists also develop contemporary models, such as Howard-Jones, et al. (2024) model for translating research into practice. For instance, their six-phase journey of research uptake (Howard-Jones et al., 2024) exemplifies how neuroscience insights can be communicated, adapted, and sustained in classrooms without undermining teacher (and education researchers') autonomy. This model demonstrates practical pathways for embedding neurocognitive findings in pedagogy. Moreover, Pizzie's (2022) perspective on math anxiety illustrates the parallel development of cognition and emotion research, areas whose overlap is the core concern of this thesis. Taken together, these debates suggest that only through open, critical, and collaborative integration grounded in rigorous behavioral *and* neuroscientific methods can both fields truly benefit one another.

After tracing the push-and-pull between skeptics and advocates, this thesis orients to a respectful, two-way integration. In agreement with Leiken (2018), who pointed out that identifying gaps between disciplines is itself a roadmap toward meaningful two-way integration (see also Leikin, 2025), I next turn to examples of prior dialogues between these disciplines. One influential case is Damasio's (1996) somatic-marker hypothesis, which has been adopted in math-education research because it explicitly links bodily states to decision-making. Examining this adoption, and contrasting it with Barrett's (2017) psychological constructionist alternative, illustrates how competing neuroscientific models can differentially inform educational research.

3.7 Damasio's Somatic Marker Hypothesis in Math Education

The preceding section (3.5) set the stage for a brief yet deeper exploration of Schlöglmann's interpretation of Damasio's ideas and neuroscientific findings related to affect and cognition. In his paper *Can Neuroscience Help Us Better Understand Affective Reactions in Mathematics Learning?* (Schlöglmann, 2003, p. 4), Schlöglmann equates the term "emotion" in neuroscience with "affect" in mathematics education research. This is a frequently encountered parsimonious solution in papers written with an interdisciplinary approach, as is the case in the present thesis project. In his summary of neuroscientific findings, Schlöglmann sequentially argues that neuroscience distinguishes brain systems that fulfill specific functions. While these systems are separate, they are interconnected, exchanging information and influencing each other in a bidirectional manner (Schlöglmann, 2003).

Antonio Damasio's ideas are grounded in his somatic marker hypothesis, which posits that *somatic markers* are bodily states that influence decision-making processes. These markers are termed *somatic* because they are linked to body-state regulation and structure (Damasio, 1996). According to the hypothesis, emotions produce distinct physiological signatures, such as changes in heart rate or facial expressions, that guide, bias, or direct behavior. For instance, anger triggers specific bodily reactions and facial expressions. Moreover, the body transmits sensory information to the brain, which, in turn, affects ongoing decision-making. This hypothesis suggests a distinction between emotion and emotional experiences, associating *emotion* with physiological processes that, while capable of influencing thought, remain separate from rational thought processes.

Within this framework, the hierarchical relationship between emotional and physiological states and cognitive thought allows for bidirectional influence between cognition and emotion systems; however, it also highlights a tension between the two. For instance, Tyng et al. (2017) discuss the influences of emotion on learning and memory, illustrating this dynamic through the concept of nested hierarchies of circular emotional control and cognitive regulation—through which specifically primary emotional processing, rooted in lower brain functions, facilitates secondary learning and memory processing. This bicircular causation demonstrates how primary emotional processing can bias thought, while secondary cognitive processes mature to exert top-down regulatory control over emotional responses (Tyng et al., 2017). Accordingly, emotions (physiological reactions in this framework) can bias thought, and cognitive processes can regulate innate emotional reactions.

Schlöglmann explicitly states that "different systems exist for cognitive processes and emotional processes" (Schlöglmann, 2003, p. 4). He then presents an evolutionary perspective on the origin, distinction, and potential interactions between these systems, drawing heavily on Damasio's work (Schlöglmann, 2003). When Schlöglmann applies this neuroscientific approach to reviewing research in mathematics education, he justifies using Damasio's theoretical framework to better understand models that describe affective reactions within mathematics learning processes. While Schlöglmann's work demonstrates that some researchers in mathematics education have paved the way for applying neuroscientific findings as relevant theoretical models in the field, it is crucial to distinguish between Damasio's theoretical proposals and other advancements in the broader field of neuroscience. One advancement is, for example, Barrett's theory of constructed emotions, which challenges some of Damasio's assumptions and presents an alternative model. Clarifying the distinctions between these frameworks is essential to understanding why this thesis adopts Barrett's model as a tool for exploring the research questions and for choosing the methodologies employed in this project.

The application of various theoretical perspectives to the study of affect in mathematics education has highlighted the interconnectedness of emotions, cognition, and learning. Damasio's contributions have provided valuable insights into these relations. His somatic marker models illuminate physiological–cognitive interactions, but they maintain a separation between innate emotional circuits and higher-order thought (Damasio, 1996). Barrett's theory of constructed emotions offers a novel approach to understanding these dynamics. Her theory of constructed emotion challenges this dualism and emphasizes context, culture, and meaning-making in the generation of emotions (Barrett, 2017). Barrett's framework then emphasizes the role of context and culture in shaping emotional experiences, challenging the view that emotions are innate physiological responses. This distinction is crucial for examining how factors such as math anxiety impact preschool children, their teachers, and the interactions between these two groups. In the following section, I will present Barrett's framework and explore its relevance to the investigation of affective relations in Swedish early childhood education.

3.8 Constructed Emotions in Mathematics Education

This thesis project builds on the understanding that the brain constructs instances of emotion in real time, using the same range of cognitive and contextual resources involved in processes such as thought, memory, and action planning (Barrett, 2007). From this cognitive affective neuroscience perspective, an instance of emotion occurs when the brain is making sense of information coming from the body and the environment. In the words of Lisa Feldman Barrett, "Interoception drives your actions, your culture wires your brain" (Barrett, 2017, p. 176). Prior knowledge impacts the process of constructing these instances, because the brain uses this information to categorize new emotional experiences by comparing them to prior ones. Thus, an emotional experience integrates physiological, cognitive, and social elements. Let me unpack these ideas, especially what Barrett means by social elements, since aspects of this tie in with the views on affect as display and stance in Ethnomethodological Conversation Analysis, which is presented below (3.9).

From the perspective of the theory of constructed emotion, the brain constructs its understanding (in the sense of actively generating predictions) of the world by integrating both external patterns and internal physiological signals, constantly monitoring the body's internal states. Interoception, the process of integrating internal sensations from the body, plays a key role in this process (Barrett, 2017). The theory does not assume that emotions are innate, nor that they *trigger* automatic actions. Instead, physiological states are integral to the overall emotional experience and are actively constructed by the brain. As a result, the brain's internal model incorporates both environmental cues and bodily states to construct behavior and decision-making. Following this view in the context of preschools, children's bodily states, such as tension during a math task, provide critical inputs to their construction of affective and emotional experiences. The internal sensations are not merely responses to environmental or mental *triggers*, but active contributors to how the brain predicts and constructs the child's affective (emotional) state on the spot.

Understanding the concept of interoception is important because in Barrett's model, interoception does not only inform emotional experiences, but the concept also serves to highlight how affective/emotional experiences are constructed *within* social contexts. For example, the physical sensation of a racing heart during a math lesson might be interpreted as anxiety in one social context, but as excitement in another. This difference arises from the culturally and socially learned emotion concepts that teachers and children use to make sense of their experiences as a whole.

Another concept that needs to be addressed in this theoretical review is the role that Barrett assigns to social reality in the construction of emotions. The theory of constructed emotion posits that emotions *are* social constructs (Barrett, 2012), created and shared through linguistic agreements and culturally established practices within and between social groups. As Hoemann, Xu, and Barrett (2019) note, "the brain also has access to the emotion words that were used in previous instances, and were used by parents and caregivers to label emotional events during development" (Hoemann, Xu, & Barrett, 2019, p. 24). These socially shared linguistic practices shape how emotion concepts are formed and used in social reality. Emotion concepts are malleable and shaped by the shared goals and contexts of social communities, rather than solely by individual objectives, because words, labels, and meanings are collectively learned (Hoemann, Xu, & Barrett, 2019). Within these culturally and socially established frameworks, emotion concepts provide structure for predicting and interpreting experiences, and these concepts drive action (Barrett, 2012). In this light, both culture and language significantly influence emotion concepts by shaping individual perceptions and experiences (Hoemann, Xu, & Barrett, 2019), while the brain's predictive and construction processes further shape emotional experience (Hoemann & Barrett, 2018).

Importantly, while Barrett rejects the idea that emotions are biologically hardwired categories, she does not deny that emotions emerge *also* from biologically grounded processes. Instead, she argues that general-purpose neural systems, involved in memory, perception, and interoception, dynamically construct emotions within social and cultural contexts (Gendron & Barrett, 2009). As a consequence, changes in one's past and current socio-emotional experiences can alter one's future affective/emotional framing.

Barrett's emphasis on emotions as social constructs further accentuates the dynamics between cultural influences and individual emotional experiences (Barrett, 2012, 2017). Social reality, shaped through language and cultural norms, plays an important role in educational settings. Examined through this lens, affect/emotions towards mathematics are not biologically determined reactions but socially constructed experiences, influenced by the ways in which teachers, children, and their peers discuss, ignore, or frame their actions during math learning situations. Additionally, children might adopt and pass on these socially constructed concepts from their socializers and role models (e.g., teachers and preschool peers) and incorporate them into their relation to mathematics as preschool activities unfold.

Within Barrett's (2012) theory of constructed emotion, psychological construction resembles a *strong* form of social constructionism, viewing emotions as cultural performances rather than biologically basic reactions (Gendron and Barret, 2009; p.318). However, while Barrett's model aligns with a strong version of social constructionism, it does not dismiss biological processes; rather, it integrates them into a broader predictive framework (for a distinction between affect and core affect as constituents of emotion, see Duncan & Barrett, 2007; for a historical perspective on psychological constructionism, see Gendron & Barrett, 2009). Emotion categories are culturally relative (e.g., shaped by social context at the group, institutional, and societal levels) and linked to individuals' biological systems, including the brain. In contrast to a *weak* form of social constructionism, where culture and norms influence basic emotions, psychological construction posits that emotion categories do not have a distinct biological basis. The cognitive and neural resources used to construct individual instances of emotion overlap with those that shape other mental states, such as thoughts, beliefs, and memories (Gendron & Barrett, 2009, p. 318; Barrett, 2009b, p. 1291; Hoemann & Barrett, 2018).

The theory of constructed emotions views the brain as a massive and complex interactive network rather than modules or networks that simply connect and communicate with each other. In doing so, it challenges the classic basic emotion notion originated in philosophy and subsequent psychological theories that assume a dichotomy between cognition and emotion. Instead, Barrett's framework argues that emotions, thoughts, and perceptions emerge from a continuous, integrated predictive process (Barrett, 2006, 2009b, 2017). The same applies to our actions. The tension between thought and emotion, as emphasized in Cartesian and traditional theories of emotion is reconceptualized in the theory of constructed emotions (Hoemann & Barrett, 2018). In this view, one's actions and verbal utterances are neither solely determined by emotional biases nor is emotion regulation dependent exclusively on control exerted by the rational mind. By reframing this tension, the theory allows this project to explore new assumptions about the nature of emotions and to investigate how they arise and function in interaction with one's physical and social environment.

Barrett's theory relies on a predictive rather than reactive brain account. Emotions are not automatic responses to events; they are the result of the brain's predictions, shaped by past experiences, cultural context (including the current discursive context), and current bodily sensations (Barrett, 2006, 2009b, 2017; 2022). For example, if someone's past experience with solving math tasks has been stressful, they might predict a similar experience in a new situation and prepare for anxiety (or an anxious state), even if the present context is not threatening. The idea of a predictive brain shifts the traditional view of how the brain processes information: predictions help the brain create mental representations of the world, which we then experience as our reality (Barrett, 2006, 2009b, 2017, 2022). If the brain actively predicts what is likely to happen and prepares the body accordingly, using prior knowledge to guess what will occur and fine-tune its predictions in advance, then emotions, thoughts, perceptions, and actions are all shaped by the brain's best guesses, which are refined through ongoing experience, including social interactions (Hoemann & Barrett, 2018; Hoemann, Xu, & Barrett, 2019; Barrett, 2022).

The possibility to refine or adjust ongoing predictions means, for instance, that if a child anticipates anxiety during a math task but encounters a supportive and positive social environment, they may adjust their predictions, reducing anxiety and influencing future emotional framing in similar situations. This theory thus places the construction of emotions within a cultural, social, and discursive context, ascribing an active role to this context in shaping the emotion concepts that individuals use to categorize their emotional experiences, and shaping how they actively participate in ongoing mathematical activities. This perspective is therefore particularly relevant for understanding how affective experiences impact preschool and preschool class-aged children, their teachers' own affective experiences with mathematics, and the interactions between these two groups.

3.9 Meaning Is Not Only Embodied; It Is Relational and Situated

Barrett's adoption of a predictive brain or a *predictive coding account of interoception* (Barrett, Quigley & Hamilton, 2016) as the basis for her theory of emotion construction essentially redefines emotions, perceptions, and thoughts as proactive, constructed experiences rather than reactive responses. This proposes that what we feel and perceive is shaped both by our brain's expectations and ongoing adjustments to reality. Thus, emotions do not arise in isolation but emerge through an active interplay between the brain's predictions built from bodily sensations, prior knowledge and social (and discursive) context. Barrett's concept of a predictive brain ties deeply into her model of relational realism (Barrett & Theriault, 2025, p. 54), the idea that everything real exists only in relation to something else—often, in relation to the self (Lloyd, 2024)[3].

In relational realism, reality isn't objective or static. Instead, what we experience as real is shaped by our relational interactions. For instance, between the brain's predictions and the external world, or between our internal states and the environment. Because the brain's predictions are influenced by past experiences, bodily sensations, and ongoing interactions with others within specific cultural contexts, every experience we have is unique to our own history, identity, and current state. This means our perception of reality is constructed through our continuous and dynamic relationship with our surroundings and with others. Emotions, therefore, are not pre-programmed biological responses but situated and flexible interpretations shaped by ongoing interactions (e.g.: humans create meaning and, in so doing, construct instances of emotion that *intrinsically depend on context:* Barrett and Theriault, 2025, p. 57, emphasis added).

A brief detour through similar & prior approaches: Embodied realism—the view that the locus of experience, meaning, and thought is the ongoing series of organism–environment interactions that constitute our understanding of the world (Lakoff & Johnson, 1999, p. 88)—is a central tenet of modern views of emotion embodiment. In this context, embodied cognition, described by Shapiro (2007, 2019) as a research programme emphasizing the role of the body in cognitive processes, provides important insights. While both embodied cognition and the theory of constructed emotion explore the relationship between body, mind, context, and emotions, they approach it from different angles, and there are several reasons why Barrett's theory of constructed emotions might be more suitable for investigating affective experiences in early childhood education.

Barrett's theory of constructed emotions emphasizes that emotions are socially constructed, shaped by cultural norms and shared language. It argues that emotional experiences are not just physiological reactions but are influenced by the meanings that individuals attach to their bodily states within specific social contexts. For instance, in the case of preschool-age children and math anxiety, Barrett's framework allows us to consider how teachers, peers, and cultural practices shape how children interpret their bodily sensations

[3]Barrett further elaborated on this idea during the third day of the Pufendorf Lectures at Lund University (Barrett, 2024), where she emphasized that relational realism provides a framework for understanding how meaning and experience emerge through ongoing interactions. In this model, reality is not something we simply perceive or respond to passively; instead, it is actively constructed by the brain *in relation to the environment and the people within it*, highlighting the role of context-specific, interactive processes.

(e.g., a racing heart) and categorize them as anxiety or excitement. This socio-cultural (and dialogistic) perspective on emotion is not traditionally a central focus in embodied cognition, which tends to concentrate more on the immediate interaction between body and cognition. However, it is important to acknowledge that many scholars, especially those applying the embodied cognition framework in developmental and cultural psychology, also explore how social and cultural environments shape bodily experiences and their interpretation (e.g., Barsalou, 2008; Gallagher, 2005; Rogoff, 2003; Tomasello, 1999; Varela et al., 1991).

Given this caveat, the novelty embedded in Barrett's theory is perhaps best characterized by its grounding in the predictive brain which is constantly making inferences about future events based on past experiences and sensory input (also referred to as active inference and Bayesian inference). This perspective is particularly valuable when considering how children might anticipate anxiety as a result of previous stressful encounters with math tasks. The theory suggests that emotional states like anxiety do not simply arise as automatic responses to environmental triggers, but as the result of the brain's predictions based on contexts, experience, and current bodily states. Embodied cognition, while it acknowledges the role of the body in cognition, does not focus on this predictive aspect in the process of emotion construction.

Furthermore, the theory of constructed emotion takes into account a dynamic integration of environmental cues, bodily states, and social influences. It sees emotions as constructed in real-time as the brain processes and integrates these various inputs. Embodied cognition, on the other hand, tends to focus more on how cognitive processes are influenced by bodily states and actions but doesn't emphasize the social and cultural construction of *emotions* as much as Barrett's theory does. Finally, Barrett's theory places significant emphasis on the role of language and emotion concepts in shaping emotional experiences. Emotions are not pre-programmed biological responses, but rather constructed through language, social interactions, and cultural learning. In educational settings like preschools, children may not simply *react* to their bodily sensations in an automatic way; instead, they may interpret these sensations based on the *emotional concepts they've learned* (from their teachers and peers, family, etc.). It is my understanding that embodied cognition does not focus as much on this social learning and the influence of linguistic constructs particularly in the study of emotion formation.

In summary, while embodied cognition (Lakoff & Johnson, 1999, pp. 74–91) provides valuable insights into how our bodily states influence our cognitive processes—often extending this frame to socio-cultural aspects—Barrett's theory of constructed emotions (Barrett, 2017) is more comprehensive for understanding the role of social and cultural influences, the predictive nature of emotion construction, and the dynamic interaction between context, body, and mind. This makes Barrett's approach particularly suitable for examining complex emotional experiences (e.g., math anxiety and the shaping of relations toward mathematical activities) in early childhood education, where social and cultural context, bodily states, and past experiences all play significant roles in shaping emotional experiences.

Why are both a mind–brain and an interactional account of emotion needed in this thesis? The embodied realism view (Lakoff & Johnson, 1999, pp. 74–91), in which the body helps to constitute the mind in a transactional and recursive relation, has been adopted by Barrett and Lindquist to explore how the body supports the creation of conceptual systems for emotion "that is, which emotion categories we have concepts for, and how conceptual knowledge is constituted" (Barrett & Lindquist, 2008, p. 246). In psychological constructionism, therefore, emotions are not reduced to the social situations in which they occur. Likewise, the importance of physical states in the body and brain is acknowledged, but emotions are not reduced to physical states. Emotions are real and distinct phenomena that need to be explained (Barrett, 2012; Gendron & Barrett, 2009).

One of the aims of this project is to increase the knowledge on the affective/emotional relations of preschool and preschool-age children, teachers, and their interactions during math-related pedagogical activities in the preschool. For the advocates of embodied realism, "Experience is always an interactive process, involving neural and physiological constraints from the organism as well as characteristic affordances from the environment and other people for creatures with our types of bodies and brains" (Lakoff & Johnson, 2002, p. 248). Additionally, "Meaning comes, not just from 'internal' structures of the organism (the 'subject'), nor solely from 'external' inputs (the 'objects'), but rather from recurring patterns of engagement between organism and environment, in other words, from 'interactional properties'" (Lakoff & Johnson, 1980, pp. 119–125, 177).

An embodiment view of the mind assumes that cognition is situated. According to Barrett and Lindquist, "Perceptions of occurrences both inside and outside the body are captured by simulators and are seamlessly bound, so that perceptual symbols are situation-specific inferences for behavior that are tailored to a given situation" (Barrett & Lindquist, 2008, p. 14, emphasis added). Barrett describes distinctive properties of the "distributed and flexible conceptual systems" of emotion (Barrett & Lindquist, 2008, p. 18), namely core affect, object representations, representations of context, inferences about behavior, emotion words, and heterogeneity in her research on emotion and her development of emotion theory. In this view, neither context, the psychological situation, nor the conceptual knowledge cause emotions. They rather help to constitute individuals' conceptualization of emotion that is "tailored to the immediate situation, represented in sensorimotor terms, acquired from prior experience and supported by language" (Barrett & Lindquist, 2008, pp. 24–25). Barrett's theory highlights the influence of culture on the formation of emotions and emphasizes the active role of cultural, social, and discursive context in shaping emotion concepts, opening up a venue for applying the theory of constructed emotions to social interaction. However, importantly, it does not seem to provide the tools to account for how emotions are constructed in social interaction, defined as activities where participants are in dialogue with each other, and where this dialogue is constitutive of the meaning that is co-constructed. In the next section, therefore, notions of emotion as social action and stance (Goodwin, Cekaite, & Goodwin, 2012) will be presented as ways to understand how emotion and affect are shaped by the discursive processes of social interaction.

3.10 An Interactional View of Emotion: Relational Meaning and Affective Stance

Whereas psychological constructionist approaches deal with internal cognitive, physiological mechanisms, and the in situ and continuous context at a macro-level, Linguistic Anthropology (LA) and ethnomethodological conversation analysis (EMCA) treats emotion as a co-constructed achievement in social interaction. In this view, emotions do not pre-exist inside an individual's mind; rather, they emerge moment-by-moment as participants engage in social action and display and negotiate affect through both verbal and nonverbal actions (i.e., multimodal action). In this field, Eleanor Ochs's seminal work reframed emotion research by viewing emotion as stance, and defining an affective stance as "the ways participants exhibit mood, attitude, feeling and disposition, as well as degrees of emotional intensity vis-à-vis some focus of concern" (Ochs, 1996, p. 410).

EMCA's core commitment is to uncover how social order and meaning are produced in everyday talk. Drawing on Garfinkel's notion of members' methods (Garfinkel, 1967; Heritage 1984) and Sacks et al. (1974) work on sequential organization, EMCA examines how participants use language, bodily movements, gestures, gaze, and other multimodal resources to co-construct meaning in real time (Schegloff, 2007; Goodwin, 1995; Deppermann & Schmidt, 2021). Crucially, as Couper-Kuhlen and Selting (2017, p. 44) note, "affect in interaction is seldom made explicit through words; rather it is indexed through verbal and non-verbal means, meaning that sequence-sensitive interpretation is required." From this perspective, affect-*laden* actions during math activities are not hidden states of mind to be inferred, but visible, multimodal accomplishments which are realized through prosody, gesture, gaze, posture, and the very *timing* of talk and actions in interaction.

Within Linguistic Anthropology, Charles and Marjorie Harness Goodwin describe in their earlier work (Goodwin, 1995, 2000; Goodwin & Goodwin, 2000) how participants draw on *configurations* of semiotic resources such as talk, prosody, gesture, gaze, material artefacts, and spatial arrangements to coordinate action and meaning-making in situated activities. This analytic focus on multiple modalities laid the conceptual groundwork for the later formulation of a local *ecology of semiotic resources* (Goodwin, 2017): an activity-specific configuration of perceptual and communicative affordances through which participants coordinate attention, assessment, and action. In between, Goodwin (2012) develops the related notion of *epistemic ecologies* to capture how semiotically charged objects, material environments, and embodied practices operate together as public substrates for action and knowing. Across these works, the physical layout, the visible bodies of participants, tools and artefacts, and embodied displays operate as an organized environment that both enables and constrains particular displays of stance. Framing the multimodal repertoire in ecological terms makes visible how affective stances are not dispersed, private events, but emergent properties of situated participation that appear at particular sequential slots and in relation to specific material and social arrangements (Goodwin, 1995, 2013, 2017; Goodwin & Goodwin, 2000).

The concepts and tools found in LA overlap with those found in EMCA research, which focuses on how people construct meaning and social action through multimodal dialogue. The core idea in EMCA is that individuals create new contributions by modifying, reusing, or adding new elements to what has already been said or done. And that these contributions also shape the context for what follows. This sequential nature of social actions plays a key role for participants' establishing of a temporal shared understanding, or an intersubjectivity. Intersubjective understanding is thus built *turn-by-turn*, where each person's contribution demonstrates how they interpret the previous statement and hence the social action under way (Heritage, 1984, p. 254 –260; Mondada, 2007, 2013, 2018). Participants exhibit their understanding by either confirming the interpretation or correcting misunderstandings, ensuring that meaning is negotiated and shared through this interactive process.

The body of literature that has introduced the term *affective stance* emphasizes the organization of emotion as an interactive practice and clearly distinguishes this analytical perspective from the view of emotion as evolutionarily anchored and situated only within the individual (e.g., Goodwin et al., 2012). This view of emotion as interactively organized stance critiques the longstanding Darwinian tradition in emotion research, in which emotions are conceptualized as universal and unintentional psychological states, a perspective that has been most prominently articulated in the modern literature through Paul Ekman's work, particularly in his emphasis on facial expressions (Goodwin et al., 2012, p. 16–17). This critique is similar to Barrett et al.'s (2025, pp. 397–399) holistic rather than reductionist view of emotion, which shifts the focus of emotion research from its physical properties (such as facial expressions) to its situatedness in a specific socio-cultural and historical context that produces unique *instances* of emotion. By conceptualizing emotions as stance, LA/EMCA highlights the role of emotion as shaping and negotiating social relations, social order, and meaning-making processes, rather than viewing emotions as pre-determined biological reactions or a process or inner state expressed by individuals.

Everyday preschool activities are inherently interactive, relying on dynamic exchanges between teachers and children to co-construct contexts for care, learning, and development (e.g., Cekaite & Ekström, 2019; Goodwin, 2017). Teachers' affective stances (manifested through prosody, gaze, gesture, and bodily orientations) are co-constructed with children using a repertoire of multimodal resources (Goodwin, 2017). These embodied and material resources are often choreographed to generate anticipation and affective involvement, for instance through the creation of suspenseful situations in activities such as storytelling, counting, or games (Strid, 2024). In storytelling interactions, teachers' embodied displays (such as smiles, laughter, prosody, and supportive touch) foster children's engagement and affective alignment (Cekaite & Björk-Willén, 2018). Children's responses show alignment (or disalignment) with teachers' cues and display their emotional investment in the activity. In other words, teachers scaffold children's affective orientation toward the task, and children's embodied responses (including for example hesitant glances, postural shifts, spontaneous vocalizations) index their emerging emotional orientations towards these activities.

These micro-interactions create a situated pedagogical environment in which caring and teaching/learning become interactionally inseparable: teachers orient to children's needs for emotional security while simultaneously sustaining their communicative involvement in the activity, and children display orientations through which care-related concerns are handled alongside participation in ongoing activities (e.g., Cekaite & Ekström, 2019; Strid & Cekaite, 2022). These local sequentially ordered practices establish the affective climate of the preschool. When math-related activities are embedded in these settings, the co-constructed climate has the potential to shape how young learners come to experience mathematical concepts, forming the basis for later positive or negative math-related affect. Building on these observations, it becomes relevant to ask what is the role of affect as stance in math-related activities such as spontaneous counting, block constructions, or snack-time measurements in the preschools, which is the focus of this thesis' Study III.

In the context of preschool mathematics, this interactional lens can help reveal how children's and teachers' affective stances are not just internal reactions to tasks, but are also publicly produced actions that are responded to within the flow of activity. Studying these co-constructed affective moments can hence provide insight into the socio-cultural processes that shape young children's emotional relations to mathematics and may help explain how certain interactional practices in the preschools contribute to more positive engagement or, conversely, to developing more negative relations to math (e.g., anxiety).

3.11 Bridging Psychological and Interactional Perspectives on Emotion

As this thesis encompasses both psychologically oriented approaches and a fine-grained interactional perspective, it becomes useful to locate the different theoretical traditions underpinning emotion research along key dimensions. The first two studies draw primarily on psychological theories of math anxiety (e.g., Carey et al., 2016). At the level of the thesis as a whole, these studies are situated within a broader psychological constructionist view of emotion, for which Barrett's theory of constructed emotion (Barrett, 2017, 2022) provides an overarching interpretive frame. Within Barrett's framework, emotional episodes are not biologically pre-packaged but are instead constructed through the integration of core affect (valence–arousal states) with culturally shaped conceptual systems. From that perspective, emotion emerges as a function of individual-level sense-making that is, nevertheless, shaped in situ by sociocultural contexts.

The third study adopts a fundamentally different perspective, informed by the theoretical and methodological traditions of Linguistic Anthropology (LA) and Ethnomethodological Conversation Analysis (EMCA), where emotion is not approached as a psychological state but as a socially situated, interactionally accomplished stance (Goodwin, 2007; Goodwin, Cekaite & Goodwin, 2012; Cekaite & Ekström, 2019). From the perspective of these traditions, affect is treated not as a signal of something internal, but as a publicly accountable, embodied, and sequentially organized phenomenon: one that emerges through the use of language, prosody, gesture, gaze, posture, and material artefacts. Emotion is thus treated as an *actional and relational accomplishment*, co-constructed in real-time by participants in social interaction. To orient the reader to the theoretical similarities and differences between the traditions, Figure 3 maps major models of emotion across two intersecting continua: (1) from biologically grounded to socially constructed views, and (2) from theories that treat emotions as discrete categories to those that view affect as continuous, fluid, and variable (see also Gendron & Barrett, 2009; Russell, 2003; Ratner, 2000).

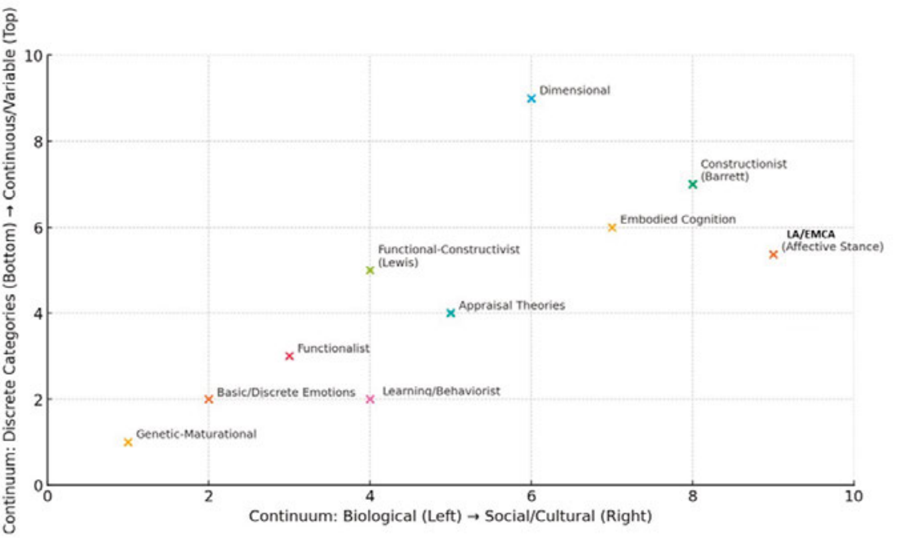

Figure 3. *Positioning major emotion models by two theoretical continua*[1]

Note.[1]Horizontal axis = biological (left) → social/cultural (right); vertical axis = discrete/categories (bottom) → continuous/variable (top). Positions are schematic and approximate; they are intended to orient the reader to theoretical differences, not to imply precise metric distances.

As seen in Figure 3, LA/EMCA occupies the far end of the sociocultural and a relatively high position in the continuous-variable axes. This positioning makes evident two key commitments. First, LA/EMCA views emotion as deeply embedded in local, situated practices, which is an emergent property of social interaction, rather than an individual's internal *response* system. Second, rather than segmenting emotions into fixed, universal categories (e.g., fear, joy, frustration), LA/EMCA is sensitive to the fine-grained, context-dependent ways in which affect is indexed and made consequential in ongoing activity. The third study of this thesis takes up these commitments by examining how affective stances are co-constructed in preschool settings during mathematics-related activities. By using the notions of *affective stance* (Ochs, 1996, p. 410) and *affective practice* (Wetherell, 2012; 2013, p. 360), the analysis focuses on how teachers and children display, respond to, and negotiate emotional orientations through multimodal conduct. This approach aligns closely with Barrett's (2022) insistence on *situated conceptualization* when shifting analytic focus from the individual in context to their interactions in context.

Through treating preschool mathematics as a multimodal, affectively laden/charged activity, this section offers a sociologically informed and empirically grounded way to study the emergence of mathematical affect, not as an individual trait, but as a socially distributed and interactionally produced phenomenon. As such, it aims to reframe the study of *math anxiety/engagement*, —more broadly defined as affective *practice* by Wetherell (2012; 2013)—as relational outcomes of specific classroom practices, teachers' and students' stances, and institutional ecologies. At a theoretical level, this interactional view resonates with the epistemological stance of constructed emotion theory, which rejects emotional meaning as directly readable from bodily signals, and with the ontological commitments of *relational realism*, in which, meaning is understood as emerging from the relational organization of experience (Barrett and Theriault, 2025).

Similar to my thesis proposition, Wetherell (2013) resists the split between affect scholarship and discourse and, drawing on Marjorie Goodwin's work, highlights how fine-grained analyses of interaction *"*investigate, *precisely*, how talk, body actions, affect, material contexts and social relations assemble *in situ."* (Wetherell, 2013, p. 351, emphasis in original). Therefore, when used complementarily, these approaches offer a layered analytic lens: Barrett accounts for the embodied and predictive processes that make affect possible, while LA/EMCA demonstrates how these processes are publicly displayed, recognized, and sustained through communicative action. Emotion can thus be understood as a construction of the embodied mind *in interaction*. To exemplify how, I turn to Charles and Marjorie Goodwin's (2000) joint work, which likewise treats emotion as situated within children's embodied language practices. Yet, there are limits to each perspective.

A common view is that cognitive and micro-sociological perspectives on emotion and affect are considered theoretically incompatible, or at least represent radically different understandings of emotion as a research object (see, for example, Drew, 2005; Potter, 2006). For this thesis' framing, it is important to note that the Theory of Constructed Emotion does not conceptualize emotions as co-constructions in interaction, and conversely, EMCA does not treat the mind as an explanatory construct. Therefore, to a large extent, this claim of incompatibility holds validity. However, for the purposes of this thesis, I argue that there are meaningful points of intersection where the two approaches can be treated as complementary rather than contradictory.

Barrett's theory of constructed emotion treats emotions as relational in a psychological constructionist sense: emotions emerge from the integration of signals coming from the body, mind and context. LA/EMCA treats emotions as relational in an interactional sense: they are accomplished publicly and sequentially in talk, gesture, and embodied practice. Their different emphases open a productive space in this thesis for examining both the individual–conceptual and the interactional–situated dimensions of affect in early mathematics education. In this sense, the two approaches can be combined to connect the physiological and psychological construction of emotion with its observable accomplishment in social practice.

The two approaches are compatible on some key points, which motivate the combination of them within this thesis. In both Barrett's theory of constructed emotion and Goodwin and Goodwin's (2000) work on emotion within the LA/EMCA tradition, emotion is viewed as *situated*, particularly in relation to children's *embodied language* practices. Barrett argues that emotions arise from core affect (i.e., valence/arousal) shaped by prior experience, language, and culture. In a classroom, this means every look, gesture, or tone carries learned meaning, while ongoing sensory input actualizes and updates those predictions *in the moment*. In LA/EMCA, by contrast, it is not assumed that all actions are inherently affect-laden. Instead, affect is treated as consequential only when participants themselves orient to it in the sequential unfolding of interaction (e.g., through displays of (dis)engagement). Talk, gaze, gesture, and stance are thus understood as multimodal resources that can become the vehicle for affective stance, depending on how participants use them in unfolding interaction. Both perspectives thus share a commitment to *situatedness*, but they locate it differently: Barrett in the continuous interplay of prediction and sensory input, LA/EMCA in the demonstrable orientations of participants to each other's embodied actions. Keeping remaining differences in mind, Barrett's notion of 'situated conceptualizations' slots in with LA/EMCA's attention to how local, multimodal resources (e.g., body posture, prosody, gaze) are used to build shared sense.

Within LA, Goodwin and Goodwin (2000) demonstrate how one can gain insights into the way individuals construct their social worlds in interactive situations. These authors ground their argument in concrete, embodied activities rather than abstract examples. Goodwin and Goodwin (2000) analyse pre-adolescent girls' hop-scotch play (showing how out calls are produced as multimodal, sequentially-located assessments) as well as family interaction with a man with severe aphasia (showing how emotional alignment can be displayed without lexical emotion terms). Their analysis of the embodied performance of affect/emotion identifies and applies concepts and tools that are essential for examining affective/emotional displays in a comprehensive way, where elements like intonation, prosody, gesture, and body posture are found to be participants' resources to engage or disengage in their co-constructed activities.

Increasing knowledge on the social practices performed in preschools, where emotions as stance emerge, requires analytical tools that focus on the co-construction of affective stances in interaction, rather than only on the individual's expression or even their construction of emotions. Goodwin et al. (2012) write that "the scope of an emotion is not restricted to the individual who displays it" (p. 17). This social constructionist perspective on emotion as affective stance highlights the role of interaction, process, and context in understanding emotions. In other words, LA/EMCA's fine-grained multimodal toolkit captures the micro-temporal ways in which affect is co-constructed. This has similarities with Barrett's model, where local meaning-making serves as a constitutive element in the construction of emotional instances (Barrett et al., 2025, pp. 402–403). From this thesis' perspective, Barrett's theory of constructed emotions and LA/EMCA are not necessarily opposed. The theory of constructed emotion emphasizes the predictive, situated conceptual basis of affect, while LA/EMCA highlights the situated, co-constructed orientations through which affect becomes consequential. The point here is not to merge these frameworks at a theoretical level, but to show how they productively intersect in the specific context of this interdisciplinary thesis project.

Having positioned Barrett's model in relation to LA/EMCA, we now turn to a key LA/EMCA concept: situated practice, where the analysis begins from specific sequential positions in interaction, rather than focusing on individual actions (Goodwin & Goodwin, 2000, p. 239). In LA/EMCA, emotion is viewed as an interactive performance that emerges in time, and participants' use of language, the body, and artefacts in interactive settings are analysed on the basis of video recordings of naturally occurring, real-life settings. These recordings allow for a comprehensive examination of the linguistic and multimodal repertoires of speech communities (Goodwin & Goodwin, 2000). Consequently, a teacher can respond to children's affective displays in different ways, and thereby contribute to how these displays become consequential for the activity, demonstrating that affective work has the potential to achieve children's engagement or withdrawal from the activity. Defining, identifying, and showing how prosody, facial expressions, and posture work in interaction can hence help illustrate how multimodality assembles affective stances in math-related activities.

The study of emotions within LA/EMCA focuses on how emotions are not merely personal or internal experiences, but rather how they are co-constructed between individuals in social contexts. For example, Goodwin et al. (2012) argue that "both stance and emotion are not add-ons to action basically displayed through language structure. Instead, they constitute central components of the situated actions participants build to carry out the mundane activities that make up the lived social worlds they inhabit together." (ibid., p. 40). Similarly, Andries et al. (2023), in their systematic review of multimodal stance-taking, note that "there is never a time out from the social action of taking stances and adopting positions" (Du Bois & Kärkkäinen, 2012, p. 438 as cited in Andries et al., 2023), implying the continuous presence of stance-taking and alignment processes through which affect *may* become relevant in interaction. Moreover, Peräkylä (2012) further proposes that emotional displays are integral to organizing specific social actions, showing that affect is not an occasional add-on but a pervasive component of interactional sequences. Hence, merely acknowledging stance-taking in interaction is not enough. In this thesis, the informative potential is in identifying how affective stances become consequential for engagement in math-related activities and the development of mathematical skills and content knowledge.

In the following illustrative sequence (Figure 4) the emergent, social nature of affect in social interaction and the mathematical activity of *counting*—a core early numeracy skill as described by Gelman and Gallistel (1978, p. 47) and Bishop (1988)—are inseparable from affective and interactional engagement, exemplifying how EMCA treats emotion as action and stance that is co-constructed in social interaction. This example sequence takes place at lunchtime. The teacher counts the number of children at one of the tables and then distributes glasses to them.

```
1     TEACH     hur många (glas behöver) >vi de här bordet<?
                       how many glasses do we need this table
2     TEACH     *en     *två    *t[re   [*fyra [*fem   [*sex   [*sj↑u:
                one     two     three   four   five    six     seven
3     teach-pt  *point  *point  *point  *point *point  *point  *point
4     BOY                       [re.   [fyra. [€fem.  [€sex.  [€sju
                                 re     four   five    six     seven
5     boy-pt                                   €point  €point  €point
6     boy-bd                                   €wiggling rhythmically-->
7     BOY       €åt*€ta €nie tie elva (°tolv tretton° °°fjorton femton°°)
8     boy-pt    €point
9     boy-prs   €performs counting rhythmically as a rap song
10    boy-gz        €at T1 --------------------------------------->
11    boy-bd            €wiggling body rhythmically
12    teach        *begins placing glasses on table while talking
                    to other children
```

Figure 4. Extract from interaction at lunchtime between a teacher and a boy (5 yrs.)[1]

[1]pt=point gestures, bd=body movements, gz=gaze shifts. Also see transcription conventions in Appendix 4.

The teacher initiates the counting activity and sets the participation framework (Goodwin, 2000; 2007; 2018) by asking *"how many glasses do we need this table?"* (line 1). She asks using high rising final intonation, and then simultaneous pointing gestures while counting. Her multimodal action enables participation and engagement of the boy by displaying an affective stance towards the act of counting. When the boy joins the counting (line 4), he uses an enthusiastic tone of voice that aligns with the teacher's engagement cues. The boy's rhythmic body movements (line 6) enact a rap song with the numbers (line 9). His way of moving his body to the beat (line 11) upgrades his engagement and demonstrates an aligning affective stance in relation to the teacher (Goodwin, 2007; Ochs, 1996). When the teacher stops counting, the boy continues counting all by himself (line 7), which demonstrates upgraded and dynamic agency and engagement. The affect in this counting sequence thereby emerges in the interaction between the teacher and the boy and is consequential for the way the boy participates and engages in the counting activity.

In this sequence, mathematical principles are directly enacted. The teacher models one-to-one correspondence, stable order, and cardinality (Gelman and Gallistel, 1978, p. 47) together with a pitch-peak on the word seven (`[*sj↑u::`, in line 2). The boy's counting overlaps with the teacher's modelled numbers (line 4), showing temporal alignment and orientation to the same sequential activity. The teacher and the boy are co-constructing the counting sequence up to this point. They share attention and multimodal resources in counting.

Figure 5. The boy shifts his gaze to the teacher

When the teacher begins placing glasses on the table (line 12), however, she disengages from the counting sequence (Figure 5). This shift marks a reconfiguration of the participation framework: The boy is now the primary actor in the counting, yet his actions remain oriented to the material (spots at the table) and social (he is *performing* the count as a rap) context scaffolded by the teacher (Goodwin, 2018, p. 224). The boy continues counting up to 15 after the teacher is finished, pointing at the plate number eight as he counts it and shifts his gaze toward the teacher (line 10). The boy's overlapping counting and gesturing allows him to notice that there is one more plate (or allocated spot) on this table (which was not counted by T1 who was *instead* counting the number of children sitting at the table). As the boy shifts his gaze to the teacher (line 10), he realizes that she has stopped counting and started putting down the glasses she is holding in her hands on the table. While pointing at plate number eight, he continues wiggling his body rhythmically, sustaining the affective alignment established earlier, during counting. In this way, the boy transforms the mathematical activity into a playful rap, demonstrating how counting can be both a mathematical and a playful activity (Bishop, 1988, p.102), while maintaining the affective stance initially demonstrated by the teacher.

The boy's transformation of the counting into a playful, rhythmic performance aligns with Bishop's (1988) argument that "fun is an important organizing construct for a mathematics curriculum" (p. 102). In Bishop's terms, play provides an aesthetic, rule-bound framing through which mathematical ideas may be explored. More concretely, Bishop describes how mathematically significant *playing activities* can take many forms, such us "movement games like hop-scotch," "folk dancing," or "number games and puzzles, such as magic squares" (p. 106). Seen in this light, B1's rap-like counting, with its rhythmic body movements and sequential structure, resonates with Bishop's examples by showing how mathematical activity (in this case, counting) can simultaneously be playful, embodied, and socially engaging, while preserving the affective stance modelled by the T1.

From an EMCA perspective, affective stances are actions co-constructed in interaction, emergent and consequential for both engagement and *doing* learning. In Barrett's terms, these interactions instantiate situated conceptualizations, showing that affect is layered, relational, and context-dependent. The positive, playful climate established in this brief counting sequence exemplifies how early math engagement is jointly produced, highlighting the inseparability of emergent emotion, embodied action, and mathematical practice. The playful enactment demonstrates how affective engagement contributes to sustained attention, mathematical exploration, and embodied practice.

Following the vignette above, we can see how affective stances are not private states but emerge in and through embodied, situated interaction. In line with the EMCA tradition, affect/emotions shape and are shaped by social relations, emphasizing the interactional dimension rather than focusing solely on the individual's emotional state. For the study of preschool mathematics, this perspective foregrounds how teachers and children co-create math-related activities where emotion is not an add-on but a constitutive feature of the action itself. To deepen our knowledge about preschool age children's affective relations to mathematics, we therefore need research instruments that capture how emotion becomes part of — and contributes to — the actions achieved during mathematical interaction. In study III, we have followed EMCA's tradition of investigating emotion as action and stance "within an environment of unfolding action being constituted in part through orientation to the bodies and actions of others" (Goodwin & Goodwin, 2000, p. 22).

The partially shared perspective on language and emotion as *embodiment* allows this thesis to combine two theoretical frameworks that are usually treated separately: Barrett's theory of constructed emotion, which focuses on the intrapersonal construction of emotional instances within the *situated* predictive, culturally shaped brain, and LA/EMCA approaches, which focus on the interpersonal, interactionally co-constructed nature of affective stances. When used complementarily, they highlight points of convergence: both approaches acknowledge that emotions are situated, contextually grounded, and relational, whether in the brain's predictive modelling or in co-constructed social interactions. Both views on emotions can then be used to understand how emotions emerge in interactional preschool settings, within their separate and respective frameworks. Rather than seeking to merge the two frameworks, this approach positions them as addressing distinct, yet mutually informative, levels of analysis. In this thesis, this creates a bridge to study the structure, content, and function of the conceptual system for affect/emotions as central to understanding what affect/emotions are and how they work in interaction. The theory of constructed emotion, together with the theoretical and methodological framework of LA/EMCA, can therefore address questions concerning the (co-)construction of affective relations in different yet complementary ways, while also allowing for the combination of methodological approaches linked to different theoretical perspectives and empirical data.

Building on this, conceptualizing emotions as both constructed by the human mind and shaped by culture and social interaction offers a comprehensive framework for understanding how emotional experiences, positive or negative, toward math activities, emerge and are navigated in the context of early childhood education. Within this framework, Barrett's theory of constructed emotion contributes an understanding of how affective experiences arise through the brain's predictive processes, integrating bodily sensations, prior experiences, and cultural knowledge into situated emotional *instances*. The framework also incorporates the role of social interaction in co-constructing emotional experiences related to mathematics, particularly in preschool settings. By viewing emotional experiences as situated within specific socio-cultural contexts, this approach supports the investigation of how children and educators jointly develop affective relations to mathematics. The present project, therefore, focuses on affective relations in young children and implications for educational paths, while also examining how preschool educators' pedagogical practices shape these affective/emotional experiences. Through this comprehensive framework, we aim to explore the interplay between intrapersonal and interpersonal dynamics in the development of affective relations to mathematics in Swedish early childhood education (i.e., preschools + preschool class). Furthermore, this theoretical framework, and advances in emotion research more broadly, have direct implications for educational practices and math education in particular.

Chapter 4. Previous Research

This chapter reviews previous research most directly relevant to the empirical studies presented in this thesis. Rather than providing a comprehensive overview of the literature, which is addressed partly in Chapter 2, 3 and in each of the individual papers, the focus here is on three lines of research that frame the present project's empirical contributions: teachers' affective relations to mathematics and their pedagogic practices (4.1), the conceptualization and measurement of affect (math anxiety) and cognitive effort in preschool class-age children (4.2), and affective practices in play-based mathematics interactions (4.3).

Because these three lines of work use different evidence and analytic conventions, I will summarize the literatures within them at a level appropriate to their traditions and the aims of this chapter. The length of the following subsections reflects the differing evidential and rhetorical demands of the literatures referenced. Reviews of large-scale quantitative and experimental research emphasize synthesis and therefore can be summarized more compactly. By contrast, LA/EMCA studies ground claims in fine-grained, multimodal excerpts, so explaining these studies requires greater sequential and embodied detail to preserve the evidential force of the analyses. Accordingly, readers should interpret differences in subsection length as methodological signposting rather than as judgments of importance. This review establishes the empirical and conceptual foundations for Studies I–III and situate their contributions within the broader fields involved. Readers interested in more detailed analytic procedures and primary data excerpts should consult the individual papers.

4.1. Math Anxiety Among Teachers and Its Potential Impact on Young Learners

Math anxiety is a phenomenon reported to affect both children and adults, and it has been observed in children from an early age (Namkung et al, 2019; Lu et al., 2021). This phenomenon has far-reaching implications, extending beyond the home environment into educational settings. For instance, a field study involving first and second-graders and their parents was able to predict children's math achievement from parent's math anxiety levels (Maloney et al, 2015). This relationship was contingent on the frequency of parental support provided in math homework and the effect did not manifest in reading performance. These findings also stress the specificity and significance of math anxiety's impact on academic outcomes. Meta-analytic evidence consolidates the negative link between math anxiety and math achievement across school-aged populations (Namkung, et al, 2019), with particularly strong effects for multistep tasks and in high-stakes evaluative settings.

Importantly, there is evidence for such associations' emergence even before formal schooling begins. Lu et al. (2021) validated the Young Children's Math Anxiety Scale (YCMAX) using a U.S. kindergarten sub-sample of 24 teachers and 355 children (kindergarteners, i.e., approximately 5–6 years old) across seven public school districts. Factor analyses supported two dimensions (worry and somatization) in their scale. Children higher on these factors showed lower math achievement, weaker math competence beliefs, and lower teacher-rated engagement. More recently, a longitudinal study in Poland tracked 369 first-graders (mean age ~7 years) across their first year of school and found math anxiety already at the beginning of the school year, with most children reporting mild anxiety but some experiencing moderate to high levels (Szczygieł & Pieronkiewicz, 2022).

The notion of *intergenerational transmission* of low math achievement and heightened math anxiety has also been proposed as passing on from teachers to students. Beilock et al. (2010) first showed this among U.S. female teachers' and their Grade 1 female students' math achievement, suggesting a gendered pathway mediated by girls' adoption of math-gender stereotypes, while no such relationship was found for boys. A more recent large-scale replication with first graders in the United States looked at children's end of the year math achievement in relation to their elementary teachers' levels of math anxiety (Schaeffer et al., 2020). In this latter study, after controlling for students' math skills at the start of the year as well as teachers' math ability, a negative association was found between teachers' math anxiety and children's math achievement by the end of the year for both girls and boys. These findings suggest that teachers' math anxiety can adversely affect children's math learning during their initial year of schooling, which highlights the importance of exploring how teachers' own math anxiety might influence their instructional practices and interactions with young learners.

The widely recognized meta-analysis conducted by Hembree (1990) revealed that college students pursuing elementary education majors tend to exhibit elevated levels of math anxiety when compared to other college majors (i.e., business majors). This discovery ignited interest in investigating the influence of teachers' attitudes and beliefs regarding mathematics on their students. Some research suggests that teachers' math anxiety impacts student performance through the mediating role of perceived immediacy (i.e., psychological closeness; Kelly et al., 2020) between teachers and students. Specific associations between teachers' teaching behaviors (such as more frequent use of ability-oriented rather than process-oriented strategies) have been found to influence students' perception of teacher mindset (i.e., teachers' views of which students are capable of becoming good at math; Ramirez et al., 2018b). Yet, these studies have been conducted with adolescent and undergraduate student samples (Kelly et al., 2020; Ramirez et al., 2018b), and while such groups' social inferences from their interactions with teachers might partially account for the relationship between teacher math anxiety and lower student performance in those age groups, what is most notable from this body of work is that the use of particular teaching strategies mediates the perception of teachers' relations to mathematics and with the students in the classrooms more broadly.

However, before further extrapolation of this type of research's validity for the preschool level can be discussed, the characteristics of both preschool teachers and the usual pedagogical practices in their environments require further attention. For example, a study by Jenßen (2021) reviewed the differences in studies with pre-service and in-service early childhood educators in Germany and provided an empirical report on whether the profession could be regarded as a *math-avoidant* choice in a context where being an early childhood educator is not regarded as a math-specific profession. Their results showed a relatively weak effect, indicating that individuals with mathematics anxiety were somewhat more inclined to choose a career as an early childhood educator. In Sweden, pre-service early childhood educators have also expressed anxiety about math, often connecting it to their career choices (Shamoon, 2014; Palmer, 2009). Although the targeted education they are receiving and their accumulated years of experience in the profession seem to contribute to an overall shift toward more positive emotional attitudes toward mathematics (Sumpter, 2020).

Several speculative conclusions have arisen from studies highlighting a prevalent yet low level of math anxiety among preschool teachers. The initial set of implications suggests that math-anxious teachers may inadvertently project a fear of mathematics to the children they teach. The second set of implications proposes that preschool teachers might choose their career path due to their enduring math anxiety, potentially as a means to avoid engaging with mathematics in depth. However, in general, knowledge on how teachers' math anxiety is manifested in their classroom practices is limited. This is also the case in Sweden, where there remains a significant gap in our understanding of how an individual teacher's perception of their own relation with mathematics influences their choices and actions related to mathematics in the preschools. We addressed this gap in the literature in Study I by analyzing self-reported questionnaires completed by early childhood educators in Uppsala, Sweden. Both in-service preschool teachers' general math anxiety and math teaching anxiety were statistically related to how frequently they reported teaching and talking about mathematics with the children in their groups. Frequency of math talk was further elicited in relation to specific usual scenarios in the preschools, including during gatherings; while setting and clearing the table; in the halls when entering or leaving the main room; during teaching situations designed to illustrate a particular math concept; and on excursions.

4.2 Math Anxiety in Anticipation and During Processing of Math Tasks

Recent studies have highlighted the incidence of math anxiety in young children (Lu et al., 2021; Petronzi et al., 2019a, 2019b), suggesting its potential impact on their cognitive and emotional development (Mononen et al., 2022; Dowker, as cited in Mammarella et al., 2019, p. 68). However, much of this research has focused on children aged six and older, particularly elementary school students. These studies often rely on self-reported measures of math anxiety and performance outcomes to examine its relationship with academic achievement in early childhood (e.g., Primi et al., 2020; Krinzinger et al., 2009). While informative, such approaches have limitations in capturing the nuanced ways in which math anxiety affects emotional arousal and cognitive effort, particularly in younger populations.

For instance, working memory (WM) and executive functions (EF) are critical for mathematical problem-solving, but both appear to be vulnerable to the disruptive effects of math anxiety. Math anxiety has been shown to reduce the availability of WM resources, impairing an individual's ability to solve mathematical problems efficiently (Ashcraft & Faust, 1994; Ashcraft & Kirk, 2001). Similarly, EF, particularly attentional control, can be disrupted by anxiety, which diminishes task efficiency by interfering with sustained focus and cognitive regulation (Eysenck et al., 2007; Li et al., 2023).

Much of the research on math anxiety has focused on its impact during task execution, but there is also evidence suggesting that the mechanisms underlying this type of anxiety may already be activated earlier, during the anticipation of math tasks. For instance, functional MRI studies have demonstrated that both adults (Lyons & Beilock, 2012a, 2012b) and children (aged 7–9 years; Young et al., 2012) show heightened activity in brain regions associated with negative emotionality during the anticipatory phase of math tasks. These findings suggest that math anxiety may interfere with performance not only during the processing of math tasks but also in the moments leading up to them. The anticipatory influence of math anxiety may stem from cognitive processes such as attention, shifting or inhibition, which play a crucial role in managing pre-task anxiety (Dowker, Sarkar, & Looi, 2016; Eysenck et al., 2007; Skagerlund et al., 2024). However, despite this evidence, the majority of studies in this field have prioritized examining task execution over anticipatory processes, leaving critical gaps in our understanding of how math anxiety exerts its effects across different stages of math task engagement.

Physiological measures, such as pupil dilation, present a valuable approach for examining the real-time effects of math anxiety on emotional arousal and cognitive load. Eye-tracking and neural studies provide compelling evidence that math anxiety disrupts attentional control and cognitive efficiency. For instance, individuals with higher math anxiety show deficits in attentional control, as demonstrated by difficulties in disregarding task-irrelevant distractors during problem solving (Li et al., 2023). Additionally, reduced activity in the central executive network, which is key for cognitive regulation and arithmetical processing, has been observed in high-math-anxious individuals (Pizzie et al., 2020). These findings emphasize the potential of non-verbal, real-time measures like pupil dilation to better understand the cognitive and emotional mechanisms underlying math anxiety. Importantly, such measures could shed light on how these dynamics unfold not only during task execution but also in anticipation of math-related activities. However, despite their promise, physiological methods remain underutilized in math anxiety research, particularly in studies involving very young children. Expanding the use of these tools in younger populations can provide insights into the early developmental trajectory of math anxiety and inform interventions targeting its effects during formative years.

Task difficulty is another key factor influencing math performance and the allocation of cognitive resources, such as attention and effort. Evidence suggests that math anxiety may disproportionately impair performance on more challenging tasks (Huber & Artemenko, 2021; Suárez-Pellicioni et al., 2013; Punaro & Reeve, 2012). Huber and Artemenko (2021) conducted a web-based experiment involving 382 participants to replicate the anxiety–complexity effect in arithmetic. They found that higher math anxiety was associated with poorer performance, especially in tasks requiring carrying or borrowing, indicating that math anxiety particularly impairs arithmetic performance when working memory demands are high. Punaro and Reeve (2012) explored how

9-year-old children experience worry related to math and literacy tasks of varying difficulty and how this worry relates to their problem-solving performance. Using a *faces worry scale* immediately after children judged problem correctness, they found that worry levels increased as task difficulty rose, especially for math problems compared to literacy and non-academic tasks.

Suárez-Pellicioni et al. (2013) combined behavioral and neurophysiological measures to investigate how individuals with varying levels of math anxiety process simple arithmetic problems paired with solutions that ranged from correct to drastically incorrect. Their findings showed that high math-anxious participants devoted more cognitive resources and required more time to evaluate obviously incorrect answers, despite performing with similar accuracy and speed as their low math-anxious peers. This increased cognitive effort was reflected in specific brain activity patterns associated with attentional control, suggesting that math anxiety reduces processing efficiency by impairing the ability to ignore distracting, irrelevant information. Importantly, these effects were observed even in low-demand tasks, indicating that math anxiety can interfere with cognitive processing before task difficulty becomes a limiting factor. However, the interaction between math anxiety and task difficulty, especially in younger children, remains poorly understood. Investigating this interaction in early childhood is crucial, as this developmental period lays the foundation for attitudes toward math and broader academic trajectories.

The focus on very young children (mean age = 5.67 years) in Study II of this thesis is unique, addressing a significant gap in the literature on math anxiety in early childhood. While previous research has extensively documented the relationship between math anxiety and task performance, the anticipatory effects of math anxiety remain underexplored, particularly in this age group. Additionally, despite advances in physiological methods such as eye-tracking, these tools have rarely been applied to examine the cognitive and emotional dynamics of math anxiety in young children. Task difficulty is another underexamined factor, with limited research on how it interacts with math anxiety to shape performance in younger populations. By investigating these dynamics in preschool class-aged children, study II sought to fill critical gaps in our understanding of how math anxiety emerges and impacts cognitive-emotional processes before formal schooling begins.

4.3 Preschool Children and Teachers' Math-Related Interactions: The Role of Affect as Stance

Research that treats affect as an interactional accomplishment, that is, affect as stance (Ochs, 1996, p. 410) and embodied affective practices (Wetherell, 2013, p. 360) provides a lens for examining how moment-by-moment teacher and child conduct might shape the affective climate of early mathematics moments. This scholarship conceptualizes emotions as multimodal, sequence-sensitive displays that participants perform and respond to in order to accomplish social action. This body of work also supplies the analytic vocabulary (e.g., stance, alignment, affiliation, participation frameworks, multimodal resources) that Study III adopts (Goodwin, 2007; Goodwin et al., 2012; Couper-Kuhlen & Selting, 2017; Stivers, 2008).

Methodologically important for Study III are two lessons from these analyses. First, affective displays are tightly linked to the *activity ecology*, where the material layout (e.g., a hopscotch grid; Goodwin & Goodwin, 2000), participants' positioning, and the sequential organization of turns provide slots where emotional displays become relevant and consequential. Second, affect is achieved through an integrated multimodal repertoire (pitch and voice quality, in-breaths/response cries, hand pointing, gaze shifts, posture and timing) that coordinates participants' access to and assessment of, ongoing events. These features, situated activity, sequential slots for affective displays, and multimodal orchestration (Goodwin & Goodwin, 2000) are the analytic tools Study III employs when examining affective stance in preschool mathematics interactions.

Swedish EMCA research on emotion demonstrates that affect plays an integral part of children's socialization processes in everyday preschool interactions. For instance, teachers normatively respond to distress, use embodied caregiving practices, and choreograph multimodal instruction that treats emotions as socially organized actions, rather than private (within the individual) states (Cekaite & Ekström, 2019; Holm Kvist, 2020; Cekaite & Bergnehr, 2018; Strid & Cekaite, 2022). While these studies are not focused on mathematics, they document the interactional resources (touch, prosody, gaze, turn design) through which affective stances are produced and made meaningful in Swedish preschools, providing essential contextual grounding for a math-focused EMCA inquiry.

Cekaite and Ekström (2019) examine how negative emotional displays are handled in Swedish early childhood institutions. Their selection of episodes includes the teachers' responses to children's individual or group expressions of negative emotions during teacher-led or free-play activities. The study analyses how the teachers addressed these situations until the conversation topic was changed or participants reoriented to a new task. They found that, when attending to peer conflict situations, institutional norms (e.g., equal sharing of toys) were non-negotiable. Teachers avoided confrontation with the children, but they also supported a certain amount of reasoning and explaining, hence making room for the children's individual and collective positioning in the discussions. For example, (Cekaite & Ekström, 2019) showed how touch and prosody work in tandem: touch to physically bring attention to a correct emotional stance, and prosody to challenge and regulate the way the child expresses their affective stance, directing the group of children toward a shared normative understanding of what constitutes appropriate emotional behavior in the group.

Strid and Cekaite (2022) studied peer interactions among 3- to 5-year-old children in Swedish preschools. In analyzing children's solicitation of recipients' attention to noteworthy objects in their environments, they noted how gaze in coordination with other embodied actions (a pointing gesture and a quick touch) index a child's affective stance (Strid and Cekaite, 2022, p. 32). Although these interactions are not math-related, they reveal how affective stances accomplished through multimodal resources play a crucial role in shaping peer engagement and topic development, a process similarly central in early mathematics activities.

These studies demonstrate the multimodal orchestration of affective stances in both teacher-managed interactions (Cekaite & Ekström, 2019) and peer-driven exchanges (Strid & Cekaite, 2022). In teacher-managed interactions, teachers use prosody, gaze, and touch to regulate and socialize children's affective stances (Cekaite & Ekström, 2019). In peer-driven exchanges, children align with one another through laughter, gaze, and embodied orientation, thereby co-constructing emotional engagement around the attended object (Strid & Cekaite, 2022). These interactions exemplify the sequence-sensitive and multimodal organization of affective displays, which Study III examines specifically in the context of early mathematics interactions.

Conversation-analytic studies in mathematics education show that teachers' micro-practices, especially evaluative third turns, prosodic design, gaze, laughter, and timing, function as sites of emotion work that can mitigate or amplify the affective stakes of phenomena with mathematical relevance, such as errors (incorrect answers) and demonstrations of uncertainty. In particular, Tainio and Laine's CA analysis of IRE (Initiation–Response–Evaluation) sequences demonstrates how teachers' third-turn designs—i.e., the evaluation—perform reassurance, humor, neutrality, or silence in ways that shape pupils' immediate affiliation and future willingness to participate in mathematics tasks (Tainio & Laine, 2015). In a study with 12–13-year-olds, they provide detailed micro-level insights into teacher–child interactions during mathematics activities. Building on prior CA research, they state that "even though they carefully analyzed delicate sequences in which pupils encountered problems in learning, the studies did not take up the emotional dimensions of dealing with the problems" (p. 70), thereby justifying taking a closer look at how emotion itself is managed in the IRE sequences. This line of research argues that interactional moves that scaffold cognition simultaneously carry affective stance, constituting a direct motivation for the focus of Study III in this thesis.

By treating incorrect pupil answers as face-threatening *dispreferred actions*, Tainio and Laine (2015, p. 69) identify how teachers' evaluative third turns become sites of emotion work. Across ten sixth-grade lessons (36 incorrect answers yielding 46 evaluative turns), they use Conversation Analysis to categorize seven distinct evaluative practices. These practices are varied, describing their sample rather than an exhaustive list of possibilities; they include, for instance, modified repetition, question reformulation, and open, scaffolded follow-ups that attend to both the cognitive and emotional stakes of committing a math error. As they observe, "Incorrect pupil answers … are always a potentially problematic, face-threatening activity for the speaker and the recipients" (Tainio and Laine, 2015, p. 69), and the teacher's third turn becomes a finely tuned performance of reassurance, humor, or neutrality that either mitigates or magnifies that threat.

Tainio and Laine (2015) show that stance in a classroom's math activity context is co-constructed through prosody, gaze, facial expression, gesture, and body posture. For instance, in their Example 1 the teacher's smiling repetition and humorous framing turn a potential embarrassment into a shared moment of affiliation. Whereas in their Example 2, frozen posture and mutual gaze communicate tension non-verbally before the teacher laughs and reframes the question. More specifically, in their first example, the teacher's use of modified repetition echoes a pupil's wrong answer with a rising intonation and a playful smile to frame the misstep as a harmless slip rather than a sign of deeper misunderstanding. "During the teacher's turn, Irma starts to smile … but then other pupils gradually start smiling together with them," they note, demonstrating how a shared affective stance can be co-constructed in the moment (Tainio & Laine, 2015, p. 75).

Tainio and Laine (2015) also draw on the idea that displays of affect can be vulnerable to "emotional contagion" (Peräkylä, 2012, p. 284), meaning that once one participant publicly shows an emotion, others in the interaction tend to pick it up and share it. Tainio and Laine argue that classroom norms around handling errors, whether charged with embarrassment or safely normalized, can shape pupils' longer-term self-beliefs and willingness to engage in mathematics.

> We suggest that displays of emotions, expressed in the details of interaction and observable not only to the addressee but to all present participants, can in time become shared by other participants. In other words, we want to suggest that in mathematics education, positive and negative attitudes toward mathematics are, at least partly, formulated in the details of everyday interaction in classrooms. (Tainio & Laine, 2015, p. 84.)

Their second example highlights a non-verbal freeze of posture and gaze that quietly indicates *this wasn't right*, and is followed by minimal verbal reformulations of the original question. Sabina's furrowed brow and the teacher's frozen stance make the affective load/charge visible even before a word is spoken. Eventually, a brief laugh from the teacher is noted to ease that tension, allowing Sabina to try again without shame. Finally, their third example illustrates practices including open questions and increasingly guided prompts that shepherd a confused pupil toward the correct—or at least teacher-preferred—type of reasoning while attending to his mounting frustration. When Jaakko exclaims "I DON'T KNOW," the teacher immediately overlaps with a reassuring correction, turning potential despair into relief: "The teacher quickly responds to Jaakko's affective turn … and gives him the clue he apparently needs" (Tainio & Laine, 2015, p. 83). Hence, their analyses demonstrate that when teachers explicitly acknowledge and manage pupils' affect (e.g., through brief humor, reassurance, or guiding questions), they help sustain participation. Yet they also caution that practices like open questions, if not carefully scaffolded, can exacerbate pupil frustration. Ultimately, these authors emphasize the pedagogical importance of treating incorrect answers as normal contributions.

The tension between established pedagogical values and practices and the emerging curricular demands in Sweden (explained in section 2.4—5 in the background) mirrors the context of studies employing conversation analytic methods to examine early mathematics education in other contexts. In both Australia and Sweden, recent curriculum reforms have introduced a more formalized approach to teaching in early childhood settings while still valuing play and care as foundational practices. In Australia, early childhood education is also firmly rooted in a play-based, emergent curriculum that prioritizes the quality of interactions between educators and children. Their Early Years Learning Framework (EYLF) encourages teachers to create environments where children can explore, represent, and communicate mathematical ideas, even though it does not prescribe specific math targets (Australian Government Department of Education, 2022). Furthermore, the EYLF advocates for *intentional teaching* within a play-based approach. Both contexts thus emphasize the importance of responsive, context-sensitive pedagogies. Moreover, the role of math education researchers in investigating situated phenomena in preschools—to provide knowledge regarding the *how* of teaching and learning in the early years—is equally emphasized by researchers in Sweden and Australia (Björklund et al., 2020; Hedge & Cohrssen, 2019).

Below, I synthesize studies by Cohrssen and colleagues, and related work from Australia on the strategic use of pauses and structured teacher-child exchanges, illustrating how micro-level interactions contribute to responsive, attuned teaching practices that are central to the cognitive–affective dimensions of early mathematics education. These studies originate from settings outside Sweden, but they share a common focus on generating knowledge that ultimately helps educators' scaffold mathematical learning without undermining the spontaneous nature of play. The studies that follow begin to unpack interactional mechanisms and therefore point toward the research gap that Study III of this thesis seeks to fill by examining the role of affective stances in creating meaningful mathematical moments in Swedish preschools.

Research studies in Australian preschools have focused on how teacher talk, particularly the deliberate use of pauses and intentional teaching strategies, can enhance learning of mathematical content. Cohrssen et al. (2014a) examined how incorporating deliberate pauses in teacher talk during play-based mathematics activities can enhance the quality of classroom discourse. The authors analyzed video-recorded interactions to show that when teachers strategically pause before responding, children are given the opportunity to process questions more deeply and to generate more thoughtful, extended responses. This research demonstrates that purposeful pauses contribute to more contingent and expansive exchanges. When teachers delay their responses, rather than filling every gap with immediate talk, children can initiate topics, explore ideas, and display their numeracy-related understanding. These pauses also allow the teacher to assess each child's level of understanding and to tailor scaffolding more effectively. For example, the extract *So how many liked the fish?* displays a sequence in which the teacher uses a bar graph that displays children's votes for different sea creatures. Initially, rapid one-word responses are elicited. However, a marked pause (e.g., an 8-second silence following a question) creates space for children to offer hesitant or elaborated responses. Following this pause, the teacher repeats part of the initial question and pauses again before rephrasing it to emphasize a comparative term (such as *less*), which leads to the correct response. This extract illustrates how waiting time, combined with verbal repetition and non-verbal cues (like pointing to the graph), helps children connect the visual representation with the underlying numerical concepts.

In contrast, the extract *"How many pebbles altogether?"* shows a different interaction with a more hurried pace. Here, the teacher's lack of extended pauses results in a rapid sequence where the child's participation is minimal. The teacher's immediate responses and quick mapping of language onto actions leave little room for the child to process or articulate understanding, thereby limiting opportunities for concept development. Another extract, *"So how many like yellow?"*, highlights multiple pauses interwoven with brief hesitations (such as *ers*) from the children. In this case, the teacher intentionally provides wait time after posing the question and uses a hint (by drawing attention to a numeral on the y-axis) to support the children in arriving at the correct answer. The use of such pauses not only supports self-correction among the children but also reinforces shared knowledge through repeated, scaffolded interactions. The article also examines moments where pauses contribute to language acquisition. For instance, in an extract titled *"Nine or six?"*, a child rehearses a numeral sequence while handling physical numeral cards. Here, the teacher uses a protracted intra-turn pause to model the correct language (such as correcting a mispronunciation by repeating the word with emphasis) while maintaining the focus on the concrete referents. This simultaneous modelling of language and concept reinforces the child's learning of ordinal terms and spatial sequencing. The authors conclude that the strategic use of pauses transforms classroom discourse from a rapid, teacher-dominated question-and-answer format into a more participatory and equitable dialogue. These pauses provide essential moments for children to engage in subvocal rehearsal and for teachers to offer individualized, contingent feedback. In doing so, teachers are better able to support and extend the children's emerging mathematical understanding, ultimately contributing to higher-quality interactions and concept development (Cohrssen et al., 2014a).

In a similar vein, Cohrssen and Church (2017) showed that when educators intentionally provide a few seconds of silence after posing a question, children get the opportunity to process the query, engage in internal rehearsal, and offer more thoughtful responses. This approach not only fosters deeper engagement with mathematical concepts but also supports the development of higher-order thinking skills, for example, demonstrations of understanding as opposed to bare claims in the sequential organization of dialogues between children and the teachers (Cohrssen and Church, 2017). By focusing on the subtle orchestration of classroom dialogue, this research highlights that the quality of teacher–child interactions is a critical factor in advancing mathematical understanding in early learning settings, an insight that resonates with similar pedagogical needs observed in Sweden and elsewhere (Cohrssen et al., 2014b; Pyle et al., 2017).

Cohrssen and Church (2017) also used conversation analysis to explore how intentional teaching is enacted during play-based numeracy activities in early childhood settings. By examining video-recorded classroom interactions across six different early childhood education contexts, the authors illustrate how teachers carefully build on children's contributions. In particular, they focus on the *third turn* in conversational sequences, a point where the teacher adapts previous responses, reformulates questions, and introduces additional information to extend children's understanding of numerical concepts. The study demonstrates that these detailed, turn-by-turn interactions are effective in eliciting and developing children's mathematical knowledge and also offer practical insights for educators. For example, rather than merely categorizing teacher actions, the detailed analysis reveals how the sequential organization of talk supports a responsive teaching practice that fosters learning. Their analysis shows that each conversational turn is carefully linked to the preceding one, ensuring that children's emerging ideas about numbers are both recognized and expanded upon. For instance, in a detailed extract involving a graphing activity, the teacher first gauges the children's understanding by asking questions about the number of votes in a counting task. When a child's response indicates partial understanding, the teacher immediately rephrases the question, uses gestures (like pointing to the graph), and offers additional hints to scaffold the children's reasoning. This strategy helps clarify abstract concepts such as equivalence, numerosity, and comparative values. The source thus emphasizes that these micro-level interactions, rather than broad categories of teacher behavior, offer a clear window into how deliberate, reflective teaching practices can emerge naturally during everyday activities. By focusing on the sequential organization of talk, the study illustrates that effective teaching is not merely about providing correct answers but about engaging in a dynamic process where each turn of conversation informs the next, thereby gradually constructing deeper mathematical understanding (Cohrssen & Church, 2017).

Cohrssen et al. (2014a) and Cohrssen and Church (2017) demonstrate that strategically timed pauses and responsive teacher talk are essential for scaffolding children's mathematical reasoning during play. Together, these studies suggest that despite geographic distance, preschools serve as dynamic sites where policy and everyday interaction intersect, ultimately shaping the cognitive-affective dimensions of early mathematics learning. Both of the contexts revised here reveal that successful curriculum enactment depends on a careful balancing act (e.g., Palmér & Björklund, 2023) and adapting established pedagogical values to meet formal curricular demands while ensuring that the inherent benefits of play and care are not lost.

In the above-mentioned studies, Cohrssen et al. (2014a) focused on how strategic wait-time and delayed responses give children additional time to think through questions and produce more considered, elaborated answers. Their analyses describe the pedagogical effects of pauses such as greater contingency, richer discourse, more accurate concept-building but they don't treat emotion as an analytic object, beyond noting that children seem more *engaged* when given time to think or that overall, the dialogues and participation in class become more equitable. Cohrssen and Church (2017) extended that work by looking at the third turn as a site of instructional elaboration, showing how teachers reformulate questions to build on children's ideas. Again, their primary lens is conceptual understanding and interactional mechanics, not the emotional stance those mechanics carry.

Section 2.5 of this thesis showed that Swedish play-based mathematics research catalogues affective descriptors such as enthusiasm, and engagement, but treats them as background perks of good pedagogy rather than as phenomena to be studied. Likewise, multimodal conversation analysis work in similar early childhood settings (Cohrssen et al., 2014a; Cohrssen & Church 2017) details the cognitive benefits of strategic pauses and third-turn scaffolding, noting in passing those children seem more engaged, yet never names how those pauses and reframing carry emotional stances (or not). What remains under-conceptualized across both research fields is how teachers' and children's moment-to-moment affective stances are constructed, negotiated, and made relevant in the flow of interaction. In other words, affect is everywhere in description, yet nowhere the explicit object of inquiry.

Both sets of studies reviewed here used CA to reveal details of teacher practices, including pauses, third-turn designs, and turn expansions. But Tainio & Laine (2015) foregrounded the affective dimension in those practices. While Cohrssen et al. (2014a, 2017) demonstrate how strategic wait-time and third-turn scaffolding deepen cognitive engagement, Tainio & Laine (2015) show how evaluative framing of mistakes scaffolds emotional safety. Together, these studies acknowledge the presence of cognitive and emotional dimensions in teacher-student interactions, and the risks of falling short in systematically unpacking the emotional stances in interactions that aim to support children's mathematical learning and understanding.

There are also multimodal EMCA studies that show how Swedish preschool children and pedagogues make mathematical content visible through embodied actions, deictics, and material handling (e.g., Gejard, 2018; Gejard & Melander, 2018). Gejard and Melander (2018) analyse participation in mathematical discourse (mathematizing; Sfard, 2008) during play with magnetic construction toys (Geomag). They demonstrate that embodied actions combined with talk (e.g., pointing gestures and deictic terms) allow the children to show their mathematical understanding as a block-play activity unfolds. The article focuses on two children and a pedagogue's orientation to geometrical properties, highlighting how the children bring each other's attention to their constructions by exploring spatial categories with "rather limited verbal resources" (Gejard & Melander, 2018, p. 501), such as response cries and sound objects (e.g., "wow," "ehh," in Excerpt 1). The children also reformulate each other's utterances to interactionally construct meaning. In between, they provide positive assessments but also challenge each other's descriptions of the constructions by bringing up how they look from different perspectives. Children are reported to orient to and actualize different geometrical aspects such as spatial locations and dimensions, whereas the teacher's positive assessment of a child's construction enables further actions from the children. This study illustrates how the pedagogue moves from an embodied child question to more formal geometric language and observations. When a child asks, "Is mine straight?" the pedagogue orients to the material object while pointing at it and reformulates the child's concern following a geometric criterion: "All the sides are equally long" **(**Gejard & Melander, 2018, p. 502). The teacher's verbal reformulation is accompanied by embodied demonstration (pressing a corner so it becomes oblique) that reframes the child's embodied question in geometric terms and creates an interactional slot for further action, thereby introducing the terms and analytic frame of square/cube. The pedagogue's uptake converts an affordance of the material ecology into formal mathematical language. This study documents multimodal procedures and occasional evaluative phrases (e.g., "wow"), but does not systematically treat those displays as *stance* or analyse their sequential, multimodal constitution as emotion work because this is not the analytic focus of the study (Gejard & Melander, 2018).

The study reviewed above constituted activities arranged as free play in the preschool's block-play area. However, in another study, Gejard (2018) focuses on two different activity ecologies involving 5-year-olds: a collaborative, whole-group book-reading activity and a more individualistic painting task (Gejard, 2018, p. 72). These different formats produce distinct participation frameworks in which the teacher's goals and the children's interests show alignments and disalignments. During the book reading, the teacher asks the children to look at the pictures of geometrical shapes present in the book by pointing and holding the book in a manner that is visually accessible to all the children. The children take initiatives to name (baptize; Sfard, 2008) the shapes. These initiatives are further expanded by the teacher's questions, such as "*How does one know that it is a hexagon?*", which enable children's active pointing and counting of the number of corners in the shape's drawing. The teacher also provides timely positive feedback, allowing the children to discern appropriate answers from incorrect attempts. In the following excerpt, size relations (biggest–medium–smallest) expressed by the children are reformulated by the teacher to extend the focus on the geometrical shapes and their interrelations (smaller-than–bigger-than). An opportunity to refine the word used to describe a shape with four corners (original Swedish: *fyrkant*) is afforded by the book (and the teacher's reading of the book) to explain that this shape is a square (original Swedish: *kvadrat*). The teacher prompts the children to count the number of squares shown on the book's page, and a child uses the term *square* repeatedly as he points at them.

The study continues by examining the related but separate activity that follows. The activity consists of the children entering the preschool's atelier in pairs to paint geometrical shapes, just like the character in the book they were reading had done. As the children work on their paintings, the focus on naming and comparing the sizes of the geometrical shapes they paint continues. However, when the teacher approaches the child who had repeatedly used the term *square* during the reading activity to comment on his painting, the teacher's differentiated goal to highlight the mathematical terms as central to the activity becomes evident. The teacher asks the child to comment on his painting, and he does so by addressing the aesthetic dimensions of it. First, the child refers to his painting being the same *type of thing* as what the book's character had done, then he refers to the colors of each square he has painted. When asked if his painting shows circles (which the teacher draws with her finger in the air), he says no. Yet, when asked what shapes are present in his painting, he uses the term *fyrkant* again. The teacher then suggests these are squares (*kvadrat*) of different sizes. However, the child does not orient to the relevance of establishing the difference between the more colloquial term *fyrkant* and the more appropriate mathematical term *kvadrat* in this sequence. This disalignment marks a tension between the teacher's and the child's focus, highlighting the complexity of picking up children's initiatives and challenging them mathematically. Together, these studies (Gejard, 2018; Gejard & Melander, 2018) illustrate that mathematical discourse in preschool is interactionally accomplished: embodied and multimodal practices, and moment-by-moment uptake by peers and pedagogues, make geometric ideas visible and actionable rather than merely evolving from knowledge transmitted or actions proposed by the teacher.

These studies provide a methodological and empirical precedent for examining how mathematical and affective meaning are jointly produced in interaction. Across these Swedish and international studies, affective stance has not been systematically analysed as a mechanism through which interactional practices shape children's immediate participation and longer-term relations to mathematics. LA/EMCA research demonstrates that affective stances are interactionally produced via multimodal resources, and that participants' moment-by-moment practices (e.g., prosody, timing, third turns, gesture, touch) have the power to shape emotional climates that encourage or inhibit participation in unfolding activities (e.g., Goodwin, 2007; Tainio & Laine, 2015; Cekaite & Ekström, 2019). However, early childhood mathematics research typically treats affect as background description rather than analytically unpacking affective stances (e.g., Cohrssen et al., 2014a, 2014b; Gejard, 2018).

Section 2.3 discussed research in early childhood settings in Sweden which documents what teachers do to support mathematical thinking, but that leave the emotional aspects of those practices largely implicit. Furthermore, the context of tension between new policy demands and long-established practices centred on play and care, described by Hildén et al. (2021) and Sundström (2025), sets up a natural segue into a more focused exploration of affect in relation to these transforming processes taking place at the preschools. That is to ask how do affective dimensions get constructed and negotiated in the moment-to-moment interactions between teachers and children, and how does it become part and parcel of teaching and learning mathematics in the preschools? Study III of this thesis addresses this question.

Chapter 5. Method

The methods in this project are conceived as a set of tools designed to address the aims of the thesis. Primarily, the project seeks to further the knowledge about preschool and preschool class children's affective relations to mathematics in connection with teachers' self-assessed math anxiety, children's engagement with math tasks, and everyday math activities in the preschool. Secondly, it aims to explore how these relations can be investigated from different theoretical and methodological perspectives. These aims were pursued through three sub-studies. Study I focused on preschool teachers' self-assessments of their math anxiety in relation to their pedagogical practices. Study II examined preschool class children's physiological, psychological, and behavioral engagement with structured math tasks. Study III analyzed affective practices in everyday math activities involving children and teachers in a preschool. Various research instruments were adapted and tested to explore both intrapersonal and interpersonal processes shaping early affective relations to mathematics.

The project originates in a real-world problem: the possible link between math anxiety and preschool children's educational paths, and how teachers' own relations with mathematics and everyday social practices shape when and how mathematics is enacted in preschools. I therefore designed studies to further the knowledge about this conceivable relation in a wide variety of contexts (i.e., an online platform, a laboratory and in a preschool), and to address the complexity of affective relations as an object of study. This called for a mixed-methods research approach (Creswell, 2013; Johnson and Onwuegbuzie, 2004). Additionally, in refining methods to ensure alignment with the interdisciplinary theoretical framework, I had to ponder upon ethical considerations, and the ability of each instrument to address the specific research questions of the studies.

When using these different methods to investigate affective relations, I sought to apply minimally invasive instruments and protocols. A key consideration in the selection of the methods was to avoid inducing negative experiences or even anxiety in participants, while still collecting meaningful data. This ethical consideration shaped the design of all three studies and guided the selection of data collection tools and protocols. In all three studies, the age group of the participants played a crucial role in determining the studies' design and methods. For instance, I needed to ensure that the tasks and instruments were age-appropriate and engaging *enough*, so as not to induce discomfort or boredom. The methods were also adapted to capture practices in ways that were contextually grounded and reflective of daily experiences in Swedish preschool settings. The differing needs and cognitive abilities of the participants in each age group required a flexible methodological approach to ensure accuracy and richness of data collected across the three studies. Furthermore, validity concerns were especially important given the use of multiple methodologies and the potential influence of different methodological designs on the outcomes. Internal, external and ecological validity considerations are integral to the overall credibility of the findings, and will be discussed in greater detail in the methodology section of each study, and in relation to each study's results. The following chapter describes the methodological choices regarding design, selection of data and ethics. Each study's overview also provides a section explaining how each of them contributed to characterizing affective relations to mathematics in preschool and preschool-age children and teachers.

5.1. Methodology in Study I

Study I was designed to test how preschool teachers' self-assessments of their own math anxiety relate to their pedagogical practices. This study does not directly focus on preschool children's affective relations to mathematics, instead, it served the primary aim of the thesis by offering insight into the potential indirect pathways (i.e., intergenerational transmission of anxiety) through which young children might be affected by teachers' own experiences with math anxiety. This study also contributed to the secondary aim of the thesis, which comprises refining research tools and ensuring they align with the interdisciplinary theoretical framework and ethical standards of the project.

For example, the Math Anxiety Scale for Teachers of Preschool (MAST-P) was developed and validated as part of this study. The tool was reviewed, refined, and validated through consultation with experts in the fields of math education, teacher training, and research, ensuring its reliability and validity. The MAST-P was designed to capture both general math anxiety and anxiety related to teaching mathematics, in alignment with the thesis's theoretical framework that incorporates psychological and educational perspectives on math anxiety. To further ensure the validity of the instrument, an exploratory factor analysis was conducted, confirming its two-factor structure and reliability measures. Additionally, to account for the ongoing challenges related to the COVID-19 pandemic at the time the study was implemented, the tools were adapted for online administration, ensuring both the ethical integrity of the research process and minimizing participant stress.

In this study, the aim was to examine the relation between teachers' math anxiety and their pedagogical practices, specifically focusing on how both general and teaching-related math anxiety may influence teachers' frequency of math-related engagement with the children in preschool settings. To investigate this, an online questionnaire was administered to teachers to assess their levels of math anxiety, both general and teaching-specific, as well as the frequency with which they engaged in math-related talk and teaching math content to the children during everyday preschool activities.

5.1.1 Study Context

The data collection process for this study was conducted during the COVID-19 pandemic, demanding the use of an online questionnaire to reach preschool teachers. Due to restrictions on in-person interactions, this approach ensured both the safety and convenience of participants while allowing for wide-reaching participation across various preschool settings. The study was carried out in collaboration with faculty members from the Department of Psychology, who were conducting a larger survey that addressed a range of research topics, including curriculum relevance, teacher confidence, language and literacy practices, and mathematics teaching (Appendix 1). This partnership enabled the integration of our specific research questions into the broader survey, offering a valuable opportunity to gather data from preschool educators throughout the local municipality, ensuring a diverse and representative sample.

5.1.2 Participant Details

The sample for Study I consisted of preschool educators from Uppsala municipality. A total of 357 educators completed the online questionnaire, of which 352 responses were suitable for analysis, yielding a participation rate of 98% among those who responded. When considering the entire invited population of approximately 1,900 educators, the participation rate was 18.8%. Demographic data were collected to contextualize teachers' experiences and explore potential correlations with math anxiety. Participants reported their age, gender, level of education, years of experience, and the age groups of children they taught (1–3 years, 4–6 years, or both). The final sample included 189 certified preschool teachers (173 female, 14 male, 2 non-binary) and 163 caregivers (149 female, 13 male, 1 non-binary).

Further analysis revealed that 187 participants were employed as preschool teachers, while 160 were employed as caregivers. A correspondence between teachers' certifications and their roles at the preschools was found, with certified preschool teachers employed as teachers and caregivers employed as caregivers. Regarding age, the mean age for preschool teachers working with children aged 1 to 3 years was 40.1 years, while those working with children aged 4 to 6 years had a mean age of 41.6 years. For caregivers, the mean age for those working with children aged 1 to 3 years was 43.1 years, and those working with children aged 4 to 6 years had a mean age of 42.1 years. Caregivers working with both age groups had a higher mean age of 47.8 years, while preschool teachers working with both age groups had a mean age of 44.4 years. These demographic variables, particularly role, gender and age of children's groups, provided important context for inferring how educators' math anxiety might influence their pedagogical practices.

Sample representativeness: To evaluate the extent to which the sample reflected the broader population of preschool educators in Uppsala, we compared key demographic characteristics between the study participants and the invited population. The sample included educators from a diverse range of preschools, capturing variations in socioeconomic and immigrant backgrounds. Additionally, distributions regarding gender and educational background aligned closely with municipal records. However, certain preschool types were slightly underrepresented, notably smaller preschools (fewer than 10 attending children) and those serving a higher proportion of Swedish-background families or single-parent households. While these discrepancies should be considered when interpreting the findings, the sample still provides a broad and diverse representation of preschool educators in the municipality. By acknowledging these demographic and institutional factors, the study ensures a more nuanced interpretation of how educators' backgrounds and work environments may shape their experiences with math anxiety and its potential impact on pedagogical practices.

5.1.3 Data Collection Instruments

MAST-P (Math Anxiety Scale for Teachers of Preschool): The MAST-P was specifically designed to assess math anxiety in preschool teachers. This tool is based on the Math Anxiety Scale for Teachers (MAST) developed by Ganley et al. (2019), but it was adapted for preschool educators. The MAST-P consists of 14 items, divided into two categories: general math anxiety (GMA) and math teaching anxiety (MTA). The first category (items 1–7), capture more emotional (somatic), cognitive, and social dimensions of anxiety in relation to mathematics. The emotional aspect includes physiological aspects such as sweating or feeling uneasy during math tasks, while the more cognitive component addresses distractions or negative thoughts that interfere with math problem-solving. The social-evaluative aspect looks at teachers’ concerns about being evaluated in math contexts. The second category of the scale measures math teaching anxiety (items 8–14), which targets teachers' specific anxiety related to teaching math in preschool settings. These items explore worries such as fear of making mistakes while teaching math or the anxiety associated with explaining mathematical concepts to children. This distinction between general math anxiety and teaching-specific math anxiety provides a more nuanced understanding of how anxiety manifests in different contexts, whether in personal encounters with math or in teaching scenarios. It also helped highlight group differences between preschool teachers and caregivers’ ratings.

Teachers rated these items on a Likert scale ranging from 1 (Completely Disagree) to 5 (Completely Agree). This scale was thoroughly adapted for Swedish preschool contexts. It underwent an iterative process of translation and validation by experts in math education, preschool teacher training, and math education research. The substantive validity was reviewed by a group of eight mathematics educators and two preschool teacher trainers, ensuring that the questions were both contextually relevant and accurately translated (Instrument validation will be discussed below).

The Frequency of Pedagogic Actions Scale was used to measure how frequently teachers taught and talked about mathematics in their daily preschool routines. This scale was designed to capture the frequency of math-related pedagogical actions, particularly in relation to core areas of mathematics in the preschool curriculum, drawing on examples from the Swedish National Agency for Education’s Preschool curriculum (Swedish National Agency for Education, 2018, p. 15). Teachers were asked to rank their frequency of teaching mathematics on a Likert scale from 1 (Almost never/never, less frequent than once a month), 2 (rarely, once a month), 3 (occasionally, a few times a week), 4 (often, every day), to 5 (always/more than once a day). Using the same scale, participants were asked to indicate how frequently they engaged in math talk with children, such as talking about counting (e.g., reciting count words, counting objects in a set, asking children to count), recognizing patterns (e.g., discussing patterns in clothing or surroundings), and identifying geometric shapes (e.g., naming geometric shapes). For each of these talk activities, teachers provided ratings for the frequency of these actions in specific settings: during group gatherings, when setting and clearing the table, in the halls when entering or leaving the classroom, during dedicated math teaching sessions, and on excursions.

The purpose of this scale was to capture both structured teaching of mathematical concepts and informal teaching opportunities that arise naturally during daily preschool routines. The varied settings were chosen to encourage teachers to think about how math teaching and talk can be integrated across typical preschool activities, beyond formal instructional periods. The approach measured the frequency of math-related actions in structured lessons and incidental learning opportunities in which math concepts are naturally introduced in everyday contexts, such as during meal times or transitions from the outside playground to the rooms indoors (Instrument validation discussed below).

5.1.4 Instrument Validation

To ensure the validity of the MAST-P and the Pedagogic Actions Frequency Scale, feedback was sought from a group of mathematics educators, teacher trainers, and math education researchers from the Department of Education at Uppsala University. These experts reviewed the items of both scales to confirm their alignment with the theoretical framework and their relevance to the Swedish preschool context. Specific modifications were made to enhance clarity, cultural appropriateness, and contextual relevance. Moreover, the translation process from English to Swedish was carefully reviewed to minimize content loss and preserve the intended meaning of each item.

For instance, items referencing difficult math tasks in the MAST were reworded to focus on teachers' experiences with math tasks rather than math task's difficulty in the MAST-P. Certain idiomatic expressions (e.g., butterflies in my stomach) were removed due to potential cultural misinterpretations. To better reflect the Swedish preschool environment, where math discussions are embedded in everyday activities rather than formal lessons, *teach mathematics* was replaced with *talk about mathematics* in relevant items. Additionally, one item was removed due to conceptual overlap, prioritizing a scenario more representative of Swedish preschool teaching practices. A more detailed account of these modifications, including a comparative panel of the original English items and their Swedish adaptations, is available as supplementary material in the published paper.

To further establish the psychometric properties of the MAST-P, an exploratory factor analysis (EFA) was conducted, confirming a two-factor structure corresponding to general math anxiety and math teaching anxiety. The Kaiser-Meyer-Olkin measure indicated strong sampling adequacy, and Bartlett's test of sphericity confirmed the appropriateness of factor analysis. The two-factor solution accounted for a substantial proportion of variance, and reliability analyses demonstrated high internal consistency for both subscales.

Similarly, the reliability of the Pedagogic Actions Frequency Scale was assessed through item-total correlations and internal consistency analyses. The scale measuring the frequency of math-related pedagogic actions exhibited strong reliability, with high Cronbach's alpha values across different areas of mathematical talk (counting, patterns, and geometry). The response options and scenarios included in this scale were refined based on expert feedback to ensure they captured a range of everyday preschool contexts (e.g., gatherings, mealtimes, hallway transitions, and excursions), which are central to math engagement in Swedish preschools. Positive correlations between these areas further indicated the coherence of the scale in capturing teachers' engagement in math-related interactions. These findings supported the robustness of the instruments used in the study to reliably capture both educators' math anxiety and the frequency of their pedagogic actions in preschool settings (for a complete description of the scales' factor structure see Paper I).

5.1.5 Ethical Considerations

The study adhered to ethical guidelines to ensure participant safety and confidentiality, particularly given the online format of data collection during the COVID-19 pandemic. Teachers were informed about the study's purpose and gave explicit consent before participating, with all responses anonymized and tracked only by a unique code. Confidentiality was strictly maintained throughout the data collection process, with personal identifiers removed to protect participant privacy. To minimize any potential anxiety or discomfort, participation was voluntary, and participants were assured that they could withdraw at any point without consequence. The study design and ethical protocols were reviewed and approved by the Swedish Ethics Review Authority (approval number: Dnr 2021-04308) and followed guidelines provided by the Swedish Research Council (2017) and the Declaration of Helsinki (World Medical Association, 2013). Additionally, the consent process included clear information regarding data storage practices and participants' rights, such as the ability to opt out, further safeguarding ethical transparency and respect for participants' autonomy.

5.1.6 Study I's Methodological Alignment with Thesis Aims

This study was designed to address both the primary and secondary aims of the thesis, integrating insights from psychology and education to examine the relationship between teachers' math anxiety and their pedagogical practices in preschool settings. A central aim of this thesis is to further knowledge on preschool children's affective relations to mathematics. Study I contributed to this aim indirectly by investigating how teachers' math anxiety may shape the frequency of early math experiences encountered by children in the preschools. By using the MAST-P and the Pedagogic Actions Frequency Scale, this study provided empirical data on the extent to which math anxiety manifests in early childhood education settings and its potential impact on children's early exposure to mathematical concepts.

The methodology reflects the interdisciplinary framework of the thesis, drawing on psychological research on math anxiety and educational research on early math pedagogy. The development and validation of the MAST-P was guided by psychological theories and empirical studies, while the Pedagogic Actions Frequency Scale was informed by educational perspectives on mathematics instruction in Swedish preschools, and by empirical research in the field. This dual focus ensured that the study captured multiple dimensions of math anxiety and its plausible behavioral implications for teachers' classroom practices.

Further, the study design followed best practices in psychometric research, employing validation procedures that tested if the instruments provided reliable and meaningful measures of the constructs under investigation. The inclusion of expert feedback, exploratory factor analysis, and reliability assessments supported the robustness of the findings and enhanced their relevance to understand how teachers' affective orientations is related to preschool children's frequency of experiences with mathematics content. By integrating these methodological considerations, Study I contributed to the thesis's primary aim by displaying one pathway through which early affective relations to mathematics may be shaped, setting the foundation for the subsequent studies that further explore these processes from complementary methodological perspectives.

5.2 Methodology in Study II

In line with the thesis's primary aim of furthering knowledge on affective relations to mathematics in early childhood education, Study II was specifically designed to examine the anticipation and processing of math tasks in preschool class children (mean age = 5.67 years) and adults (one of the child's parents). By employing an interdisciplinary methodology that blended eye-tracking technology with cognitive assessments, this study advanced our theoretical understanding of children's physiological, psychological and behavioral engagement with math tasks while simultaneously refining methodological practices tailored to the unique needs of older preschool-aged children. In doing so, Study II also contributes to the project's secondary aim of investigating affective relations to mathematics from different theoretical and methodological perspectives. In this case, to better capture the temporal dynamics of children's affective and cognitive engagement during math task anticipation and processing, which is a crucial step for informing future educational practices.

Study II took a laboratory-based approach to capture the real-time indicators of children's physiological arousal during anticipation and processing of math tasks. Specifically, the study employed pupillometry to measure pupil dilation as a proxy for affective and cognitive processes. In the published paper, these measures were presented as emotional arousal and cognitive load constructs. In the thesis, they are discussed under the broader conceptual categories of affective and cognitive processes, which encompass these constructs. These physiological data were integrated with other behavioral measures, such as visuospatial working memory assessments via a Corsi-block tapping task, and self-reported affect towards mathematics (the latter published as math anxiety). This integration allowed us to address a critical research gap: determining whether, and to what extent, anticipatory processes rather than just task execution reflect affective relations to mathematics of children attending the first semester of preschool class[4] (Förskoleklass) in a lab context.

While prior research has predominantly focused on school-aged children and the processing phase of math tasks, limited evidence exists on how anticipatory processes manifest in physiological terms, especially in younger populations. By capturing real-time indicators of affective and cognitive processes (i.e., emotional arousal and cognitive load, both associated with math anxiety or math tasks in previous studies), Study II refined our understanding of the temporal dynamics of young children's affective and cognitive engagement and contributed to the broader objective of developing minimally invasive tools for investigating the multiple dimensions of math-related experiences.[5]

This section describes all tasks employed with the children and the adults such as the age-adapted eye-tracking tasks and visuospatial working-memory tests to maintain transparency and clarity in the description of the workflow. However, the main interest in this thesis is in connection to the results from the children group, and the implications of these specific findings for the

[4] The preschool class (förskoleklass) is a Swedish compulsory, free-of-charge school form for six-year-olds that acts as a bridge between preschool and primary school. It follows the primary school academic year and combines preschool pedagogy with primary school methods. The activities focus on play, creativity and social development (Skolverket, 2022; *Swedish Education Act*, SFS 2010:800, ch. 9.)

[5] Although both the children and the adult group provided self-reports of affect towards mathematics and reading, the present study and project focus exclusively on measures connected to math.

overarching aims of the thesis project. This will become more evident as the results of the study and its implications from the findings in the children's group are reported.

5.2.1 Participants

The sample comprised 60 children and one parent per child. Children's mean age was 5.67 years and the sample included 27 females. Parents' mean age was 38.4 years with 50 females represented within this group. We recruited a total of 120 participants from the Child and Baby laboratory's database in Uppsala, Sweden. The inclusion criteria were twofold. Firstly, the child had to be enrolled in the first semester of Förskoleklass (reception year) in the municipality at the time of the study. Secondly, both the child and one of their parents had to be available to attend a laboratory session at Uppsala University between August 2022 and January 2023.

5.2.2 Ethical Considerations

In accordance with ethical guidelines (Swedish Research Council, 2017; Declaration of Helsinki), all procedures received approval from the Swedish Ethics Review Authority (approval number: Dnr 2022–01163–01). Written informed consent (Appendix 2) was obtained from parents and verbal assent from children prior to every task in the data collection process. To further protect participant confidentiality, all original names were replaced with pseudonyms during data processing. Pseudonyms were used for all data types (eye-tracking recordings, behavioral measures of math affect, and visuospatial working memory scores) to facilitate tracking of parent–child dyads while maintaining anonymity. In addition, all data were stored on encrypted, password-protected servers accessible only to authorized research personnel. The linking key between pseudonyms and the original identities was stored separately and securely, and was destroyed once the analyses were completed. Together with the removal of any additional identifying information prior to analysis, these measures meant that only aggregated data were reported.

5.2.3 Experimental Design and Procedure

The researcher followed a standardized protocol for each child–parent dyad. The protocol will be described now, and each measure used next so as to improve readability of this text. While the parent completed paper versions of the self-reported affect measures (adult math anxiety, reading anxiety, and general anxiety (PANAS-GEN) scales, the researcher engaged the child in an interactive rating task designed to capture the child's affective relation to math tasks (and reading tasks). After a brief break during which children could select stickers as a reward, the children were invited to a training session in front of an HP laptop. Here, a training task was presented to familiarize the children with the screen-based eye-tracking procedure.

After completing the training session, the children participated in an age-adapted eye-tracking task that lasted, on average, approximately 12 minutes. This task was designed to capture their anticipatory and processing pupil dilation changes while engaging with math and reading stimuli in an age-appropriate format. Subsequently, the parents completed a comparable version of the eye-tracking task following the same format with stimuli tailored to adults. Parents took around 14 minutes to complete the task, with a light-coloured curtain separating the adults' testing area from the ongoing children's session to minimize interference between groups. While the parents were engaged in their session, children were provided with materials such as colour pencils and sticker booklets to play independently.

The eye-tracking tasks consisted of two main stages: the calibration stage and the task sequence stage. The calibration stage is a crucial step in eye-tracking studies during which the system maps the participant's eye movements to specific screen coordinates, ensuring that the device can precisely record where the participant is looking during the experiment. Following calibration, the task sequence stage was executed, comprising several distinct phases. The anticipation phase involved presenting a cue (e.g., an image of dice or letter blocks for the children group) to signal the upcoming math or reading task. The confrontation phase immediately followed, during which the math or reading task was displayed, introducing the participant to the task content. This was succeeded by the processing phase, during which a blank screen was shown to allow the participant time to process the stimulus. Lastly, the responding phase occurred when a speech bubble appeared to prompt the participants to provide their answer orally. Detailed timing and trial parameters are discussed further in each measures' section.

Finally, both children and parents participated in the analogue Corsi-block tapping test. The children completed the forward condition immediately after the parents, and the backward condition was also first completed by the parents and then by the children. This order was maintained to maximize the children's possibility and capability to fully comprehend the task.

5.2.4 Self-Reported and Interactive Measures

One way of measuring affect in Study II was *Adults' self-reports of math anxiety*. Adults completed the first section of the Math Anxiety Scale for Teachers of Preschool (Galeano et al., 2024). Participants rated their agreement with seven statements on a Likert scale (α = .855). The items contained in this scale were described in section 5.1. Two other scales were incorporated into this study's design to facilitate the collection of anxiety-related data while minimizing an explicit focus on mathematical constructs. Reading anxiety was assessed through seven items adapted from the Foreign Language Classroom Anxiety Scale (Horwitz et al., 1986), translated into Swedish and modified to focus on reading (α = 0.808). No additional findings related to this scale are discussed in this project. General anxiety was measured with the PANAS-GEN, a Swedish translation of the Positive and Negative Affect Schedule (Watson et al., 1988), in which participants rated 20 words based on their emotional experiences over the past week. The translation was carried out by native Swedish-speaking developmental psychology researchers affiliated with the psychology department at Uppsala University.

Another way of measuring affect in Study II was *Children's affect towards math* (referred to as math anxiety in the published study). Prior research has revealed that relying solely on self-report questionnaire scores poses significant challenges in capturing the full scope of math anxiety in very young children. For example, Lu et al. (2021) highlighted difficulties in accounting for kindergarten children's partial understanding of items referring to somatic sensations (e.g., fast heartbeat) and cognitive concerns, such as worrying about falling behind peers. To account for these types of problems, some researchers have developed new questionnaires or refined existing ones such as the Abbreviated Math Anxiety Scale (e.g., Primi et al., 2020). However, such instruments may still be too imprecise or complex for preschoolers, as pictorial representations or vocabulary may not be simple enough for their developmental level (see: Krinzinger et al., 2009; Lu, et al., 2021; Primi et al., 2020). Recognizing these limitations, we designed an interactive rating task for preschoolers to capture a more holistic view of affective relations than traditional adapted questionnaires provide.

The *interactive rating task* was grounded in the view that self-reported affect (referred to as math anxiety in the published study) is a multidimensional construct. It incorporated methodological recommendations to support greater internal, external, and ecological validity (Palmér & Björklund, 2024a). The task was tailored to be sensitive to the unique perspectives and needs of preschoolers in Sweden and emphasized a holistic evaluation of affect by integrating open-ended questions that allowed children to express affect freely and make personal choices, thereby fostering agency (Aubrey & Dahl, 2005). The researcher modelled the expected behavior (e.g., demonstrating how to place blocks/dice on a mat) while emphasizing that each child's response was personal. Modelling was combined with playful encouragement (e.g., high-fives) and short interactive prompts to create a supportive testing atmosphere. Tangible manipulatives (e.g., wooden dice and letter blocks) were used to maintain interest and to support clear communication of task instructions (Hunting, 1997). The selection of these manipulatives was deliberate because using objects uncommon to children's everyday experience risks reducing internal validity (Gripton & Vincent, 2021); dice and letter blocks are standard in Swedish preschools and are relevant to early arithmetic and phonological activities (Skolverket, n.d.).

The *interactive rating task* was structured to capture complementary dimensions so that a single placement of the dice or letter blocks on a mat could reflect cognitive, physiological/affective, and social aspects of engaging with mathematics (see Fig. 4). Cognitive demands were elicited via short interactive tasks (play, count, addition with dice) in which the children themselves discussed what type of tasks they can perform with dice and letter blocks. Physiological/affective aspects were sampled via simple emotion judgments and prompts (e.g., "How does he (the emoji on the mat) feel? Social framing was sampled via scenarios about shared activities (e.g., "How much do you like it when someone reads a book to you?"). The researcher illustrated ratings with concrete, contrasting examples to make the affective meaning explicit (for example: "I love swimming because I feel good while I swim; I'd put my block here (orienting towards higher score end)," contrasted with the modelled line used in the session, "I don't think sleeping is as fun, but I still have to do it, like, everyday; so, I'd put the block that represents sleeping over here (orienting towards lower score end)"). These demonstrations ensured children's placements could capture both affective valence (more positive/more negative) and acceptance of necessary but less enjoyable activities, embedded within social frames. More specifically, math and reading activities that occur frequently in the preschool, such as counting and identifying phonemes, thereby preserving ecological validity and the subdimensions (cognitive, emotional, social) indexed by the adult math-anxiety scale.

The procedure of the *interactive rating task* was standardized and child-centered. After inviting the children to sit on the floor by the materials (see Figure 6 below), the researcher and child described a mat (a ruler-like continuum with emojis at each end), and read the numbers on the scale aloud together. Both experimented counting and reading words using the dice/letter blocks, and then the child placed a die or block on the mat to indicate how they rated each domain (numbers/dice; letters/reading). The researcher verbally confirmed each placement (e.g., "You put the die at seven, is that right?"), recorded the confirmed rating in writing, and photographed the mat to document exact positions. Children's placements were coded numerically (1–10). Math ratings (die placements) were then reverse-scored for analysis so that lower rating of math activities could be mapped onto higher math-anxiety scores. An exemplar transcript and a short video clip of the task are provided as Supplementary Material with the published study.

Figure 6 *Modelling die placement on the mat*

5.2.5 Eye-tracking Measures

One of the main motivations for incorporating a pupillometry paradigm in this study was to address the limitations inherent in relying solely on self-reported measures of affect (i.e., the interactive rating task and anxiety questionnaires). While self-reported measures provide valuable insights, they depend on participants' ability to accurately introspect and articulate their emotional and cognitive experiences. This is an issue that has been widely discussed in educational and psychological research (Gaete et al., 2017; Hook & Rosenshine, 1979; Koziol & Burns, 2015). Therefore, in addition to the behavioral and self-reported measures described above, this study employed pupillometry as an integral component of the eye-tracking paradigm to capture physiological markers of emotional arousal and cognitive load. It is important to note that when we refer to a physiological marker here, we do not imply a fixed physiological fingerprint (e.g., as conceptualized in Damasio's theoretical framework); rather, we view these markers as co-occurring physiological processes that accompany mental (cognitive-affective) processes.

Pupillometry, which involves tracking changes in pupil size, provides continuous and objective data on emotional arousal and cognitive load, a particularly valuable asset when working with very young children (Laeng, Sirois, & Gredebäck, 2012). This method builds on a longstanding tradition in cognitive research, where pupil dilation has been used to assess mental effort during tasks such as math calculations (Kahneman & Beatty, 1966; Hess & Polt, 1964). In the case of children, this methodology is particularly innovative, as the fine-grained temporal resolution of eye-tracking offers insights into real-time emotional arousal and cognitive processes while solving math tasks.

Research indicates that pupil dilation not only increases with cognitive effort but also in relation to emotional stimuli (Bradley, Miccoli, Escrig, & Lang, 2008; Henderson, Bradley, & Lang, 2018), with findings suggesting that math-related cues can elicit such pupil changes (Layzer, Shechter, & Rubinsten, 2022). Given that both heightened emotional arousal and increased cognitive load contribute to pupil dilation, our paradigm distinguishes between these sources by recording pupil size during time locked anticipatory and processing phases of the math tasks. During the anticipation phase, increases in pupil diameter (at the group level) are interpreted as reflecting emotional arousal (i.e.: when participants realize they are about to engage in a math task). In contrast, pupillometry measurements taken during the processing phase are linked to the cognitive effort required by the task, and are sensitive to both task difficulty and self-reported affective measures.

Moreover, pupillometry's high temporal resolution (far exceeding that of techniques such as fMRI: Landgraf et al., 2010) allowed us to capture rapid fluctuations in pupil size. This precision enables us to, for example, build comparative linear mixed models (LMMs) that account for the temporality of affective (e.g., math anxiety) effects on pupil dilation, providing nuanced insights into the dynamics between emotional arousal and cognitive effort in our participants. All pupillometry sessions were conducted in a uniform laboratory environment with strictly controlled lighting conditions. For the eye-tracking task, participants were seated at an approximate distance of 60 cm from a screen equipped with a Tobii X3-120 eye-tracker. Tasks were centrally displayed on the screen using a blue hue (RGB #2E9AD6) against a grey background (RGB #848484) in the Calibri font, with the size and luminance of the displayed information carefully calibrated to maintain consistent visual parameters across trials. Participants were instructed to keep their gaze fixed on the screen throughout each session, with the opportunity to request breaks when needed to further safeguard data quality.

5.2.6 Visuospatial Working Memory

In line with the principle of maintaining methodological consistency across participant groups, we employed the same visuospatial working memory task for both children and adults. We used an analog Corsi block-tapping test to assess participants' ability to store and manipulate visuospatial information.

In this task, nine blocks were arranged in a fixed configuration on a table. In the forward condition, the researcher tapped a sequence of blocks at a constant pace (one block per second), starting with a sequence of two blocks. Immediately after the demonstration, participants were tasked with replicating the sequence in the same order. With each correct reproduction, the sequence length increased until the participant failed to recall the sequence accurately on two successive attempts. For the backward condition, participants must repeat the sequences in reverse order. The final score corresponds to the longest sequence correctly reproduced, with possible scores ranging from 2 to 9. These tasks' results were incorporated not as mediators but as predictor variables, allowing us to examine their effect on cognitive load which was indexed by changes in pupil dilation during math tasks processing.

5.2.7 Children's (Pre-Eye-Tracking) Training Session

A children's training session was designed to familiarize them with the structured sequence of the eye-tracking paradigm and to help them understand the distinct phases of the task. Although the training session introduces these phases in a pedagogically adapted order, it effectively prepares the children for the sequence of events in the experimental procedure. The session was divided into two parts. In the first part, children were presented with diverse animal pictures and were instructed to focus on the screen, identify each animal by its name, and withhold their response until a speech bubble appeared (see Fig. 1 in Paper II). This phase served to train the children in maintaining attention and delaying their verbal responses, mirroring the demands of the processing phase of the experimental trials.

After completing 10 animal identification trials, the training progressed to the second part, in which the anticipatory stage was introduced as an additional step. In this phase, children first viewed pictures of dice or letter blocks (the same stimuli used in the interactive rating task) followed by a corresponding math or reading task, a blank screen, and finally, a speech bubble that indicated they could provide their oral answers.

For clarity, note that in the actual experimental procedure, the sequence is as follows: first, an anticipatory phase marked by the appearance of dice or letter blocks to signal the upcoming task; next, a stimulus presentation phase (confrontation) during which they must maintain focused attention; then, an approximately 4-second interval for internal processing and calculation; and finally, a response phase indicated by the speech bubble, at which point participants provide their answers. By clearly delineating these phases in the training session, the children were well-prepared for the experimental tasks, enhancing the quality and consistency of the eye-tracking data.

5.2.8 Eye-Tracking Task and Measures Correspondence

In this study, eye-tracking was employed to capture both affect towards math (i.e., through emotional arousal) and the effect of task difficulty on cognitive load, using pupil dilation as a co-occurrent physiological marker of emotional arousal and cognitive effort. The eye-tracking task was divided into several phases: the anticipation phase, processing phase (subdivided into confrontation and task processing interval), and the responding phase. During the anticipation phase (0–400 ms of each trial), participants viewed a cue indicating whether a math or reading task would follow. This phase was designed to capture potential anticipatory changes in pupil dilation, where increased pupil dilation could indicate emotional arousal linked to math anticipation or self-reported affect (e.g., math anxiety). The processing phase was subdivided into two main periods, confrontation and task processing interval. Both participant groups first encountered the math or the reading task and then engaged in solving it. Importantly, participants in both groups were randomly exposed to different levels of task difficulty during the confrontation phase (400-600 ms of each trial). For both groups, pupil dilation measured during the confrontation phase reflects the initial cognitive load associated with task processing. The task processing phase was liable to the effect of task difficulty. By which, including a self- reported measure of affect towards math in the study design, we were able to statistically test the effect of both task difficulty and self-reported affect towards math during the processing of math tasks' phase.

For the children, math easy trials involved addition tasks with addends up to 6, while difficult trials involved sums resulting in totals up to 9. The reading trials included two-letter words in the easy condition and four-letter words in the difficult condition. These words were rated by five native Swedish speakers based on their ease of decoding and pronunciation. Both math and reading trials were piloted to ensure they elicited the intended level of challenge. The adult math tasks were organized into three difficulty levels: easy trials consisted of single-digit multiplications (multiplicands times 2 or 3), medium trials involved multiplications of single digits by 5 or 6, and difficult trials required solving two-digit multiplications (with numbers below 19 multiplied by 8 or 9). Reading tasks were drawn from diverse sources to represent increasing levels of complexity: the easy condition comprised words of up to five letters taken from a preschool book; the medium condition featured words with more than seven letters sourced from a middle school book; and the difficult condition involved words exceeding nine letters, selected from a teacher's training manual. These words were also rated by native Swedish speakers and were tested across three piloting opportunities along with the math tasks to ensure that the assigned difficulty levels corresponded with the study's levels of difficulty categorization.

After the confrontation with the task, participants were shown a blank screen (Task Processing Interval: 600-1000 ms of each trial) before being prompted to respond. During this period, pupil dilation continued to reflect cognitive effort during task processing. Given the initial random exposure to varying difficulty levels, this phase allowed us to assess how cognitive load changed across tasks of different difficulty levels. We expected that higher difficulty levels would be associated with greater cognitive load, as indicated by increased pupil dilation. Succeeding task processing, participants were prompted to provide an oral response. This stage was not analyzed directly in this study, though it is of interest for future research regarding emotional and cognitive dynamics during math tasks processing and their relation with performance accuracy. Through this detailed design, we were able to measure pupil dilation changes from the baseline (set 200 ms prior to each phase) to the analysis window for each phase (anticipation, confrontation, and task processing interval) in both groups.

5.2.9 Pilot Studies and Task Design Optimization

We conducted a series of pilot studies to optimize our experimental design and fine-tune task difficulty levels, ensuring that the easy, medium, and difficult conditions reliably elicited distinct performance challenges across both age groups (as detailed in the section above). Additionally, given the high sensitivity of our eye-tracking equipment to participant movement, we established a minimum of 20 trials per domain (math or reading) exceeding the 16 trials suggested by Orquin and Holmqvist (2018) to ensure robust stimulus representation and adequate statistical power. In one of the pilots with adult participants, where 40 trials per condition were examined, we observed that an extended task duration could lead to participant fatigue and diminished motivation, threatening the external validity of the data. Recognizing the distinct needs of our diverse age groups, we tailored the trial structure so that preschool-aged children completed 10 easy and 10 difficult trials for each domain, while adult participants engaged in 10 easy, 10 medium, and 10 difficult trials per domain. Trials were presented in a randomized order to secure an unpredictable alternation of difficulty levels, mitigating order effects and preserving internal consistency. Overall, these pilot studies were instrumental in refining our protocol and balancing methodological rigor and data quality with the need to maintain participant engagement.

5.2.10 Study II's Methodological Alignment with Thesis Aims

Study II was designed to contribute directly to the primary aim of this thesis: furthering knowledge on preschool and preschool class-age children's affective relations to mathematics, specifically in a controlled laboratory setting. While Study I examined teachers' math anxiety as a potential influence on children's early mathematical experiences, Study II focused on capturing children's physiological, psychological and behavioral engagement with structured math tasks.

The methodology of Study II reflects the interdisciplinary framework of the thesis, addressing also the secondary aim of investigating affective relations to mathematics from different theoretical and methodological perspectives: pupillometry was used to capture co-occurring physiological markers of affective and cognitive processes and complementary behavioral measures, which allowed children to express affective, cognitive and social dimensions of their relation to mathematics in an age-appropriate manner. Together, these instruments offered insights linking moment-to-moment physiological changes with self-reported affect.

The design and piloting of tasks ensured that all measures were developmentally appropriate and valid for preschool class-aged children. Training sessions, calibration phases, and task sequencing prepared children to participate of the experimental tasks, while the use of familiar manipulatives (e.g., dice and letter blocks) supported clarity and ecological relevance. Methodological rigor, including standardized procedures, randomized trial orders, and trial optimization, supported the reliability of the collected data. Adult participants provided comparative data, allowing for a cross-age perspective on affective relations to mathematics and highlighting the developmental specificity of math tasks anticipation and processing. By situating the laboratory study within the larger framework of the thesis, Study II complements the survey- and preschool-based research in Studies I and III, together forming a comprehensive investigation of preschool and preschool class-age children's affective relations to mathematics across contexts, methods, and theoretical perspectives.

5.3 Methodology in Study III

Study III was designed to investigate how children and early childhood educators display and respond to affective stances while they explore mathematical concepts and operations. This study contributes to the thesis's primary aim of furthering knowledge on preschool children's affective relations to mathematics in the preschool setting, as well as to the secondary aim of examining affective relations from different theoretical and methodological perspectives. Both aims were in this case realized within the LA/EMCA framework, which was used to analyze how affective stances are interactively achieved by participants in naturally occurring math-related activities. In this way, Study III provides preschool-context evidence that complements the thesis's overall mixed-methods design.

The strength of Linguistic Anthropology and Ethnomethodological Conversation Analysis lies in their detailed, fine-grained analysis of the sequential and multimodal organization of social action, sensitive to how participants use talk, gesture, gaze, posture, and prosody as semiotic resources to accomplish social meaning (Goodwin & Goodwin, 2000; Deppermann & Schmidt, 2021). Goodwin and Goodwin's contributions in the field of Linguistic Anthropology focus on the study of naturally occurring social interactions and the ways in which people use semiotic resources to construct meaning and make sense of their social worlds (Goodwin & Goodwin, 2000). They examine various aspects of human interaction, including talk, embodied communication, and the handling of objects. Their work has been influential in understanding how individuals engage in social practices, negotiate meaning, co-construct their identities in everyday interactions, and use emotional/affective practices as resources to achieve social action. Researchers within LA explore various aspects of social interaction and communication in diverse contexts.

One influential EMCA researcher is Elizabeth Couper-Kuhlen, whose work tackles emotion in talk-in-interaction in terms of *affect displays* that are situated, localizable with reference to ongoing activities, and specific to particular local sequential contexts. It follows that one of the ways of studying affect in interaction is to single out types of sequential contexts, and examine empirically what kinds of displays are found to occur within them (Couper-Kuhlen, 2012, p. 454). Together, these perspectives offer a framework for Study III's focus on preschool mathematics interactions, enabling the examination of how teachers and children co-construct affective stances moment-by-moment in real-world settings. These methodological choices couple with EMCA's commitment to uncovering the multimodal and sequential organization of affect as a socially situated phenomenon.

Data for Study III consist of video recordings of authentic preschool mathematics activities, providing a source of naturally occurring interaction for multimodal analysis. The analytic focus is on how teachers and children co-produce affective stances during mathematical tasks, such as counting, measuring, or spatial play, and how these stances contribute to the ongoing mathematical meaning making processes. Overall, this methodological framework allows for an in-depth analysis of how early mathematical engagement and related affective experiences are co-constructed, thus contributing to furthering the knowledge on how children's early affective relations to mathematics are shaped by classroom interactional practices.

5.3.1 The Preschool

In Study III, I video recorded interactions between teachers and students in a preschool located in an area where mainly families with a Swedish background live. The purpose of these recordings was to capture naturally occurring math-related activities where children and educators participated together in everyday educational settings, such as mealtime, play, and structured learning activities. To select a suitable site, we first contacted five preschool principals in one of Sweden's larger cities. Educators responsible for activities with the school's five-year-old children were invited to complete previously validated math, reading, and general anxiety scales (the same scales used in Study II). These instruments helped us choose a preschool characterized by a diverse set of educator's relations to mathematics within the same teaching team.

Two of the five preschools expressed interest in participating. I visited both sites on December 4, 2023, to discuss ethical and practical aspects of the study with the principals and teachers. In these meetings, we deliberated on the appropriate length of each daily visit, their preferences for the length of my presence in the preschools (first as a silent observer, then as a video-recorder) and explained the consent procedures for the teachers. Following these conversations, consent forms were distributed to the teachers, and we developed a protocol for reaching the children's legal guardians. This included posting a photo of me with basic study information (Appendix 3, 13.2) at the preschool entrance so parents/legal guardians could recognize me. A printed information sheet about the project (Appendix 3, 13.3) and a QR code to digitally sign the consent forms were displayed as an optional mechanism of response.

During the month of December, printed consent forms for children's participation were distributed by teachers at the end of the day. At one of the preschools, approximately 90% of the legal guardians signed and returned the consent forms within two weeks, whereas fewer than 50% responded at the second preschool. A follow-up round of distribution at the latter site did not improve the response rate, and the teachers suggested this reflected limited interest. Based on this, I proceeded with data collection only at the first preschool.

The selected preschool's indoor layout consisted of two dressing rooms, a main room, and several adjoining spaces organized for different activities. One dressing room was directly connected to the main room (Figure 7) and used for storing children's shoes and coats, while the second, (located downstairs, see Figure 8) was reserved for snow boots and overalls to facilitate outdoor transitions.

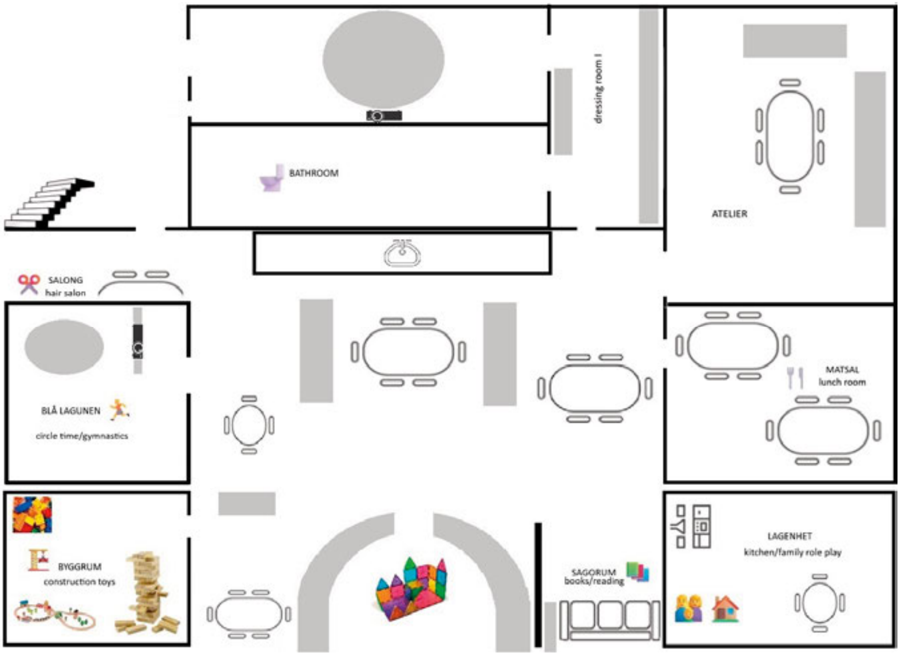

Figure 7. *Indoor layout of the preschool.*

The main room contained access to a sink with storage cabinets, four tables of different sizes (seating 4–8 children each), and shelves with basic materials (glue, pencils, rulers, sharpeners, paper). A section of the room was delimited by cabinets holding magnetic construction sets, next to a corner sofa with books available for free or guided exploration during storytelling time (SAGORUM). Another corner of the main room was arranged as a hair salon (SALONG) with chairs and role-play toys.

Connected rooms further diversified the activity spaces. A building room (BYGGRUM) with Lego and other construction materials; a room with a whiteboard, projector, and circle rug used for gatherings and free play, including gymnastics with mattresses and stairs (BLÅ LAGUNEN); and a room with a wooden toy kitchen, utensils, small tables, and a baby bed for role play (LÄGENHET). Finally, a connected dining room included two tables and a shelf where glasses and plates were stored during lunch time (MATSAL).

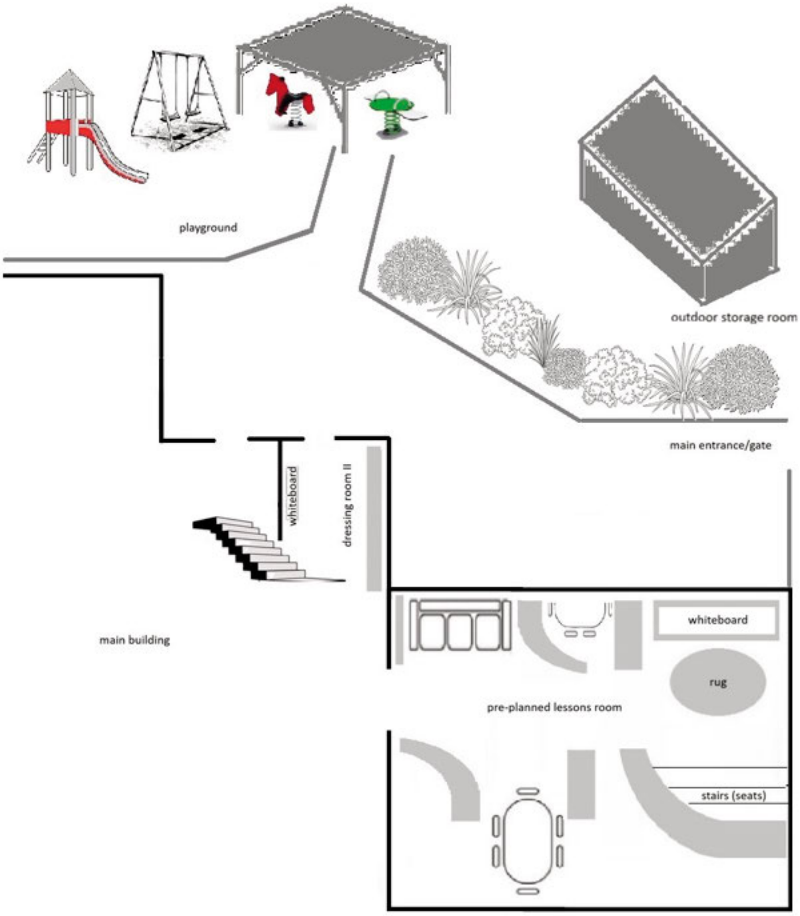

Figure 8. *Location of the preschool's pre-planned sessions room in relation to the playground.*

Below the dining room, there was a room where the five-year-old children were separated from the younger children for pre-planned learning sessions connected to the goals established in the preschool curriculum. Figure 8 shows the location of that room in relation to the available playground as both were located at the bottom floor.

5.3.2 Participants

The selected preschool was led by two preschool teachers (one male and one female) who organized daily activities for 20 children aged 3–6 (seven girls). Both teachers had completed preschool teacher education in 2016; however, the male teacher had begun working as a substitute as early as 2010. He was designated as the main curriculum-responsible teacher for the group. The female teacher had been part of the preschool pedagogues' team with this age-group for three years at the time of data collection.

Participating children were those attending the preschool between January 8 and 19, 2024. Silent observation was conducted between January 8 and 12 while the field notes were taken. The recordings were then made between January 15 and 19.

5.3.3 Ethical Considerations

The study received approval from the Swedish Ethical Review Authority (Dnr 2023-03796-01). Consent procedures were implemented at multiple levels: written informed consent was obtained from teachers and children's legal guardians (Appendix 3. 13.3—13.5), and assent was actively sought from children before and during participation. During data collection, I continuously negotiated consent and monitored participants' comfort, in line with recommendations that consent should be viewed as a negotiated and ongoing process rather than a single event (Christensen & Prout, 2002).

Recordings were paused on two occasions when participants appeared uneasy (e.g., a child staring attentively at me as I approached the area where they were playing). These practices reflect a reflexive posture toward the ethics of video-based research, consistent with Flewitt's (2005) emphasis on attending to children's perspectives, confidentiality, and the researcher's impact on interaction. In this way, the final dataset captured authentic mathematics-related interactions while respecting ethical standards for research with young children.

Video data were handled with confidentiality and anonymization protocols. Recordings were stored securely in a password protected server, and identifying features were removed during transcription and analysis. Names were replaced by pseudonyms and pictures were converted to negatives or penciled-line images.

5.3.4 Ethnographic Field Notes and Reflections

A crucial part of this study was remaining flexible and responsive to the everyday rhythms of the preschool environment to ensure ecological validity. The goal was to video-record naturally occurring math-related interactions between educators and children taking place in a preschool. To accomplish this, it was essential for the researcher to first become an element in their everyday environment, causing the least amount of disturbance possible. As agreed with the teachers, I began with a week of participant observation without video recording to acclimatize teachers and children to my presence. During this time, I took ethnographic notes to reflect on how my presence shaped the context and interactions. Those field notes were consulted to develop the reflections presented in this section.

I attended the group from 9–11 in the mornings and joined one lunch routine. During this week, a teacher student completing her practicum was also present, occasionally joining activities with the children. She was present for the whole observation week and one day during the subsequent filming. During participant observation, I noted that daily routines followed a rhythm. Around 9 a.m., once most children had arrived, teachers and children shared a fruit snack. A teacher distributed the fruit to the students one to one, but the ongoing conversations often included all present students engaging in comparisons of fruit size, color, and who in the group was hungrier. At times, this snack occurred in a circle-time format; other times, it took place in the hallway near the exit to the playground so that children could simultaneously prepare to go play outside.

Teachers emphasized that, weather permitting, mornings were spent outdoors, either in the playground or on excursions to the nearby forest. Outdoor play mixed free exploration with teacher-led group games, though participation in these games was always voluntary. Indoors, children had opportunities to freely choose activities, either individually or in self-organized groups. Teachers moved around the main room, offering support with tasks such as cutting paper shapes or checking the spelling of names under drawings.

Transitions between activities, including excursions, were structured around lining up while counting, or singing. Teachers also engaged the children with questions about the environment, for example by asking them to speculate about why snow beneath a tree appeared yellow while the group was on its way to the nearby forest.

Through this participant observation period, there was no clear division of teacher roles in terms of supporting specific activities. Instead, teachers planned each week and day broadly in advance, assigning responsibilities for key activities based on the number of children and adults expected to be present. Overall, this planning enabled teachers to remain flexible and responsive to children's initiatives and unexpected events, such as staff absences. The teachers also explained to me that once a week, the five-year-old children were separated from the larger group to engage in more structured, pre-planned curriculum-related activities. One such session was selected for video recording, and teachers shared their planning of this lesson with me in advance (Appendix 13.6). Following this initial observation week, I returned with the cameras to begin video data collection.

5.3.5 Video Recordings and Data Screening

Data collection procedures were implemented to balance ecological validity with analytic rigor: recordings were made with two cameras and sessions were scheduled to minimize disruption or regular activities in the preschool. One of the cameras was always hand-held and used most of the time (ca 4,5 hours), except for the recordings of the pre-planned activities for which a second camera was set on a tripod (ca 2 hours).

The full data set comprises 42 video clips. The first set of 34 clips was collected over four consecutive days—Monday through Thursday—in January 2024, focusing on regular preschool activities without a pre-planned subject focus, allowing for the documentation of spontaneous interactions between children and teachers. The second set of 8 clips was collected on a Thursday in March 2024, and includes both pre-planned activities centered on mathematics and literacy, as well as spontaneous interactions occurring outside the scope of the structured lessons. The pre-planned mathematics activities were filmed using two camera angles, one handheld camera and one stationary camera placed on a tripod. This approach resulted in a holistic representation of the preschool context, encompassing both routine and teacher-guided aspects of daily preschool life while also providing varied perspectives on specific interactions. The total amount of video is 5 hours, 12 minutes, and 22 seconds, where footage with two angles is regarded as one clip. Number of clips and their length per type of activity are displayed in Table 1.

Table 1. *Number of video-recorded clips and their length.*

Type of activity	Number of clips	Total length
Spontaneous	34	03:25:45 (ca 4h)
Pre-planned	8	01:45:37 (ca 2h)

The video material was systematically organized and screened using an inventory designed to capture both descriptive and contextual features of each recording. Each video clip was logged with basic metadata, including clip identification number, day it was recorded, duration of clip, and reference to the corresponding transcript file. To situate the interactions within the preschool context, additional information was added regarding the physical setting (e.g., dressing hall, playground, meal table) and the number of participants present during the recorded episodes.

Beyond these descriptive parameters, the screening also included interpretive dimensions. Researcher 1 categorized each clip according to whether it contained pre-planned teacher-initiated mathematical activities (as reported by the teachers to researcher 1, see appendix 13.6) or an episode of spontaneous interaction in the preschool. For every recorded clip, short annotations summarized the nature of the activity (e.g., having lunch, playing with snow buckets, tea-time house play), the mathematical content or practice being engaged with (e.g., counting number of children present, comparing and describing size), and salient affective or embodied aspects of interaction (e.g., use of gesture, modulation of voice, posture). These elements were annotated by researcher 1 in relation to the flow of the ongoing sequence, with particular attention to the moments preceding and following the focal action in order to understand how such affective features and mathematical activity emerged in interaction and how the participants oriented to them. The purpose of the screening was to help both researchers structure the data to identify potential sequences of interest.

Following the initial screening of the material, Researcher 2 reviewed the entire video data set using the inventory developed by Researcher 1 as a starting point. While the inventory provided a structured overview of each recording, Researcher 2's task was not to verify the existing annotations, but to identify potential *episodes of analytic interest* based on observable displays of mathematical engagement and affective stance. This phase was thus partly guided by the inventory and partly inductive, allowing new instances to be noted when relevant features emerged that had not been emphasized in the original screening.

At this stage, both researchers worked independently to mark sequences that were simultaneously math-related in the broad, observable sense of involving quantities, comparisons, or spatial relations, as well as affect-laden, that is, displaying affective stance through verbal, prosodic, or embodied means (e.g., tone of voice, laughter, bodily orientation, or gestures). Through this process, a total of 17 focal sequences were jointly selected for further analysis, representing spontaneous and pre-planned activities (11 and 6 sequences, respectively) involving both children and teachers. These episodes constituted the empirical foundation for the fine-grained multimodal analysis presented in Study III. The combination of structured data organization and inductive identification enabled an analytic balance between systematic overview and openness to emergent interactional phenomena. The independent identifications were then compared and discussed in a series of consensus meetings to resolve disagreements and refine the inclusion criteria. Some of the sequences were also presented and discussed at seminars within the *Child Learning and Identities as Interactional Practices* research group at Uppsala University.

The ethnographic notes and preliminary screening revealed recurrent tendencies across both planned and spontaneous activities. For instance, counting and quantification appeared in both contexts whether in the form of naming numbers, comparing quantities, or using counting as a shared routine (e.g., countdowns, tallying present children). Children displayed heightened affect when engaging in mathematics, using emphatic voice ("JÄT-TEMÅNGA snäckskal"), bodily movement, and laughter to value quantities or sustain participation. Teachers likewise mobilized affect and embodied conduct (gestures, countdowns, prosodic modulation) to manage attention and organize group involvement. Participation was co-constructed in the sense that children also initiated mathematical talk, completed teacher utterances, and collaboratively repaired or extended number sequences.

Yet, certain tendencies clustered around planned activities, such as extended math talk (e.g., measurement, ordering, units) and tighter teacher control over task boundaries and appropriate child behavior. Spontaneous episodes, by contrast, often featured mathematics emerging opportunistically from the environment (e.g., counting shells appearing in the snow, or noticing that two children have the same name by stating "Två Ellen") and affective displays that opened space for mathematical engagement. These patterns align with prior research distinguishing child-initiated and teacher-initiated mathematics (Delacour, 2013), opportunities for mathematical exploration in both spontaneous and planned activities (Björklund, 2017), and the role of bodily engagement for younger children (Franzén, 2015). Hence, although the wider corpus contains both planned and spontaneous activities, paper III's analysis does not treat these as analytic categories. Instead, the comparison across the corpus helped sensitize us to the different interactional ecologies in which affect becomes consequential for mathematical activity. These tendencies informed our understanding of affective practices in specific contexts, but paper III's analysis focuses on how affect functions interactionally within the chosen extracts rather than on comparing activity types.

5.3.6 Study III´s Methodological Alignment with Thesis Aims

Study III contributes directly to the primary aim of the thesis by investigating how affective relations to mathematics are cooperatively constructed in natural preschool settings. While Study I and Study II explored teacher and children's intra-level affective relations to math, Study III addressed the interpersonal, interactional processes through which affective stances towards mathematics activity are negotiated in the preschools.

The study's use of LA/EMCA provided the methodological arm of the project that attends to multimodal, sequential, and interactional construction of affect in naturally occurring preschool contexts. This approach adds a complementary theoretical and methodological perspective that directly addresses the thesis's secondary aim too. That is, showing how these specific analytic lenses illuminate aspects of affective relations that are different from those accessible via surveys or physiological measures. Methodologically, Study III balanced ecological validity and analytic rigor as video recordings of naturally occurring preschool math-related activities were collected with procedures designed to minimize disruption and preserve authenticity. Data were transcribed and analyzed using established multimodal Conversation Analysis conventions (combining Jefferson, 1984 with Mondada, 2018). Analytic checks (e.g., cross-coding, iterative transcription reviews, data seminars) supported the trustworthiness of the findings. By doing so, Study III supplies interactional evidence of how teachers and children co-produce affective relations to mathematics in everyday practice, thereby completing the triad of contexts (survey, lab, preschool) and enabling the thesis's combined exploration of intrapersonal and interpersonal processes.

5.4 Metatheoretical Mapping of Studies (I-III)

Here, I return to Hannula's matrix to map the methodological choices made across Studies I–III. In Chapter 3, Hannula's three-dimensional metatheory (2012) was introduced as a heuristic to organize the conceptual diversity of math-related affect research. There, I used it to situate the theoretical perspective of this thesis in its third dimension, which spans physiological, psychological, and social accounts of math-related affect (this thesis, p. 35). More specifically, the Theory of Constructed Emotion (Barrett, 2017; 2025) and LA/EMCA (Goodwin & Goodwin, 2000; Couper-Kuhlen & Selting, 2017), discussed in Chapter 3, established how this thesis approaches affect as simultaneously embodied, psychological, and social.

This mapping makes visible how the thesis was designed to sample complementary dimensions and timescales of affect (embodied/physiological, psychological, and social; state and trait) rather than confining itself to a single cell. Using Hannula's heuristic as an organizing device, Figure 9 shows where each study primarily sits within the field of math-related affect. The goal is not to force studies into rigid categories but to display their main focus and to further clarify what each method contributes. The mapping also shows my deliberate integration of methods to capture affect as a multidimensional, situated phenomenon.

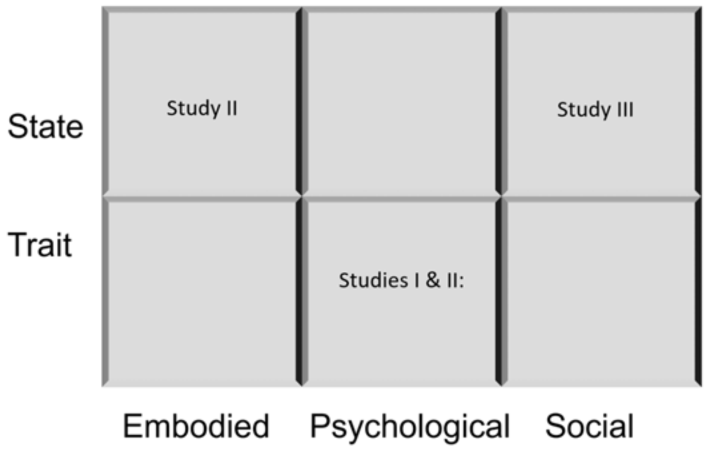

Figure 9. *Mapping the thesis' study of math-related affect within the third dimension in Hannula's (2012) metatheory: emotion.*

Figure 9 positions this thesis within the emotion dimension of the math-related affect metatheory (Hannula, 2012) rather than within the beliefs or motivation dimension (see Figure 1). In this column, the studies span across the embodied, psychological, and social levels. Below, I list each study's primary placement, the aspects it samples, the timescale involved (trait or state), and key limits of this mapping to bear in mind.

Studies I and II address psychological traits of math-related affect (mathematics anxiety) through self-reports (surveys and the interactional rating task used with the children). Study II investigates embodied dimensions of affect through pupillometry. Study III examines emotions as *affective stances* that are cooperatively constructed in social interaction. The thesis engages in this manner with trait-level phenomena (more stable orientations, as in math anxiety surveys) and state-level phenomena (situated arousal and interactional stances) (Hannula, 2012; 2020). This mapping already shows the multidimensional scope of affect in the thesis. Here, affect in mathematics education is not confined to one explanatory level or timescale, but examined across physiological, psychological, and social dimensions, and across states and traits.

Moreover, the survey instruments used in Study I and II address cognitive, physiological and social dimensions of general math anxiety. In Study I, the instrument also accounted for anxiety related to teaching mathematics, representing cognitive and physiological components embedded in social situations such as talking about mathematics, and explaining mathematical concepts to a group of children, or doing so while being observed by the preschool principal. Similarly, the Frequency of Pedagogic Actions Scale captured habitual social/practice aspects of math teaching. Both instruments are retrospective self-reports (trait orientation).

Study II employed an interactive rating task that sampled cognitive, affective/physiological, and social aspects of engaging with mathematics. Children completed short interactive tasks with dice and blocks (cognitive), made simple emotion judgments (affective), and responded to socially framed scenarios (e.g., playing a game with dice, or shared reading). Although the interactive rating task was originally published as a measure of math anxiety, in the thesis it is conceptualized as indexing broader affective relations to math-related activities. In Study III, the embodied dimension of affect was analyzed through the transcription of *multimodal* (embodied) resources used in interaction (LA/EMCA), contained within the unfolding of cognitively demanding math-related activities (state orientation). It is therefore that this matrix initially helps clarify which methodological choices were used to capture different facets of math-related affect. However, limiting the mapping of the studies only to the emotion dimension without the further clarifications presented above, would be misleading.

Importantly, it would overlook two core assumptions of the theoretical framework that also guided methodological choices of this thesis, and were presented in section 3.7: (a) that neural resources used to construct individual instances of emotion overlap with those that shape other mental states, such as thoughts, beliefs, and memories (Duncan & Barrett, 2007; Gendron & Barrett, 2009, p.318; Barret, 2009b, p.1291) and (b) that those general-purpose neural systems, involved in memory, perception, and *interoception*, dynamically construct emotions within social and cultural contexts (Gendron & Barrett, 2009). The decision to combine self-reports, pupillometry, and interaction analysis in this thesis project was therefore not arbitrary. It intended to probe multiple sources and timescales that contribute to early math-related affect in coherence with a psychological constructionist perspective on emotion (Theory of Constructed Emotion), in which emotions are understood as emerging from the dynamic integration of bodily signals, conceptual knowledge, and contextual/social cues (Barrett, 2017). LA/EMCA, in turn, provided methods for analyzing affective practices as an inherently interactional phenomenon, aligning in important respects with the contextual and *relational* notions embedded in Barrett's account of constructed emotions.

Chapter 6. Summary of Results

This thesis project was primarily exploratory in nature. The design of Study I and II was informed by prior findings on the low yet prevalent levels of math anxiety across cultures, age groups, and math ability (Foley et al., 2017). Additionally, we considered the time-bounded socio-cultural characteristics of Swedish preschools, including reports of math anxiety among preschool teachers and student teachers in Sweden (Shamoon, 2014; Palmer, 2009). We also explored potential gender differences in math anxiety, both among preschool teachers (Geist, 2015; Vos et al., 2023) and in children's self-reports. In considering children's age groups, we took into account research suggesting that math anxiety tends to increase with age (Dowker et al., 2016), but also reports that highlight a contrasting trend, noting stronger math anxiety already in the early years of primary school (Barroso et al., 2021). Reports of math anxiety in preschool-aged children (Petronzi et al., 2019a; 2019b; Szczygieł & Pieronkiewicz, 2022) in geographically proximal countries raised the possibility of this phenomenon also being present in the Swedish samples in our studies.

6.1 Study I

Study I provided normative measures and allowed for population-level predictions. The MAST-P teacher measures captured distributional patterns of anxiety that were related to the teacher's math teaching and math talk frequency. With this data, we could identify which educator subgroups and preschool settings showed the strongest relations between anxiety and (lack of) practice.

Until now, no publication had reported math anxiety levels of preschool teachers in Sweden using a validated scale. In our sample, certified preschool teachers scored 14.97 (SD = 7.84, range = 1–35) on General Math Anxiety and 12.69 (SD = 6.75, range = 1–35) on Math Teaching Anxiety. Caregivers reported slightly higher general math anxiety (16.05, SD = 8.34, range = 1–35) and significantly higher math teaching anxiety (15.20, SD = 7.42, range = 1–35; $p < .001$, $r = .208$). Differences in Frequency of Math Teaching (teachers: 4.03, SD = 0.92, range = 1–5; caregivers: 3.88, SD = 0.72, range = 1–5) and Frequency of Math Talk (teachers: 53.52, SD = 8.38, range = 1–75; caregivers: 54.48, SD = 8.99, range = 1–75) were small and not statistically significant.

Consistent with Ganley et al. (2019), we found that teachers working exclusively with younger preschool groups reported higher math anxiety across all MAST-P items. This suggests that working with younger age groups may be associated with greater discomfort around mathematics, even within early childhood education contexts. Despite the fact that male teachers made up only 7.4% of the sample, they reported teaching math more often than the female teachers in our sample. This effect should be interpreted cautiously due to the small number of male teachers in our sample.

In our predictive models, higher General Math Anxiety (GMA) was linked to lower frequency of math teaching, explaining an additional 3.2% of the variance. Math Teaching Anxiety (MTA) also predicted lower teaching frequency when considered alone, adding about 2% to explained variance. When both were included together, neither emerged as a unique predictor, which indicates overlapping effects. However, as the model containing both predictors remained significant, it can be stated that together they still explained 3.21% of the variance in teaching frequency.

Teachers working with both younger (1–3) and older (4–6) children talked about math more often than those working only with older children. Higher GMA was linked to less frequent math talk, adding nearly 4% explanatory power; MTA added about 5%. As with teaching frequency, including both types of math anxiety together resulted in overlapping effects: neither was uniquely significant, but together the model explained about 5.3% of the variance. For caregivers, no statistically significant predictors were found, suggesting that math anxiety does not explain their reported teaching or math talk in the same way it does for certified teachers. This may be due to differences in professional roles or perceived responsibility for pedagogical quality, ideas presented in the published study.

In practical terms, when we say *math anxiety explains some of the variation*, we mean that if you lined up all teachers from *frequently teaches/talks about math* to *rarely does so*, part of what differentiates them is their anxiety level. Teachers with higher math anxiety tend to be further toward the *rarely* end. Contextual factors, such as gender of the teacher and age group taught also matter, but anxiety effects are consistent (Galeano et al., 2024). These findings reflect patterns in this particular population and are not intended as causal claims.

6.2 Study II

Study II supplied high temporal resolution physiological measures that disaggregated anticipatory and processing stages of children's engagement with math tasks. Demonstrating through this disaggregation that objective task difficulty reliably drives physiological indices of cognitive load even in very young children, while physiological arousal as an index of anticipatory anxiety was not evident (Galeano & Gredebäck, 2024).

Until now, no publication had reported preschool class children's physiological indices of math-related affect and cognitive load. In the published study, descriptive statistics show that the children (M_{Age} = 5.67) reported slightly higher math anxiety (M = 2.93) than adults (M = 2.35), though direct comparisons are complicated by different scale ranges. Because children and adults responded on different numeric scales (children: 1–10; adults: 1–5), I rescaled the children's mean to the adult metric using a linear transformation:

$$\text{Rescaled} = \left(\frac{x - A}{B - A}\right) \times (D - C) + C$$

For our specific case:

$$\text{Rescaled} = \left(\frac{2.93 - 1}{10 - 1}\right) \times (5 - 1) + 1$$

The children's mean (2.93 on 1–10) becomes ≈ 1.86 on the 1–5 metric, whereas adults' mean remains 2.35. Thus, on a comparable metric adults report higher math anxiety. This rescaling must be interpreted cautiously because differences in item wording and response formats may affect comparability. Linear rescaling assumes the two scales map linearly and that endpoints correspond conceptually. Because question wording, and response formats between instruments, and children's and adults' comprehension depth can differ, cross-age comparisons even after rescaling should be interpreted cautiously. Preferably, using measurement-invariance testing or common instruments (when possible) for stronger claims.

Children also had lower visuospatial working memory scores (Forward: M = 4.90; Backward: M = 4.67) compared to adults (Forward: M = 6.02; Backward: M = 5.83), consistent with developmental expectations. Pupillometric measures revealed smaller mean pupil dilation in children during both anticipatory (M = −0.10) and task processing intervals (M = 0.12) relative to adults

(Anticipation: M = −0.04; Processing: M = 0.14), reflecting physiological baseline differences.

Affect and pupil dilation: Children's math anxiety scores were not significantly associated with either anticipatory pupil dilation (0–400ms) or task processing (400–1000ms). This indicates that physiological arousal primarily reflected task difficulty (cognitive load) rather than pre and on-task anxiety (emotional arousal). This should be interpreted in light of the specific task design and developmental stage tested.

Working memory correlations: Forward and backward visuospatial WM scores were positively correlated ($r = .32$, $p < .05$), confirming these measures capture related cognitive capacities. Neither WM measure, however, was significantly associated with affect (math anxiety), suggesting that anxiety as measured in this study does not relate to these cognitive processes in preschool class-age children.

Parent–child affect (anxiety) link: Children's math anxiety was not significantly correlated with parental math anxiety ($r = .02$, $p = .84$). This suggests that, in this sample, early math anxiety may be relatively independent of parental anxiety, a potentially important finding for our interpretation of intergenerational effects in this sample.

Task-related pupil correlations: Pupil dilation measures across task stages were highly intercorrelated (e.g., processing interval vs. confrontation with task, $r = .96$, $p < .001$), confirming that these physiological indices consistently track physiological arousal over time. Importantly, across children, task difficulty reliably drove pupil dilation, demonstrating that the method captures variations in cognitive load even at very young ages.

Together, these findings portray a developmental snapshot in which some preschool class-age experience measurable math-related challenges, reflected in slightly higher self-reported affect (published as anxiety) scores. The children group showed increased pupil dilation changes in relation to task difficulty, and anticipatory physiological arousal signals were minimal and non-significant. Further, no evidence for a relation between children's and parents' anxiety was found. Hence, it was inferred that children do not yet seem to exhibit a clear coupling between affective relations to math, cognitive capacity, and parental anxiety.

6.3 Study III

Study III was informed by local evidence regarding teachers' roles as socializers and children's roles as co-creators of moral and emotional order (Cekaite & Ekström, 2019; Cekaite, 2020), which played an informing role in our close examination of teacher-student interactions in the pre-school. Likewise, our analysis of affective stances in teacher-student mathematics related meaning making processes, where emotions are analysed as interactional achievements (as emerging through social engagement), draws on Goodwin et al.'s (2012) suggestions that speakers' emotional stances are performed in specific social and sequential contexts, where emotions emerge as socially responsive acts and are consequential for future interactions. The key point being that emotion is an inter-subjective phenomenon rather than an intra-subjective phenomenon.

Until now, no publication had reported on affective practices in math-related activities in the Swedish preschool. Study III shows, through the selected extracts, three interrelated results. These results remain extract-based and illustrative, but they show how teacher responses to children's affective initiatives become locally consequential in mathematics-related activities. First, the analysis shows that alignment and affiliation practices appeared across both spontaneous and pre-planned mathematics-related activities. In the sequences analyzed, teachers displayed alignment and varying degrees of affiliation in both type of contexts. Second, the analysis shows that when teachers did align and affiliate with children's affective stances in the spontaneous activities, these responses were more likely to develop into shared, embodied affective practices (as illustrated in Extract 1). These are multimodal, coordinated interactions (e.g., joint pointing, shepherding, choral counting, animated prosody/facial expression). In Extract 1 (the Eleven Wings sequence), an initial display of disengagement is transformed into a joint embodied counting practice that progresses pedagogically toward writing the numeral. Taken together, these interactional moves suggest how affective practices can shape the trajectory of a single, local spontaneous math activity. Third, the sequences show that downgraded or delayed responses (e.g., repair initiation, withholding uptake) tended to steer activities toward maintaining institutional and pedagogical goals, reducing opportunities for joint embodied affective participation (as illustrated in Extracts 2 and 3). These dynamics preserved task focus or moral order, but offered fewer opportunities for shared affective engagement.

These results are derived from the selected sequences and are meant as analytic insights into interactional possibilities rather than generalizable patterns across all preschool settings. While both spontaneous and pre-planned activities in our small sample contained these dynamics, a finer-grained comparison of the sequences suggests that teachers' embodied involvement was more prominent in spontaneous activities, where touch, joint pointing, and shepherding contributed to shared embodied affective practices. By contrast, in the pre-planned activities analyzed, teachers more often relied on verbal prompts, with comparatively fewer embodied uptake opportunities. This suggests a difference in the affective quality of engagement in the analyzed extracts. Responses to affective stance displays indexed three roles of affective work in the sequences studied (1) supporting engagement, (2) initiating embedded correction, and (3) indexing moral work. We treat these as analytic characterizations of the affective work in the selected sequences, not as exhaustive categories for all preschool mathematics. Across these roles, responses also varied along a preference continuum—from immediate, affiliative, and aligning responses to delayed, mitigated, and repair-oriented ones—shaping how engagement and participation unfolded locally.

Chapter 7. General Discussion

This General Discussion integrates the empirical findings in the thesis to argue that affective relations to mathematics start forming early, are situated in interactional contexts, and matter for the didactics of math education. In this discussion I have included the published findings, but also analytic interpretations that extend beyond the published papers, and data/results that are part of manuscripts in preparation. Wherever a result is not yet published I explicitly mark it so the source is clear.

This thesis set out to deepen our knowledge of early affective relations to mathematics in Swedish early childhood education by focusing on (i) preschool teachers' self-assessments, (ii) 5–6-year-old children's physiological, psychological and behavioral engagement with math tasks, and (iii) everyday mathematical activity in the preschool classroom. Together, the three empirical studies produce a layered account of how affect is (co)constructed and made consequential in early childhood mathematics education. Framed through an early childhood mathematics education lens, the results emphasize that the preschool teacher does not simply introduce mathematical activities but actively shapes and negotiates the relational conditions under which young children encounter and explore mathematics. The empirical base assembled here shows three interlocking points:

(a) Action frequency matters: Teachers' affective relations to mathematics (math anxiety, math teaching anxiety) are related to the frequency of pedagogic actions that bring mathematics into children's everyday preschool lives.

(b) Context matters: Teacher's and children's affective relations to mathematics are situated and interactionally constructed in particular contexts of practice (spontaneous talk, gatherings, planned teaching situations, excursions).

(c) Task temporality matters: Anticipation and processing phases of math tasks can be empirically separated (via pupillometry) and in preschool class-age children, pupillary dilation is driven primarily by task difficulty, rather than math-related affect. This indicates that children's physiological arousal and engagement with math is context-dependent, and shaped by the immediate demands of the task.

Therefore, instead of treating affect towards mathematics as a peripheral variable, or an internal trait that teachers or children carry with them, this thesis proposes that affect can be treated as emergent, situated, and consequential for children's mathematical experiences in the preschool. The thesis contributes to the didactics of mathematics education by showing that affective relations (e.g., teachers' emotional orientations and interactional responsiveness to children's affective stances) are a constitutive element in the didactics of math education and should be treated as a teachable object in teacher education and curriculum design. Making sure that affect is recognized as a relevant part of didactics is the central claim that this thesis defends. The following sections discuss the empirical findings (7.1) theoretical contributions (7.2), methodological advances enabled by this account (7.3), and how these insights call for a relational view of affect in education (7.4).

7.1 Empirical Findings and Contributions

Across the three studies, the findings collectively demonstrate that affective relations to mathematics are dynamic, socially situated processes that shape early educational experiences. Teachers' emotional orientations shape the opportunities children encounter (Study I) while interactional practices determine if those opportunities foster engagement with the mathematical tasks, and affiliation between the participants or not (Study III). Physiological data further suggest that pupil dilation in children is tied more to task demands than to affective dispositions, reinforcing the view that affect emerges and is made meaningful in context (Study II). These patterns display the pedagogical significance of affect as part of the didactics of math education.

Teacher affect and pedagogic actions: Study I provided the first population-level benchmarks for math anxiety and math teaching anxiety among Swedish preschool teachers and caregivers. The principal quantitative finding in Study I was an inverse relation between certified preschool teachers' math anxiety and the frequency of pedagogic actions that involve mathematics: teachers reporting higher math anxiety reported less frequent math teaching and math talk. This relation remained consistent in predictive models that also accounted for gender of the educators, and the age of children in the groups (Galeano et al., 2024).

High/low math-anxiety settings and situational patterns: When we examined teachers' math-talk frequencies across different preschool scenarios, specific situations (gatherings and situations designed specifically to teach math concepts) showed negative relations with teachers' math anxiety across all areas of mathematics. For counting and geometry, excursions also showed negative relations. We interpreted these results as indicating the presence of higher- and lower-anxiety settings in the preschool. Settings where teachers attempt to teach explicit mathematical content may induce higher anxiety and thereby reduce teacher-initiated math talk, whereas spontaneous everyday talk may permit lower-threat opportunities for mathematical interaction (Klibanoff et al., 2006; Von Spreckelsen et al., 2019; Galeano et al., 2024).

Interactional affordances and spontaneity: This insight was followed up in study III, where the repeated observations of video recorded data pointed to a need for comparison between spontaneous and pre-planned mathematics' activities in the preschool. Study III illustrates similarities but also differentiated types of alignment and degrees of affiliation between teachers and children across these settings. In the manuscript III extracts, the patterns found reinforce the interpretive thrust that spontaneity and interactional affordances matter for whether mathematical content is realized in low-threat ways (e.g., through alignment and affiliation or through alignment and a math task focus with reduced affiliation) and in parallel or not with socialization of moral behavior (e.g., Cekaite & Evaldsson, 2020; Holm Kvist, 2018). These are extract-based observations rather than population-level claims. They also raise further questions about teachers' need for support in discovering how to balance play-care and teaching-learning practices, a matter of prior reported concern stated by preschool principals (Sundström's, 2025).[6]

Caregivers' vs certified teachers, a differential pattern: A notable empirical puzzle in study I was that the inverse relation between math anxiety and frequency of math talk appeared in the certified teachers' group but not in the caregivers' (preschool pedagogues) group. Possible interpretations include: (a) ambiguity in responsibility distribution (who is expected to be responsible for math teaching) which may interact with teachers' certifications and roles; (b) selection effects (some individuals select roles in early childhood education to avoid in-depth engagement with mathematics); and (c) differences in training, pedagogical content knowledge (Jenßen et al., 2021; Geist, 2015) and levels of confidence in math ability. These hypotheses point to specific measurement needs in future research (role definitions, pedagogic content knowledge measures, task allocation) to further test explanations for the observed group differences. They also resonate with Sundström's (2025) findings, where principals pointed out the complexity of new role distributions as preschool policies are translated into enacted practice and Hildén et al.'s (2021) reports of collegial discussions being needed to develop teacher agency

[6] These Study III-related inferences are grounded in the selected sequences; broader generalization will require more data.

and handle tensions between curriculum goals and child-centred pedagogy, and between teacher responsibility and team traditions.

At a first glance, the use of trait measures as a research tool in Study I might suggest a more stable individual affective characteristic (i.e., math anxiety) urgent to remediate in teachers alone. However, the findings also showed that the consequences related to these measurements are context-dependent. Correlations between teachers' math anxiety and math talk were negative across contexts. However, in structured teaching situations such as gatherings and planned lessons, correlations tended to be larger in magnitude than in more spontaneous activities, suggesting that the relation between teacher anxiety and math-related pedagogic actions may be more evident in certain types of preschool activities. This descriptive pattern is consistent with the thesis' claim that even more stable (i.e., trait level) affective dispositions are enacted through situated practices and mediated by the ecology of preschool interactions. The absence of this relation among caregivers further points to the role of institutional expectations and distributed responsibilities in shaping how affect translates into pedagogical actions. Beyond institutional role structures, affective relations to mathematics unfold over time, both developmentally and within the temporal structure of math tasks. Study II addressed some relevant aspects of this temporal dimension.

Developmental dynamics and temporality: Prior research (e.g.: Lyons & Beilock, 2012a; Young et al., 2012) has focused on school-aged children or adults, leaving a critical gap in understanding how anticipatory processes manifest in early childhood. In Study II, we examined anticipatory and processing phases of math task performance in preschool class-age children. Consistent with prior literature on cognitive load and pupil dilation (Beatty, 1982; van der Wel & Van Steenbergen, 2018), task difficulty reliably predicted increased pupil dilation in children, whereas math-related affect effects were not observed in either phase. This pattern suggests that children's physiological engagement with math is primarily driven by the immediate cognitive demands of the task, and highlights the context-dependent nature of early math engagement.

Although not a primary aim of Study II, no correlation between parents' and their children's affect (i.e., math anxiety) was found ($r = .02$, $p = .84$). This null result is noteworthy in light of discussions about the intergenerational transfer of math anxiety (Maloney et al., 2015; Zhang, 2023). As parental self-reported affect (math anxiety) was not significantly correlated with children's affect in this dataset, then environmental, school-based, and interactional mechanisms (teachers' practices, peer interactions, classroom affordances/opportunities) become primary candidate explanations for shaping early affective relations to math to a greater extent in this population. This aligns with the thesis' relational and situated perspective on affect that aims to account for teachers' orientations and pedagogical and interactional practices, as they may offer greater explanatory power for children's early affective relations to math within the Swedish context sampled here.

Responses to affective stances are consequential for engagement: In Study III's analyzed extracts, we saw fine-grained evidence that affective stances and interactional resources (e.g., prosody, gesture, gaze or embodied practices and material arrangement) are integral to the emergence of opportunities to engage with mathematics in preschool. Multimodal interactional analysis revealed how affect is co-constructed in interaction, that is, the sequential arrangements and the ecology of semiotic resources that make both alignment and affiliation between the participants, and engagement with mathematical meaning making processes more or less possible. The findings reported in manuscript III add to our understanding of the intertwining of cognitive and affective dimensions in math-related interactions. For instance, how affect-laden turns serve to frame joint math-related activities (Galeano and Norén, in prep.). I propose—based on the analyses in manuscript III—that interaction analysis can demonstrate that teachers may align (e.g., direct or deflect their attention to ongoing actions) with children's affective stances initiatives, and thereby scaffold emergent affiliation or disaffiliation processes during math-related meaning making in the preschool.

In sum, Study I provided normative benchmarks showing that teachers' self-reported math anxiety is inversely related to their reported frequency of math teaching and math talk (Galeano et al., 2024) and that situational features of preschool practice shapes how anxiety relates to pedagogic action. Study II showed that pupillary dilation in very young children is driven by task difficulty, and that pupillometry does not capture a clear anticipatory arousal signature in preschool class-age children (Galeano & Gredebäck, 2024). Study III (manuscript III) illustrated how moment-to-moment interactional practices, (whether teachers align and affiliate to children's affective initiatives in spontaneous and pre-planned activities) shape the trajectory of mathematical activities in the analysed extracts from interactions in the preschools (Galeano & Norén, in prep.). The empirical findings from the three studies carry implications for theory, or how we conceptualize the role and function of affect in mathematics education. Also, for method, in terms of what using mixed methods buys us, and for practice, discussed here as implications for teacher education and everyday pedagogic design.

7.2 Theoretical Contributions

This thesis shows that affective relations to mathematics can be understood as emergent, socially situated, and (co-)constructed. Children's experiences of mathematics are inseparable from the relational environment/ecology of the preschool: from teachers' orientations and pedagogic practices (Galeano et al., 2024) to the micro-interactional affordances of everyday activities (Galeano and Norén, in prep.). While children's physiological engagement (e.g., pupillary dilation) is sensitive to task difficulty, it is not a straightforward marker of negative affect among preschool class-age children in this context, emphasizing the experience related contextual and relational nature of early affective engagement with math tasks (Galeano & Gredebäck, 2024).

These findings fit Barrett's claim that bodily signals (such as pupil dilation) are not pure markers of specific emotions but are interpreted within context, shaped by the body's state and the conceptual knowledge children bring to the situation. Moreover, Barrett's model is congruent with a developmental perspective, as it conceptualizes physiological, cognitive, and social elements of emotion as dynamically interrelated and shaped over time (Barrett & Theriault, 2025; Barrett et al., 2025). Her framework makes room for the idea that more easily detectable (more stable, e.g., perceivable at group level albeit accounting for variability) physiological components of anxiety might emerge later in life, after repeated experiences with mathematics. Study II results hence match Barrett's emphasis on emotion concepts as learned and predictive, as the absence of extended exposure to formal mathematics schooling matched the absence of anticipatory physiological markers, giving prominence again to the important role of experience and situated conceptualization in the process of forming affective relations towards mathematics as a subject.

Affect towards mathematics in this period of life may be primarily shaped in the social-interactional domain, as indicated by the LA/EMCA findings in Study III. It may also only later in life manifest in anticipatory physiological patterns, once repeated experiences with schooling and math-related challenges have taken place. Such findings are consistent with developmental and reciprocal models of math anxiety and math performance (e.g., Carey et al., 2016) and provide support for this thesis' proposal that early affective relations are emergent, socially situated, and constructed from experience, rather than pre-determined by innate abilities or individual differences in *trait* math anxiety. Recent meta-analytic evidence (Pelegrina et al., 2025) is also consistent with this view, showing that affect (specifically math anxiety) is only moderately stable early on but becomes increasingly trait-like with age (with apparent stability declining as the test–retest interval lengthens), and that affect and performance exert reciprocal prospective influences of comparable magnitude over time (Pelegrina et al., 2025). Taken together with these findings, this thesis supports a developmental picture in which experience shapes affect and affect guides subsequent engagement and achievement. In this thesis, I interpret that later ‘trait-like’ profile as the developmental consolidation of situated affective practices rather than an innate disposition. Thus, in agreement with the overall constructed-emotion (psychological constructionist + social constructionist) perspective of this thesis, which views physiological signals as contextually interpreted, rather than fixed markers of emotion.

The LA/EMCA analyses in Study III further illustrate how affective relations are co-produced in real time through teachers’ and children’s responses to each other’s’ affective stance initiatives. Rather than treating affect as an individual state, the analyses document how different response practices—upgrading, downgrading, or delaying affective involvement—accomplish distinct interactional actions, such as reengagement, repair, and moral work, with direct consequences for children’s opportunities to participate in mathematical activities.

Across the analyzed sequences, teachers’ responses to children’s affective initiatives achieved or indexed different forms of alignment and affiliation. Upgrading affective stances combined with shared counting practices supported reengagement in mathematical and other ongoing activities (e.g., drawing). Downgrading the affective stance, however, still aligned with the children’s answers, but also projected trouble and worked to decrease the children’s embodied involvement in the pre-planned math activity. And finally, delaying the response to a child’s teasing handled the delicate dual task of securing his participation and engagement in an ongoing group counting activity while simultaneously distancing from (disaffiliating with) subversive aspects of the teasing. Consequently, what is noted here, as illustrated in these sequences, is a difference in the affective quality during the mathematical activity. That is, whether affective work achieves and sustains affiliation between the child and teacher through the math-related activity or task and to what degree.

Yet, teachers’ interactive practices do not only promote/demote engagement but also perform normative work. Teachers routinely socialize children into local moral orders (Cekaite & Evaldsson, 2020) and rules about what kinds of behavior (including affective stances and practices) are acceptable in preschool math contexts. When more neutral (e.g., task focused) or verbal-only responses become the norm in a specific context (e.g., in moments planned for mathematical instruction), children may learn that playful affect is less legitimate in mathematical activity. These interactional findings resonate with research on teacher immediacy (Kelly et al., 2015) and math anxiety in older learners. Studies of immediacy in higher-education contexts show that instructors' immediacy cues (verbal and nonverbal behaviors that reduce social distance) are associated with increased intrinsic motivation and decreased quantitative-reasoning anxiety, and that perceived immediacy mediates this effect (Kelly et al., 2015). Conversely, non-immediate or *misbehaving* instructor behaviors (e.g., antagonism and lecturing) have been linked to increased student anxiety via reduced perceived immediacy (Kelly et al., 2020). Although those studies concern older students and different institutional settings, they provide a plausible, theoretically consistent mechanism for interpreting our preschool data.

Embodied, playful uptake (e.g., close proximity, touch, shepherding of the child's hand, animated prosody and facial staging, see Galeano & Norén (in prep.) can be understood as immediacy cues that increase affiliation in the interaction, thereby supporting engagement with mathematical activity. In contrast, verbally dominated and corrective responses (Galeano & Norén, in prep.) function as lower-immediacy moves that maintain social distance and prioritize task order. Such patterned affective regulation practices, though well-intentioned and justified, may, over time, contribute to trajectories of engagement that may have long-term consequences for children's emerging relations toward mathematics, potentially contributing to reduced interest or less positive affective relations towards math in the future (e.g., Oral, 2025). A pedagogically productive balance is thus needed, one that maintains the regulatory functions of order while preserving the embodied, affiliative practices that contribute to make early mathematical engagement affectively rewarding. Importantly, given the small, observational sample, I do not claim causal links to later math anxiety; rather, I propose—based on the analyzed sequences—that the perceived immediacy framework offers a productive hypothesis for future longitudinal and intervention research examining whether early embodied immediacy reduces the risk of developing negative relations toward mathematics over time.

To make this contribution explicit, building on the empirical patterns observed in the broader Study III dataset, and aligned with theoretical accounts of teacher immediacy and affective socialization, I propose the following *working hypothesis*: Teacher immediacy— mediated by embodied, affiliative response practices—increases teacher–child affiliation, which in turn supports children's (re)engagement in mathematical activity. In contrast, lower-immediacy, verbal-only responses may maintain topical alignment while reducing embodied involvement. I further hypothesize—based on recurring observational patterns across the broader dataset—that this immediacy → affiliation → engagement pathway is stronger in spontaneous activities, which afford more embodied co-engagement than pre-planned instructional moments. These propositions outline a program for future comparative and longitudinal research on how early interactional practices may scaffold emerging affective relations to mathematics over time. These interpretations are offered as provisional, given the small, observational sample and the non-experimental design, which do not permit causal inference.

7.3 Methodological Contributions

One of the thesis' key contributions is the use of a mixed methods approach which provides a more multidimensional and comprehensive account of affect in early mathematics education than any single method could. Before Study I was published there were no data about certified preschool teachers and caregivers' in-service in Sweden and their math anxiety and math teaching anxiety scores as measured by a validated scale. To address this gap I translated, adapted and tested an instrument for reliability and construct validity and then connected it to a scale developed to collect teachers' self-reported frequency of teaching and talking about mathematics with the children in their groups (which could be 1–3-year-olds, 3–5-year-olds, or both in smaller preschools). These methodological steps produced psychometric evidence for adapted measures in the Swedish preschool context, and a novel frequency-of-math-talk scale that permitted the statistical testing of relations between teacher affect and pedagogic actions (Galeano et al., 2023). The now published population-level benchmarks include averages of preschool teachers and caregivers' ratings on validated math anxiety and math teaching anxiety scales providing in this way the first Swedish baseline that can be compared to other national and international samples under different curricular and pedagogical organizations. Reflections regarding the items contained in these scales and practical implications for education are discussed partly in paper I and also in section 7.4.1).

Study II provided several novel contributions to the literature on math anxiety and cognitive development. Firstly, it is the first study to use pupillometry to investigate the relations between affect (i.e., math anxiety) and physiological arousal in such young children, specifically at preschool class age (average 5.67 years). By extending pupillometric research, previously applied primarily to adults and school-aged children, to this younger population, we tested an innovative methodological approach that allows continuous, objective measurement of cognitive effort and emotional arousal in children who may have limited capacity to reliably self-report their experiences. Secondly, our approach advanced knowledge in the field by examining not only the effects of math anxiety during task execution but also during task anticipation, enabling the investigation of the temporal dynamics across the different stages. This is relevant because pupil dilation can index both cognitive effort and emotional arousal, which complicates interpretations if changes in pupil size are not temporally disambiguated. The methodological contribution was to separate (a) anticipatory arousal (pupil dilation change during the presentation of a cue indicating an upcoming math task) from (b) processing-related dilation change (pupil size change while solving the math calculation). This design was motivated by the hypothesis that collecting participants' pupil size during the anticipation of math tasks would inform us about the levels of participants' emotional arousal at the moment they realized they would have to solve a math calculation. Thirdly, by pairing self-reports of affect with physiological measures of pupil dilation, we tested the relation between subjective emotional experience and objective markers of physiological arousal. This last point also contributes to bridging the gap between questionnaire-based and physiological assessments, offering a novel interactive rating task to index multidimensional affect (math anxiety in the published study) in early learners.

The combination of pupillometry and behavioral measures allowed to adjudicate competing accounts about when and how anxiety impacts performance: during anticipation, during task processing, or both (Eysenck & Calvo, 1992; Lyons & Beilock, 2012a, 2012b; Young et al., 2012). The child data indicated that cognitive demand (task difficulty) exerts a reliable effect but anticipatory anxiety may be less detectable with the tools and tasks used, or may manifest differently in early development. These findings in the published study were indirectly compared to the findings in the adults' group, which provided evidence consistent with self-reported math anxiety effects in the early stages of task processing (that is, task confrontation: the first moment participants were capable of seeing the mathematical calculation they were to solve). Hence reinforcing the importance of temporally sensitive measures and developmentally appropriate paradigms for studying math-related affect in young children (Lu et al., 2021; Petronzi et al., 2019a).

The weaker pupillometry–age effects observed in the children group (who were attending the first semester of preschool class), also suggest that physiological arousal in young children may be driven more strongly by other developmental confounds. These include the ongoing development of working memory capacity, differing understandings of the symbolic anticipatory cues used in the study (e.g., adults' *M* letter cue vs children's dice picture), and individual differences in baseline arousal regulation. These considerations are not specific to children attending preschool class as an institutional form, but reflect broader challenges in measuring cognitive and affective processes in young children. The field in general needs richer cognitive/affective developmental measures suitable for early childhood populations across early educational contexts. In Study II, we contributed by testing several such possibilities within a pupillometry-based paradigm. In this process, we anticipated that the trustworthiness and generalizability of the findings in Study I and II were tightly linked to the sample sizes, which also affect the broader relevance of the findings when embedded within larger bodies of knowledge on the subject (Schoenfeld, 2002).

In Study III, ecological validity was particularly central, motivating why video recordings were used to capture naturally occurring mathematics activities. This preserved the authenticity of teacher–child interactions and allowed insights into real-world practices beyond controlled laboratory conditions. While Study III did not introduce a new analytic framework, it illustrated the methodological value of EMCA for studying affect in early mathematics education. By operationalizing affect as an interactional achievement and tracing alignment and affiliation practices through multimodal resources, the study demonstrated in selected sequences how sequential analysis can reveal processes that remain invisible to questionnaires or physiological measures taken at a lab. These methodological choices strengthen the ecological validity of the thesis and exemplify how interactional methods, when theoretically informed, can complement other approaches in mixed-methods research to maintain sensitivity to emergent, socially situated phenomena.

Collectively, the methodological choices enabled the thesis to address affect from multiple vantage points capturing population-level patterns, temporal dynamics of physiological measures, and interactional practices. The purpose was to investigate intrapersonal and interpersonal processes connected to different dimensions of affective relations to mathematics that would remain invisible through a single lens. These methods produced distinct but complementary forms of evidence. Questionnaires and scale development (Study I) produce population-level benchmarks, linking teacher affect to self-reported practices, and creating instruments that can be placed in cross-national comparisons for math anxiety level or pedagogical practices frequency prognosis. Multimodal EMCA video analysis (Study III) provided ecological validity and attention to the sequential detail necessary to demonstrate how affect is made relevant (or not) by the participants themselves in interaction; the fine-grained interactional practices that link teacher orientations to children's lived math-related experiences in the preschool (Galeano & Norén, in prep.). In Study II, temporally sensitive physiological measures (pupillometry) let us begin to disaggregate anticipatory arousal from processing-related cognitive effort (Kahneman & Beatty, 1966). When combined with observation and self-reports, pupillometry enriches our understanding of when, how, and in whom affective processes may become relevant for math performance, even when such effects are not directly observable at the behavioral level.

At the same time, each method highlights different limitations and suggests complementary follow-ups (e.g., adding pedagogic content knowledge measures, collecting longitudinal data, making use of richer cognitive batteries, and replicating interactional findings through observations across diverse settings). My methodological approach reflects the exploratory nature of the thesis project, and accentuates the complexity of studying affect as a relational and situated phenomenon.

7.4 Relational Realism and EMCA

Relational realism (Barret, 2006b; 2017; Barrett & Theriault, 2025). 2025) and EMCA offer complementary perspectives that allow us to treat teachers' and children's affective relations to mathematics as situated, interactionally produced phenomena rather than solely as stable individual traits. From a relational-realist standpoint, emotions are not private, fixed dispositions but dynamic states that acquire meaning as they emerge in relations among people, activities, and material arrangements across time. EMCA directs attention to the moment-by-moment talk and embodied practices through which participants display, negotiate, and transform affective stances in interactional practices. Bringing these perspectives together matters for didactics because it reframes both the object of study (affect in math education) and the locus of intervention.

While more traditional approaches to emotion would treat teacher affect (e.g., math anxiety) as an individual attribute (or trait) that might reduce instructional quality or frequency, a relational-EMCA frame highlights how emotions (as states) are performed, recognized, and managed within pedagogic interactions and how those interactional patterns provide opportunities for children to encounter mathematical ideas in the preschool. The empirical findings reported in this thesis illustrate this complementarity: Study I showed small but systematic relations between teachers' reported math (trait) anxiety and their reported teaching and math talk frequency (Galeano et al., 2024), and Study II's temporally sensitive physiological data revealed differing anticipatory and processing (state) patterns in adults versus very young children with no relation to affect in the case of children (Galeano & Gredebäck, 2024). Study III's interactional analyses then supply micro-analytic evidence of the practices through which affective stances are displayed and responded to in preschool settings, and the consequences of this for engagement in mathematical activities. Together, Studies I and II point to the tendency to avoid math content by preschool teachers who score higher on math-anxiety traits, whereas Study III illustrates how the centrality of affective work in supporting children's participation and engagement becomes visible through the subtle, embodied, verbal, and prosodic cues with which teachers align to children's affective stances in everyday preschool interactions.

The theoretical consequence is twofold. First, physiological measures (for example, pupil dilation) and questionnaire scores gain interpretive power when situated within an interactional ecology: they index intra-individual characteristics but can also to some extent inform about the affordances and constraints offered by the contexts the children inhabit daily (in the preschool). Second, didactic interventions that aim to reduce the transmission of negative affect (e.g., math anxiety) could therefore focus less on treating emotions as fixed regulation deficits and more on shaping interactional routines and reflective practices that foreground the preventative potentials of affective work in everyday preschool activities. Practically, this suggests teacher-education activities that combine consideration to (a) conceptual reappraisal of emotions as dynamic and relational, (b) analytic reflection on brief interactional episodes (e.g., affect's role in doing alignment and affiliation in interaction) that make the role of affect visible and actionable. By situating practice in grounded preschool scenarios, such focused measures are likely to increase teachers' awareness of how affective work shapes and is shaped by everyday pedagogic actions.

In short, a relational view of affect points to preventative approaches that treat affective relations as a resource to be shaped and accomplished in interaction rather than a fixed trait to be merely controlled, easily transmitted or reduced.

7.4.1 Practical Implications

The three studies in this thesis converge on a clear practical claim: affect matters for what children experience and learn in early mathematics. Our empirical findings indicate that affective relations to mathematics are emergent, interactional, and consequential for children's early math learning. If affect can be treated as a teachable component of mathematics education, teacher education and everyday practice must pivot toward deliberately shaping the relational conditions for mathematical engagement. Below, I outline exemplar practical implications and concrete recommendations that arise from the three studies.

Study I (MAST-P item-level focus): Study I showed that teacher affect constrains the frequency of math teaching and math talk (Galeano et al., 2024). To make some implications of Study I findings more concrete, I examined the

MAST-P item-level responses (Section 7.1; Supplementary 2). The MAST-P ranking presented here is intended as an exemplar for how practitioners and educators can *identify* context-specific affect and shape targeted interventions, but not as a prescriptive curriculum. As an example, Table 5 lists the seven (out of fourteen) highest-rated items (weighted averages) from our sample.

Table 1 *Highest rated items in MAST-P (Study I).*

MAST-P items in rating order according to weighed averages:	Weighted avg on 1-5 agreement scale	Scale sub-dimension
5. I feel self-conscious if I don't know how to solve a math problem right away	(2.63)	Social/evaluative subdimensions of general math anxiety
7. I would feel nervous if I had to figure out a math problem in front of others	(2.59)	Social/evaluative subdimensions of general math anxiety
11.When I am talking about math, I avoid going into depth about concepts I don't feel comfortable with	(2.38)	Math Teaching Anxiety subdimension
9. I would be nervous teaching math to students in förskoleklass or grade 1	(2.34)	Math Teaching Anxiety subdimension
6. I get nervous when I think my math ability is being evaluated	(2.29)	Social/evaluative subdimensions of general math anxiety
3. When I see a complicated math problem, I worry	(2.23)	Worry (cognitive) subdimension of general math anxiety
4. I get distracted by other thoughts while I am trying to solve math problems	(2.1)	Worry (cognitive) subdimension of general math anxiety

Table 5 includes three items from the social/evaluative subdimension of general math anxiety, two from the math teaching anxiety subdimension, and two from the cognitive worry subdimension.

Examining the items teachers most strongly endorsed suggests specific situations that teacher education programs would benefit from targeting. The following recommendations translate empirical findings into actionable steps to help teachers expand children's opportunities for mathematical engagement. These item-level patterns cluster around social/evaluative anxiety (items 5, 7, 6), teaching-specific avoidance and math knowledge concerns (items 11, 9), and cognitive worry related to task difficulty and distraction (items 3, 4). Practically, this suggests a call for teacher education and in-service training prioritization of (a) reducing performance/evaluation threat, (b) rehearsing responses to spontaneous child questions, and (c) building interactional fluency that supports deeper content engagement.

For instance, teachers expressed concern about teaching mathematics to slightly older age groups (item 9) and reported avoiding in-depth discussion of unfamiliar concepts (item 11). Such avoidance was already evident in the broader results of Study I, but the item-level analysis suggests that MAST-P can serve as a reflective diagnostic tool in teacher education. The tool can also be used with pre-service teachers to reason about the need of mathematics skills above the minimum required to teach in their group levels, and paired with occasions where pre- and in-service teachers put these higher levels of math knowledge to practice. This could help them prepare for addressing questions that go deeper than those they could foresee when planning activities for their preschool groups alone. Importantly, The MAST-P ranking is context-bound and the example presented here is intended as an illustrative diagnostic template. Interventions derived from these items should be piloted and evaluated locally before broad implementation.

Study II (Affective relations & difficulty focus): Study II examined how self-reported affect (math anxiety) and task difficulty relate to pupil dilation (a proxy for emotional arousal / cognitive load) in adults and very young children. The core empirical pattern was clear: task difficulty drove pupillary responses in both groups, but the link between self-reported math anxiety and pupil dilation differed by age. In adults, higher math anxiety was associated with increased pupil dilation during the initial phase of task processing (suggesting an early, anxiety-related spike in cognitive load), whereas in children the math affect (anxiety)–pupil link was absent and pupillary changes related to task difficulty alone. The pattern in the children group was interpreted as either (a) early resilience/enjoyment of mathematical problem solving in these preschool class-age participants, or (b) an indicator of broader, systematic avoidance of math in preschool that delays the emergence of negative affect (anxiety)-related cognitive effects until after more formal schooling begins in this context. However, these findings do not suggest that math anxiety or affect towards math is irrelevant in early childhood; rather they point at educationally important possibilities with distinct practical consequences.

On the one hand, preserving low-threat, play-oriented math encounters align with a preventive focus. Preschool contexts that emphasize play, exploration, and low-stakes problem solving may be helping keep early math experiences enjoyable and non-anxious. Strategies to design frequent, brief, low-stakes math interactions (games, story problems, use of manipulatives) and to introduce challenge gradually while minimizing performance evaluation may contribute to fostering positive affective relations to mathematics and act as a protective buffer against later anxiety.

On the other hand, evaluation threat can be supported by setting transparent expectations, group problem solving, public error-tolerant talk to reframe difficulty as common and informative. For instance, emphasizing process over speed (Ramirez et al., 2018), and establishing classroom norms that decouple mistakes from judgment (Tainio & Laine, 2015). Moreover, sequencing tasks with fine-graded increases in difficulty and scaffolding children's processing (prompting, modelling, visual support) can help reframe challenge as manageable rather than evaluative. Discussing with teachers how to interpret children's signs of load versus distress (e.g., task-related pausing, off-task distraction, avoidance behaviors) and on targeted responses: more scaffolding when load (e.g., difficulty) is high; affect-sensitive support (comfort, modelling) when distress is present. Over time, this might help teachers avoid either (a) removing all challenge (which may stifle learning) or (b) exposing children to evaluative pressure prematurely.

Finally, math avoidance, though not immediately visible, poses a silent risk. Limited exposure may delay anxiety but also weaken foundational skills and reduce later resilience. Teachers can help mitigate this by combining low-stakes, enjoyable math encounters with opportunities that expand children's skills (e.g., practicing how to respond to unexpected questions as opportunities for mutual exploration rather than circumventing or avoiding them). Such balanced exposure could help children develop both competence and tolerance for challenge before formal schooling raises evaluative pressures.

These recommendations derive directly from the empirical pattern in Galeano and Gredebäck (2024) and from conservative inference about developmental trajectories; they are not claims of causation about long-term anxiety development. The study was sample-specific (preschool class-age children in Uppsala) and used pupillometry as a proximate measure of arousal/cognitive load. Both aspects counsel local piloting before broader changes are implemented. Yet, Study II can be used as a principled guide for preventive, scaffolded, low-threat practice, and local evaluation.

Study III examined how teachers' responses to children's affective stance initiatives shape engagement and participation in math-related activities. The findings illustrate that affective work is consequential for alignment and affiliation practices and also for the trajectory of mathematical activities, and that spontaneous activities afford more embodied co-engagement than pre-planned ones. These results point to the importance of recognizing that affect is not only a component of eventually measurable fixed traits, but that it is also situated within—and accomplished through— interactional practices, relations, and local mathematical contexts, thereby contributing to the social actions in which it is embedded.

Rather than prescribing specific affective strategies, these results suggest the value of sensitizing teachers to the role of affect in shaping mathematical engagement. The extract-based approach in Study III (detailed multimodal and sequential analysis of representative examples) could be further developed into reflective tools that help teachers notice how affective practices emerge in real time and how they matter for participation and engagement in their own teaching. Such tools would not aim to teach predefined behaviors but to sensitize teachers to the relational conditions that shape mathematical activity. At the same time, the study highlights the need for more research on affect in early math education, particularly across diverse contexts and populations. Future work should examine how age, gender, ethnicity, and social class intersect with affective practices, and how these dynamics play out in different educational settings. Such research can further inform teacher education and curriculum design by showing the relational conditions that support both engagement and participation in early mathematics teaching and learning.

7.5 Concluding Remarks

Early interactions with mathematics can significantly influence an individual's educational trajectory and career choices (Sokolowski & Ansari, n.d.; Szczygieł & Pieronkiewicz, 2022); Baas, 2020). Positive early math experiences can foster confidence, curiosity, and a sense of competence (Fitz & Price, 2025; Gashaj, et al., 2023; ten Braak et al., 2021). Negative experiences, particularly those involving or eventually resulting in math anxiety as a measurable *trait*, can lead to immediate and long-term avoidance and disengagement (Shabab, 2024; Kyttälä & Björn, 2022; Pizzie & Kraemer, 2017). Math anxiety, if not addressed, can diminish a child's willingness to engage with math-related subjects (Lau et al., 2024). This reluctance can limit opportunities for practice and development of critical mathematical skills and math content knowledge. For example, by reducing children's help-seeking behavior (Wang, Zhang, & Pellicioni, 2025), which may hinder later academic performance and/or professional pursuits. Over time, these early affective experiences create patterns that can influence whether students continue their studies in mathematics and related fields, or opt out, ultimately contributing to the persistence of gender and other demographic disparities in STEM representation (Ahmed, 2018; Daker et al., 2021; Eidlin-Levy et al., 2023; Håkansson, 2024).

Education, ideally, serves as a foundation for both competence and positive relations towards learning, targeting to nurture both skills and a genuine interest in and resilience toward effort in subjects like mathematics. For this vision to be realized, early childhood education must provide environments that promote exploration, experimentation, failure, and achievement in mathematics in a way that feels safe and supportive. Children need opportunities to grapple with mathematical ideas in a cognitively and affectively stimulating manner. Such developmental approach aligns with the broader socio-cultural processes that recognize learning as an interactional, relational, and emotional journey. Creating these environments requires educators who understand and address the affective dimensions of learning, which foster children's comfort and confidence with math from the earliest stages.

This thesis contributes to that vision by showing that affect in early mathematics education is a set of complex interactional and relational phenomena that involves both teachers and children. By integrating relational realism and EMCA with empirical evidence from survey, physiological, and interactional data, the work frames affect as both theoretically significant and practically actionable, inviting a shift in teacher education toward shaping relational conditions for mathematical engagement. Looking ahead, continued research across developmental stages and cultural contexts will be essential to refine these insights and design interventions that promote positive affective relations to mathematics from the earliest years. A natural next step would be to integrate these methodological perspectives within a single longitudinal design, following the same children across time. Future studies might, for example, combine video-recorded interaction analysis with teacher recall interviews and physiological or survey measures to provide a more comprehensive account of how affective relations to mathematics emerge, stabilize, and change.

Chapter 8. Sammanfattning på svenska

Bakgrund och syfte

Denna avhandling undersöker affektiva relationer till matematik i svensk utbildning för yngre barn (förskola och förskoleklass). Den för samman psykologiska, fysiologiska och interaktionella metoder för att öka förståelsen av hur yngre barns orienteringar mot matematik och matematiska aktiviteter skapas och upprätthålls. I forskningsfältet matematik och affekt finns en växande samstämmighet om att affekt är grundläggande – inte perifer – för matematiskt lärande och deltagande (Hannula, 2012, 2019; McLeod ,1992). Samtidigt fokuserar mycket forskning på äldre barn, vilket lämnar begränsad kunskap om hur affektiva relationer till matematik formas och stabiliseras före den formella skolstarten (Dowker et al., 2012). Mot bakgrund av förskolans läroplan Lpfö 18, som betonar både barns emotionella utveckling och tidig matematisk utforskning, undersöker avhandlingen lärares affektiva relationer till matematik, barns affektiva och fysiologiska engagemang i matematikaktiviteter, samt affektiva praktiker som görs i vardaglig social interaktion.

Det övergripande syftet var att fördjupa kunskapen om förskole- och förskoleklassbarns affektiva relationer till matematik, i relation till (i) lärares självskattade matematikängslan, (ii) barns samspelsnära engagemang i matematikuppgifter i realtid, och (iii) interaktionella praktiker genom vilka affektiva hållningar och positioneringar visas upp, responderas på och hanteras i vardagliga aktiviteter i förskolan. Ett andra syfte var att belysa hur olika metodologiska och teoretiska perspektiv kan belysa yngre barns affektiva relationer till matematik. Två forskningsfrågor vägledde arbetet:

1. Hur (sam)konstruerar lärare och barn affektiva relationer till matematik i tidig utbildning?

2. Vad bidrar olika forskningsmetoder med i analyser av affektiva relationer till matematik i tidig utbildning?

Teoretiskt ramverk

Avhandlingen förenar en psykologisk konstruktionistisk syn på emotioner med ett dialogiskt perspektiv på emotioner som deltagares hållning eller positionering i social interaktion. Barretts teori om konstruerade emotioner utgör en teoretisk ram och beskriver emotion som en framväxande situerad process som bygger på interoceptiv, konceptuell och kontextuell information (Barrett, 2017), vilket möjliggör att affektiva relationer till matematik förstås som kontextkänsliga, kulturellt formade och utvecklingsmässigt rörliga. Ytterligare en teoretisk ram hämtas från de båda närliggande traditionerna lingvistisk antropologi och etnometodologisk samtalsanalys, där emotioner och affekt inte behandlas som ett intrapersonellt tillstånd utan som offentligt uppvisad affektiv hållning eller positionering, samskapad av deltagare genom löpande samordning av språkliga och kroppsliga handlingar inom ramen för lokala sociala aktiviteter (Goodwin & Goodwin, 2000; Ochs, 1996). Hannulas metateori (2012) används som en heuristik för att lokalisera de olika teoretiska och metodologiska valen i Studie I–III inom det bredare forskningsfältet om affekt. Tillsammans stödjer de olika teoretiska ramarna en metodologisk design med blandade metoder (mixed methods) som kan hantera både intrapersonella (t.ex. fysiologiska indikatorer) och interpersonella dimensioner av affektiva relationer (t.ex. responser på affektiva initiativ) i tidig utbildning — utan att reducera affekt till vare sig bara ett inre tillstånd eller bara en interaktionell process.

Metod

Avhandlingen använder en design med flera metoder: en större enkät till yrkesverksam personal i förskolan (Studie I), laboratoriebaserade fysiologiska och beteendemässiga mått med förskoleklassbarn och en förälder vardera (Studie II), samt detaljerad videoanalys av vardagliga matematikrelaterade aktiviteter i en förskola (Studie III). Designen möjliggör analys av affektiva relationer på flera nivåer — konceptuell, fysiologisk, beteendemässig och interaktionell — samt att följa hur nivåerna konvergerar och divergerar mellan kontexter. Deltagare var förskollärare, barnskötare, barn i förskoleklass och en av deras föräldrar, samt barn 3–6 år i förskola. Samtliga studier etikprövades.

Data och deltagare: I korthet omfattade avhandlingen en kommunal enkät till personal i tidig utbildning (N = 357) med en anpassad lärarskala för matematikängslan samt ett index över frekvensen av matematikrelaterade pedagogiska handlingar (Studie I); en laboratoriestudie med barn i förskoleklass (M = 5,67 år) och en förälder vardera som kombinerade pupillometri med en barnanpassad affektskattning och visuospatialt arbetsminne (Studie II); samt en videoetnografi (> 5 timmar video) inom vardagliga matematikaktiviteter i förskola analyserade med multimodal samtalsanalys (Studie III). Samtliga metodologiska upplägg godkändes av Etikprövningsmyndigheten. Studie I: Dnr 2021-04308. Studie II: Dnr 2022–01163–01. Studie III: Dnr 2023-03796-01.

Studie I–III

Studie I: Lärares matematikängslan och pedagogiska handlingar

Tidigare forskning visar att matematikängslan är vanlig bland personal i tidig utbildning och kan prägla vilka matematikmöjligheter som barn erbjuds i praktiken, men kopplingen till vardagliga förskolepraktiker är otillräckligt specificerad (Jenßen, 2021; Palmer, 2020; Schaeffer et al., 2020; Beilock et al., 2010). I Sverige vilar mycket matematik i förskola på lärarinitierade matematiksamtal i dagliga rutiner, vilket gör det centralt att förstå om och hur personalens egna affektiva relationer till matematik samvarierar med frekvensen av och karaktären på sådana handlingar (Björklund & Barendregt, 2016; Lpfö 18). Studie I använde en anpassad MAST-P och ett frekvensmått för matematikrelaterade pedagogiska handlingar i återkommande situationer (samling, måltider, hall, planerad undervisning, utflykter) i en kommunal enkät (N = 357). Tvåfaktorlösningen (allmän respektive undervisningsnära ängslan) bekräftades. Studien visade att förskollärares matematikängslan hängde samman med lägre rapporterad frekvens av matematikundervisning och matematiksamtal, särskilt i mer strukturerade situationer, medan en motsvarande relation inte framträdde för barnskötare. Detta identifierar en yrkesrollsspecifik möjlig väg genom vilken lärares affektiva relationer formar barns exponering för matematik före formell skolstart.

Studie II: Förväntan och bearbetning av mattetal i förskoleklass

I forskning om äldre deltagare har matematikängslan kopplats både till förväntan (före uppgift) och bearbetning (under uppgift) samt till arbetsminnesbelastning, men tidig ålder och fysiologiska mått har studerats mindre och ofta utan tydlig åtskillnad mellan faser. Studie II prövade därför om (a) föregripande aktivering uppträder inför mattetal, (b) uppgifts-svårighet driver pupillvidgning under bearbetning, och (c) barns barnanpassade självskattning av affekt samvarierar med fysiologiska mått. Resultaten visar att uppgiftssvårighet tydligt driver pupillvidgning under bearbetning, medan föregripande aktivering var minimal i gruppen. Samband mellan barns affektskattning och pupillmått framträdde inte, och ingen korrelation kunde ses mellan barns och föräldrars matematikängslan. Tolkningen är att fysiologiska komponenter knutna till matematikängslan ännu inte är konsoliderade i denna ålder i denna kontext

— inte att affekt saknas — och att lokala ekologier i förskola/förskoleklass är viktiga för hur affektiva relationer tar form.

Studie III: Affektiv hållning i förskolans matematik

Samtidigt som interaktionell forskning i förskola visar att lärare och barn rutinmässigt förhandlar affektiv hållning eller positionering multimodalt (Björklund et al., 2018; Johansson et al., 2012; Cohrssen et al., 2014), är de affektiva dimensionerna av deltagande i tidiga matematikrelaterade aktiviteter relativt outredda. Studie III analyserade >5 timmar vardaglig matematikinteraktion i en förskola med multimodal samtalsanalys och undersökte hur lärares responspraktiker i samband med barns uppvisade affektiva hållningar bidrar till att organisera deltagande i olika aktiviteter. Tre huvudsakliga sociala handlingar dokumenterades i samband med olika responspraktiker: återengagering när lärare graderar upp barnets affektiva hållning genom att bjuda in till en multimodal räknesekvens i en lekaktivitet där barnet tagit initiativ till att dra sig ur, reparationsarbete och pedagogiska förklaringar när lärare graderar ner barnens affektiva hållning under produktionen av felaktiga svar under en planerad mattelektion, samt moraliskt arbete när lärare fördröjer responsen på ett barns milt retsamma och lekfulla ordlek och därmed värnar normer för deltagande i en gemensam emergent matteaktivitet. Samtliga responspraktiker involverade verbala, prosodiska, kroppsliga och materiella resurser för att demonstrera tillhörighet eller avvikelse från en initierad/pågående affektiv handlingssekvens, vilket möjliggjorde närmande, reparerande eller normåberopande handlingar beroende på vad som stod på spel lokalt. Sammantaget visar resultaten att affekt som interaktionell hållning och koordinerat arbete inte är perifert utan centralt för hur matematikaktiviteter organiseras i förskola.

Samlade resultat

Tillsammans visar studierna att affektiva relationer till matematik i tidig utbildning är relationella, situerade och utvecklingsmässigt emergenta. Studie I identifierar en yrkesrollsspecifik koppling mellan förskollärares matematikängslan och barns tidiga möjligheter att möta matematik. Studie II visar att fysiologiskt engagemang under bearbetning av en matematisk uppgifts hos barn i förskoleklass främst drivs av uppgiftssvårighet (snarare än självrapporterad affekt). Studie III visar att affektivt arbete i matematiska aktiviteter bidrar till olika sociala handlingar beroende på sekventiell kontext och aktivitet. På avhandlingsnivå ger kombinationen av psykologiska, fysiologiska och interaktionella metoder en lager-på-lager-bild av hur affektiva relationer formas, iscensätts och hanteras i tidig utbildning. Teoretiskt länkas en konstruktionistisk emotionssyn till en syn på affekt som multimodal, förkroppsligad och kontextspecifik; metodologiskt visas genomförbarheten och mervärdet av blandade metoder i samband med forskning om och med yngre barn; praktiskt betonas behovet av att ge lärare kunskaper om betydelsen av affektiva orienteringar i samspelet med barn, se affektivt arbete som en kärna i pedagogiken och utforma tidiga matematikmiljöer där kognitiva utmaningar förenas med interaktionella praktiker som orienterar mot och tar till vara barns affektiva engagemang i matematiska aktiviteter.

Betydelse/Implikationer

Teoretiskt konceptualiserar arbetet tidig matematisk affekt som en emergent och relationell prestation snarare än som ett fast personlighetsdrag och för samman situerad analys av emotioner som fysiologiskt och kognitivt konstruerade med situerad analys av affekter som interaktionellt samskapade. Metodologiskt visas att kombinationen av enkätinstrument, pupillometri och multimodal samtalsanalys är genomförbar och insiktsgivande i studier av yngre barns emotioner/affekter i matematikaktiviteter och ger både konvergerande och divergerande fynd mellan analysnivåer. Praktiskt motiverar resultaten professionsutveckling som (i) stödjer lärares egna affektiva orienteringar till matematik, och (ii) framhäver kontextuella, kroppsligt förankrade, och relationsskapande praktiker tillsammans med kognitiv utmaning vid design av tidiga matematikmiljöer.

Begränsningar och fortsatt forskning

Avhandlingens resultat är baserade på data från en kommun och data från studier med observations och labbdesign; ett naturligt nästa steg är en longitudinell inomkohortstudie som kombinerar återkommande videoinspelningar under en längre tid, recall-intervjuer med lärare och barn efter inspelningarna, samt fysiologiska och självrapporterade mått för att pröva hur tidiga interaktionella praktiker konsoliderar—eller buffrar—affektiva relationer till matematik över tid.

Aguyje Mante!

Då

Jag hade precis flyttat tillbaka till Paraguay efter mitt år och ett halvt i Storbritannien. Det var mitt under pandemins början, och jag bodde ensam i en månad. Pappa och mamma kom förbi med mat och kärlek i vardagen — det var faktiskt ganska fint. Jag trodde att det skulle ta lång tid innan jag skulle hitta en doktorandtjänst, särskilt efter att ha tackat nej till en PhD-plats i Bristol.

Två eller tre dagar efter att jag äntligen kunde flytta hem till mamma och mormor publicerade Marcus Lindskog en doktorandutlysning vid Institutionen för pedagogik, didaktik och utbildningssociologi. Han var också psykolog och arbetade vid ett Child and Baby Lab. Dreams *do come true*, va?!

Uppsala lät fint. Jag tänkte: ja, där kan jag se mig själv. En internationaliserad stad där människor "säkert" skulle förstå vad jag sa om jag pratade norska. Jag mejlade Marcus och frågade om det fanns något hans labb ville undersöka mer. Han svarade bara: math anxiety. Det var allt.

De tre veckorna som följde visste mamma och mormor att jag antingen skulle komma ner bara för lunch, middag eller för att träna i vår trädgård. Jag ringde några vänner och sa: “Jag har byggt ett projekt och sökt ett jobb i ett labb i Sverige. De kommer förmodligen inte ens läsa klart min ansökan — men det är okej. Min plan är ändå att flytta till djungeln, undervisa och översätta på distans tills någon svarar på mina ansökningar.”.

Nu

It’s been a bit over 5 years...

“Man, sometimes it takes a long time to sound like yourself.”

-Miles Davis

I like to zoom in and out.

Perspective taking has always been my method,
long before I knew it had a name.

This thesis was written without describing a single lobule of the brain in detail.

Mitt i Mellan

When my first supervisor team fell apart, it was Gustaf Gredebäck who first asked me whether I was going to stay. That question mattered more than he probably knows. Gustaf has repeatedly seen me as a whole person rather than only as a worker, and that way of relating has been central to my motivation and resilience through the most demanding parts of this project. His steady trust and willingness to engage with both my doubts and my ideas gave me the confidence to keep going. For that, I am deeply grateful.

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I understand the trade-off between specialization and breadth in scientific work, and I made the conscious choice of standing in the middle of several research fields. This is because I'm trying to paint a better picture than the ones we already have, which is difficult. My thesis therefore reflects many rounds of discussions among colleagues in the Math Education group, the Uppsala Child and Baby Lab team, and the seminars with Gosia Marschall, Bert Jonsson, and Markku Hannula.

Three networks have also contributed decisively to my work: Studies in Childhood, Learning and Identities as Interactional Practices (CLIP); Preschool and Children: Experiences, Practices, and Development (PACED); and the Nordic Evidence-Based High-Quality Early Childhood Education and Care Research Network for Social Justice. Thank you all for holding patience and making room for a junior scientist full of —sometimes annoying— questions!

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My identity is not defined by whether I manage to momentarily communicate my ideas in a way that is accessible to experts in parallel fields. I always knew this, but sometimes I for*get*. Special thanks to Hanna & Matilda for the constant reminders.

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Lastly, I need to address my family — both of them. Moving to Sweden felt homier knowing that mina Norska föreldrarna Anne-Gurie og Trond Erlandsen were nearby, and that Tante Benthe, Loppa, and Thomas would come by to visit. It has been beautiful to watch Carroe and Fredrick's family grow from a little closer over these years, just as inspirational as watching Carly and Fabi mature as partners and parents while sharing Rosalind Sofía's joy through countless video calls.

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It's not like anyone was expecting me to pursue a PhD, thanks for teaching and reminding me in this and after taking any other decision,

that I'm always allowed to change my mind.

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My sincere gratitude.

Marcus left, mormor dog and Kajsa too.

Now Marcus is back from the boring dark side, and it still feels like my nan and Kajsa never really left. I think of Ati, Clau, Esteban, *Gabriel* and all the seasonal friends... in much the same way.

Workwise, *my hope is that this thesis guides us toward more complex and more specific research questions* — also, to richer avenues for future ***inter-disciplinary*** collaborations. And fun! After all, if anything—I think I was at least partly hired to do this job because of my outsider—foreign—other-worldly vibes.

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Appendices

Appendix 1. Study I

11.1 Pre-school Personnel Survey

I denna enkät kommer du få en rad frågor som undersöker hur du (och dina kollegor) upplever läroplanens olika mål, först allmänt och därefter mer specifikt i relation till språk och matematik. Vi kommer inte koppla resultatet tillbaka till dig som person. Istället är vi intresserade av hur ni som arbetar på förskolan upplever läroplanens olika mål och i vilken utsträckning ni upplever att ni har de verktyg och den kunskap som behövs för att uppfylla de många krav som ställs på förskolan. Kom ihåg att det inte finns några rätta svar, det är först när kunskaps- eller resursbrister identifieras som dessa diskuteras och åtgärdas.

BAKGRUND

Ålder _____

Kön
- Kvinna
- Man
- Icke binär

På vilken förskola arbetar du? _______________

Vad är din position?
- Förskollärare
- Barnskötare
- Annat _____________

Vilken barnåldersgrupp arbetar du oftast med?
- Yngre barn (ca. 1-3 år)
- Äldre barn (ca. 3-6 år)
- Både yngre och äldre barn

Vilken utbildning har du?
Förskollärare med legitimation
Pedagogisk högskoleexamen
Gymnasial utbildning för arbete med barn
Övrig utbildning
- Om ja, vilken ________________

När avslutade du din utbildning? (år) _______

Var tog du din examen? __________________

Hur många år har du arbetat i förskolan (som förskollärare, barnskötare, etc.)?

Hur trivs du på din nuvarande arbetsplats?
Mycket bra
Bra
Okej
Dåligt
Mycket dåligt

TEMAN I LÄROPLANEN

Rangordna följande nio teman från förskolans läroplan (Lpfö18) efter hur viktiga du tycker att de är som uppgifter i förskolan från (1) minst viktig till (9) viktigast.

a. Egen identitet och självständighet (t ex förmågan att uttrycka tankar och åsikter och att få inflytande i klassrummet)
b. Estetiska uttryck och skapande (t ex förmågan att uttrycka sig genom bild, sång och dans)
c. Mångfald och jämställdhet i samhället (t ex barns utveckling av sin kulturella identitet och lärares jämställdhetsperspektiv)
d. Matematik (t ex förståelse för rum, tid och form och förmågan att använda matematiska begrepp)
e. Motorik och fysiskhälsa (t ex barns koordinationsförmåga och kroppsuppfattning)
f. Natur och hållbarhet (t ex en förståelse för samband i naturen och intresse i hållbar utveckling)
g. Sociala förmågor med andra barn (t ex förmågan att kunna samarbeta och förstå rättigheter)
h. Språk, kommunikation (ett nyanserat talspråk och ordförråd och ett intresse för skriftspråk)
i. Teknik och digitala verktyg (t ex förmågan att upptäcka och utforska teknik i vardagen)

Jag har kunskapen och resurserna för att stödja barns utveckling inom detta område. För varje område, indikera i vilken grad du instämmer från (1) inte alls (5) stämmer helt.

a. Egen identitet och självständighet (t ex förmågan att uttrycka tankar och åsikter och att få inflytande i klassrummet)
b. Estetiska uttryck och skapande (t ex förmågan att uttrycka sig genom bild, sång och dans)
c. Mångfald och jämställdhet i samhället (t ex barns utveckling av sin kulturella identitet och lärares jämställdhetsperspektiv)
d. Matematik (t ex förståelse för rum, tid och form och förmågan att använda matematiska begrepp)
e. Motorik och fysiskhälsa (t ex barns koordinationsförmåga och kroppsuppfattning)
f. Natur och hållbarhet (t ex en förståelse för samband i naturen och intresse i hållbar utveckling)
g. Sociala förmågor med andra barn (t ex förmågan att kunna samarbeta och förstå rättigheter)
h. Språk, kommunikation (ett nyanserat talspråk och ordförråd och ett intresse för skriftspråk)
i. Teknik och digitala verktyg (t ex förmågan att upptäcka och utforska teknik i vardagen)

Hur ofta undervisar du inom detta tema? För varje område, indikera hur ofta från nästan aldrig/aldrig, färre är en gång om månaden (1) till alltid, mer än en gång om dagen (5).

a. Egen identitet och självständighet (t ex förmågan att uttrycka tankar och åsikter och att få inflytande i klassrummet)
b. Estetiska uttryck och skapande (t ex förmågan att uttrycka sig genom bild, sång och dans)
c. Mångfald och jämställdhet i samhället (t ex barns utveckling av sin kulturella identitet och lärares jämställdhetsperspektiv)
d. Matematik (t ex förståelse för rum, tid och form och förmågan att använda matematiska begrepp)
e. Motorik och fysiskhälsa (t ex barns koordinationsförmåga och kroppsuppfattning)
f. Natur och hållbarhet (t ex en förståelse för samband i naturen och intresse i hållbar utveckling)
g. Sociala förmågor med andra barn (t ex förmågan att kunna samarbeta och förstå rättigheter)
h. Språk, kommunikation (ett nyanserat talspråk och ordförråd och ett intresse för skriftspråk)
i. Teknik och digitala verktyg (t ex förmågan att upptäcka och utforska teknik i vardagen)

När du genomför aktiviteter inom detta område, är dessa planerade eller mer spontana? För varje område, indikera graden av planering/spontanitet från oftast spontana (1) till oftast planerade i förväg (5).

a. Egen identitet och självständighet (t ex förmågan att uttrycka tankar och åsikter och att få inflytande i klassrummet)
b. Estetiska uttryck och skapande (t ex förmågan att uttrycka sig genom bild, sång och dans)
c. Mångfald och jämställdhet i samhället (t ex barns utveckling av sin kulturella identitet och lärares jämställdhetsperspektiv)
d. Matematik (t ex förståelse för rum, tid och form och förmågan att använda matematiska begrepp)
e. Motorik och fysiskhälsa (t ex barns koordinationsförmåga och kroppsuppfattning)
f. Natur och hållbarhet (t ex en förståelse för samband i naturen och intresse i hållbar utveckling)
g. Sociala förmågor med andra barn (t ex förmågan att kunna samarbeta och förstå rättigheter)
h. Språk, kommunikation (ett nyanserat talspråk och ordförråd och ett intresse för skriftspråk)
i. Teknik och digitala verktyg (t ex förmågan att upptäcka och utforska teknik i vardagen)

I vilken utsträckning håller du med om påståendet att det finns en tydlig samordning från förskola eller kommun kring undervisning och utveckling av aktiviteter som stärker barns utveckling inom detta område? För varje område, indikera i vilken grad du håller med från. Håller helt med (1) till mycket oenig (5).

a. Egen identitet och självständighet (t ex förmågan att uttrycka tankar och åsikter och att få inflytande i klassrummet)
b. Estetiska uttryck och skapande (t ex förmågan att uttrycka sig genom bild, sång och dans)
c. Mångfald och jämställdhet i samhället (t ex barns utveckling av sin kulturella identitet och lärares jämställdhetsperspektiv)
d. Matematik (t ex förståelse för rum, tid och form och förmågan att använda matematiska begrepp)
e. Motorik och fysiskhälsa (t ex barns koordinationsförmåga och kroppsuppfattning)
f. Natur och hållbarhet (t ex en förståelse för samband i naturen och intresse i hållbar utveckling)
g. Sociala förmågor med andra barn (t ex förmågan att kunna samarbeta och förstå rättigheter)
h. Språk, kommunikation (ett nyanserat talspråk och ordförråd och ett intresse för skriftspråk)

i. Teknik och digitala verktyg (t ex förmågan att upptäcka och utforska teknik i vardagen)

LÄROPLANENS MÅNGA MÅL

Här kommer en lista med olika delmål från läroplanen (Lpfö18). För varje komponent, ange hur självsäker känner du dig för att integrera detta delmål i förskolan från Inte alls självsäker. (1) till mycket självsäker (5).

Mångfald och jämställdhet i samhället

Barnet ska ges förutsättningar att utveckla…

1. sin kulturella identitet
2. ett intresse för olika kulturer
3. en förståelse för värdet av att leva i ett samhälle präglat av mångfald
4. intresse för det lokala kulturlivet
5. en förmåga att upptäcka, reflektera över och ta ställning till etiska dilemman och livsfrågor i vardagen
6. en förståelse för demokratiska principer och förmåga att samarbeta och fatta beslut i enlighet med dem

Förskolläraren/arbetslaget ska…

7. medvetet och aktivt inkludera ett jämställdhetsperspektiv så att alla barn får likvärdiga möjligheter till utvidgade perspektiv och val oavsett könstillhörighet
8. uppmärksamma barnen på att människor kan ha olika värderingar som styr deras uppfattningar och handlingar och samtidigt förankra de grundläggandena värdena
9. uppmärksamma och problematisera etiska dilemman och livsfrågor i vardagen
10. samarbeta med vårdnadshavare, samt diskutera regler och förhållningssätt i förskolan med vårdnadshavare, för att främja barnets utveckling till en ansvarskännande människa och samhällsmedlem

Sociala förmågor med andra barn

Barnet ska ges förutsättningar att utveckla…

11. en förmåga att lyssna på och reflektera över andras uppfattningar samt kunna reflektera och ge uttryck för egna uppfattningar
12. en förmåga att ta ansvar för sina egna handlingar och för miljön i förskolan
13. en förmåga att ta hänsyn till och leva sig in i andra människors situation samt vilja att hjälpa andra
14. en förmåga att fungera enskilt
15. en förmåga att kunna samarbeta med andra, kompromissa, reda ut missförstånd och hantera konflikter när de uppstår

16. en förmåga att förstå rättigheter och skyldigheter samt att ta ansvar för gemensamma regler
17. får goda förutsättningar att bygga upp tillitsfulla relationer och känna sig trygga i gruppen

Förskolläraren/arbetslaget ska…

18. samverka i arbetet med aktiva åtgärder för att förebygga diskriminering och kränkande behandling
19. stimulera barnens samspel samt hjälpa och stödja dem att bearbeta konflikter, reda ut missförstånd, kompromissa och respektera varandra.

Egen identitet och självständighet

Barnet ska ges förutsättningar att utveckla

20. ett intresse för samt en förmåga att uttrycka tankar och åsikter så att de kan påverka sin situation
21. sin identitet
22. trygghet i sin identitet samt medvetenhet om rätten till sin kroppsliga och personliga integritet
23. självständighet och tillit till sin egen förmåga

Förskolläraren/arbetslaget …

24. ansvarar för att barnen får sina behov respekterade och tillgodosedda och får uppleva sitt eget värde
25. ska säkerställa att alla barn får lika stort inflytande över och utrymme i utbildningen oavsett könstillhörighet
26. ska inspirera och utmana barnen att bredda sina förmågor och intressen på ett sätt som går utöver könsstereotypa val
27. ska respektera varje barns rätt att uttrycka sina åsikter med olika uttrycksformer samt säkerställa att barnens uppfattningar och åsikter tas tillvara och kommer till uttryck i utbildningen

Natur och hållbarhet

Barnet ska ges förutsättningar att utveckla…

28. ett växande ansvar och intresse för hållbar utveckling och att aktivt delta i samhället
29. en förståelse för samband i naturen och för naturens olika kretslopp samt för hurcmänniskor, natur och samhälle påverkar varandra
30. en förståelse för hur människors olika val i vardagen kan bidra till en hållbarcutveckling
31. en förståelse för naturvetenskap, kunskaper om växter och djur samt enkla kemiskacprocesser och fysikaliska fenomen

32. en förmåga att utforska, beskriva med olika uttrycksformer, ställa frågor om och samtala om naturvetenskap

Förskolläraren/arbetslaget ska…

33. skapa förutsättningar för barnen att förstå hur deras egna handlingar kan påverka miljön och bidra till en hållbar utveckling

Motorik och fysiskhälsa

Barnet ska ges förutsättningar att utveckla…

34. motorik, koordinationsförmåga och kroppsuppfattning
35. förståelse för hur viktigt det är att ta hand om sin hälsa och sitt välbefinnande

Förskolläraren/arbetslaget …

36. ansvarar för att erbjuda en god omsorg med balans mellan aktivitet och vila

Matematik

Barnet ska utveckla…

37. förmågan att använda matematik för att undersöka, reflektera över och pröva olika lösningar av egna och andras problemställningar
38. förståelse för rum, tid och form, och grundläggande egenskaper hos mängder, mönster, antal, ordning, tal, mätning och förändring, samt att resonera matematiskt om detta
39. förmågan att urskilja, uttrycka, undersöka och använda matematiska begrepp och samband mellan begrepp

Teknik och digitala verktyg

Barnet ska ges förutsättningar att utveckla…

40. förmågan att utforska, beskriva med olika uttrycksformer, ställa frågor om och samtala om teknik
41. förmågan att upptäcka och utforska teknik i vardagen

Förskolläraren/arbetslaget …

42. ska utmana barnens nyfikenhet och förståelse för teknik
43. ska försäkra att barnet får använda digitala verktyg på ett sätt som stimulerar utveckling och lärande

Språk och kommunikation

Barnet ska ges förutsättningar att utveckla…

44. förmågan att använda och förstå begrepp, se samband och upptäcka nya sätt att förstå sin omvärld

45. ett intresse för berättelser, bilder och texter i olika medier, såväl digitala som andra, samt sin förmåga att använda sig av, tolka, ifrågasätta och samtala om dessa
46. ett nyanserat talspråk och ordförråd samt förmåga att leka med ord, berätta, uttrycka tankar, ställa frågor, argumentera och kommunicera med andra i olika sammanhang och med skilda syften
47. ett intresse för skriftspråk samt förståelse för symboler och hur de används för att förmedla budskap
48. sina kunskaper om det svenska språket
49. det egna nationella minoritetsspråket, om barnet till hör en nationell minoritet
50. sitt modersmål, om barnet har ett annat modersmål än svenska
51. svenskt teckenspråk, om barnet har hörselnedsättning, är dövt eller av andra skäl har behov av teckenspråk

Förskolläraren/arbetslaget ska…

52. utmana barnens nyfikenhet och förståelse för språk och kommunikation

Estetiskt uttryck och skapande

Barnet ska ges förutsättningar att utveckla…

53. sin förmåga att kommunicera, dokumentera och förmedla upplevelser, erfarenheter, idéer och tankar med hjälp av olika uttrycksformer, såväl med som utan digitala verktyg (bild, form, drama, rörelse, sång, musik och dans)
54. förmågan att bygga, skapa och konstruera med hjälp av olika tekniker, material och redskap

SPRÅK OCH LITTERACITET

Nedan följer ett antal påståenden som beskriver olika aktiviteter och praktiker kopplade till språk och litteracitet i förskolan. För varje påstående, indikera i vilken grad du instämmer från. (1) aldrig till (6) alltid.

Högläsningssituation

1. Jag nämner saker i bilder medan jag läser högt.
2. Jag spenderar tid på att prata om bilderna i böcker.
3. Jag pratar om hur bilderna relaterar till texten.
4. Jag ber barnen att relatera till sina egna upplevelser till berättelserna jag läser.
5. Jag ställer ”V-” frågor till barnen under läsningen (dvs. vem, vad, var, varför).
6. Jag ställer öppna frågor till barnen medan jag läser högt.

7. Jag låter barnen avbryta, kommentarer och ställa frågor medan jag läser högt.
8. Jag lägger lika mycket tid på att prata om den bok jag läser som att läsa den.
9. Jag ber barnen gissa vad som händer härnäst i berättelser.
10. Jag förklarar okända ord när jag läser.
11. Jag använder karaktärsröster medan jag läser högt.
12. Jag pratar om de känslor som berättelserna förmedlar.
13. Jag läste olika typer av böcker (dvs. rim, fiktion, sakprosa, alfabet).
14. Jag väljer böcker relaterade till vad vi gör i förskolan.
15. Jag ber barnen återberätta bekanta historier.

Böcker och text

1. Jag demonstrerar hur text fungerar (dvs. ord läses från vänster till höger, upp till ner, etc.).
2. Jag introducerar böcker genom att prata om titeln, författaren och illustratören.
3. Jag använder mitt finger för att följa ord när jag läser högt.
4. Jag demonstrerar hur böcker fungerar (dvs fram och bak, håll rätt uppåt, vänd sidor från höger till vänster, etc.).

Litteracitet i lek

1. Jag gör saker som att skriva menyer när barn leker restaurang, matlistor när de leker affär eller bokstäver när de leker postkontor, etc.
2. Jag initierar lekar som restaurang, butik, postkontor, bibliotek, skola etc.

Fonologisk medvetenhet

1. Jag läser böcker med rimtexter.
2. Jag demonstrerar de ljud som bokstäverna ger.
3. Jag hjälper barn att ljuda ord (dvs. / s / + / ol / = sol).
4. Jag demonstrerar hur vissa ord slutar med samma ljud (dvs katt, hatt).
5. Jag demonstrerar mönster i ord (dvs. bana, banan).
6. Jag demonstrerar hur vissa ord börjar med samma ljud (dvs pojke, pall).
7. Jag visar rimmönster när jag läser berättelser.

Bokstavskunskap

1. Jag hjälper barnen att bli bekanta med bokstäverna i alfabetet.
2. Jag använder alfabetsböcker med barnen.
3. Jag lär barnen bokstäverna i deras namn.
4. Jag hjälper barnen att skriva bokstäverna i alfabetet.
5. Jag lär barnen skillnaden mellan stora och små bokstäver.

Framväxande läs- och skrivförmåga

1. Jag skriver ner de berättelser som barnen berättar och läser dessa tillbaka.
2. Jag lyssnar medan barnen läser eller låtsas läsa högt.
3. Jag berömmer barnen för deras försök att läsa och skriva.
4. Jag hjälper barnen att läsa enkla ord.
5. Jag hjälper barnen att skriva sina egna namn.

SPRÅK OCH LITTERACITET – TIDSOMFÅNG

Nedan följer ett antal påståenden som beskriver olika aktiviteter och praktiker kopplade till språk och litteracitet i förskolan. För varje påstående, indikera hur ofta du gör detta i minuter under en typisk dag från (1) noll minuter till (6) tjugo eller fler minuter.

1. Jag läser högt för barnen i förskolan.
2. Jag skriver ner de berättelser som barnen berättar och läser dem tillbaka.
3. Jag är inblandad i att läsa och skriva i lek (dvs. hjälpa till att skriva inköpslistor, menyer, recept, kvitton etc.).
4. Jag hjälper barnen att lära sig bokstäver.
5. Jag pratar om förhållandet mellan bokstäver och ljud.
6. Jag visar på ljudmönster i ord (dvs katt, hatt).
7. Jag hjälper barnen att skriva.
8. Jag gör alfabetiska aktiviteter med barn (dvs leker med bokstäver, magneter, pussel etc.).
9. Jag lyssnar på barn som läser eller låtsas läsa högt

VAD TYCKER DU OM MATEMATIK?

Nedan följer ett antal påståenden som beskriver olika aktiviteter och praktiker kopplade till matematik i förskolan. För var och en påståendena, indikera i vilken grad du instämmer i påståendet från (1) ”Instämmer inte alls” till (5) ”Instämmer helt”.

1. Jag svettas om handflatorna och känner mig olustig när jag behöver göra matematiska beräkningar
2. När jag försöker lösa matematiska övningar känner jag mig obekväm
3. När jag ser ett komplicerat mattetal så oroar jag mig
4. Jag blir distraherad av andra tankar när jag försöker lösa matematiska problem
5. Jag känner mig självmedveten om jag inte omedelbart vet hur man ska lösa ett matematiskt problem
6. Jag blir nervös när jag tror att någon utvärderar min matematiska förmåga
7. Jag skulle känna mig nervös om jag var tvungen att lösa ett matematiskt problem framför andra

8. Jag oroar mig för att göra misstag när jag pratar om matematik med barnen (på min avdelning/i min barngrupp)
9. Jag skulle vara nervös över att undervisa elever i förskoleklass eller första klass i matematik
10. Jag skulle känna mig obekväm om en kollega iakttog mig när jag pratade om matematik med barnen
11. När jag pratar om matematik undviker jag att gå in på detalj om olika koncept som jag inte känner mig helt bekväm med
12. Om ett barn skulle be mig att utveckla ett matematiskt koncept så skulle jag känna mig obekväm
13. Det gör mig nervös att prata om matematiska problem om jag inte redan har klurat ut lösningen
14. Jag oroar mig för att inte kunna svara rakt av på barnens frågor om matematik

MATEMATIK I FÖRSKOLAN

I detta avsnitt kommer du att få svara på frågor om i vilken utsträckning du pratar med barnen om olika matematiska begrepp i olika situationer på förskolan. För var och en påståendena (ae), indikera i vilken grad du instämmer i påståendet från (1) ”Aldrig” till (5) ”Alltid”.

1. I vilken utsträckning pratar du med barnen om att räkna (t. ex räkna upp räkneorden, räkna antalet objekt i en mängd, eller be barnen att räkna) i följande situationer?

a. Under samlingar
b. När vi dukar bordet
c. I hallen när vi ska gå in eller ut
d. I specifika undervisningssituationer avsedda för att lära barnen vad räkning är
e. Under utflykter

2. I vilken utsträckning pratar du med barnen om nummerordning (t. ex hänvisa till ett objekt som det 5:e i en sekvens) i följande situationer?

a. Under samlingar
b. När vi dukar bordet
c. I hallen när vi ska gå in eller ut
d. I specifika undervisningssituationer avsedda för att lära barnen vad räkning är
e. Under utflykter

3. I vilken utsträckning pratar du med barnen om mönster (t. ex “din tröja har ränder. Röd, blå, röd, blå, röd, blå …”) i följande situationer?

a. Under samlingar
b. När vi dukar bordet
c. I hallen när vi ska gå in eller ut
d. I specifika undervisningssituationer avsedda för att lära barnen vad räkning är
e. Under utflykter

4. I vilken utsträckning pratar du med barnen om geometriska begrep (t. ex, namnger geometriska former) i följande situationer?

a. Under samlingar
b. När vi dukar bordet
c. I hallen när vi ska gå in eller ut
d. I specifika undervisningssituationer avsedda för att lära barnen vad räkning är
e. Under utflykter

5. I vilka situationer pratar du med barnen om matematiska begrepp (t.ex, räkning, mönster, ordinarie, kardinalitet, etc) ?

____

____

Appendix 2. Study II

12.1 Information letters, a) children; b) parent

a) Matte, läsning och oro

Uppsala Child & Baby Lab

UPPSALA UNIVERSITET

Information till forskningspersoner

Vi vill fråga dig om du och ditt barn vill delta i ett forskningsprojekt. I det här dokumentet får du information om projektet och om vad det innebär att delta.

Vad är det för ett projekt och varför vill ni att jag ska delta?

Med detta dokument vill vi beskriva en studie om hur barn och vuxna oroar sig för matematik och läsning och hur det relaterar till förmågan att lösa uppgifter som kräver huvudräkning och högläsning. Du blir tillfrågad om deltagande eftersom du är förälder och/eller arbetar på förskola.

Hur går projektet till?

I studien kommer du och ditt barn att få lösa matematiska uppgifter (1+2 = ?) och läsa ord (med olika många bokstäver) och berätta svaret på varje uppgift högt för en försöksledare. Samtidigt kommer dina och ditt barns ögonrörelser och pupillstorlek mätas med en ögonrörelsekamera. Det viktiga är inte att svar rätt utan att göra så gott ni kan. Vissa uppgifter är svåra att lösa för de allra fresta personer som deltar. I samband med studien kommer du också få fylla i ett mindre antal frågeformulär som ställer frågor om oro kopplat till matte, läsning och mer generellt i vardagen. Du och ditt barn deltar en i taget, men ni kan hela tiden vara nära varandra, i samma rum.

Studien kommer att ta ca 20 minuter att genomföra per person, samt lite extra tid för frågor och information.

Information från studien kommer att användas för att skriva vetenskapliga artiklar och hjälpa oss förstå hur människor lär sig orsakssamband. När data från studien publiceras kommer all information om deltagarnas identitet vara borttagna.

Forskningshuvudman för projektet är Uppsala universitet. Med forskningshuvudman menas den organisation som är ansvarig för projektet. Ansökan är godkänd av Etikprövningsmyndigheten, diarienummer för prövningen hos Etikprövningsmyndigheten är Dnr 2022-01163-01.

Möjliga följder och risker med att delta i projektet

Vi ser inte några risker med eller följder av projektet.

Vad händer med mina uppgifter?

Projektet kommer att samla in och registrera information om dig.

Data kommer att lagras utan information som kan identifiera dig eller ditt barn (vi kommer inte inkludera namn, adress eller annan information som kan användas för att spåra data tillbaka till deltagare). Data (ögonrörelser och svar på frågeformulär) kommer att kopplas till en 6-siffrig kod. Dessa kommer att sparas på en lösenordsskyddadad server på Uppsala universitet och enbart användas av forskare som aktivt deltar i projektet.

Kvantitativa data (datamatriser med siffror) kommer att göras tillgängliga i publikationer men då utan information som kan användas för att identifiera deltagarna.

Uppsala universitet är ansvariga för lagring och hantering av persondata som lagras i Uppsala. Data kommer att sparas i 10 år.

Dina svar och era resultat kommer att behandlas så att inte obehöriga kan ta del av dem.

Ansvarig för dina personuppgifter är Uppsala universitet. Dataskyddsombud nås på dataskyddsombud@uu.se. Behandling av personuppgifter sker enligt EU:sdataskyddsförordning, GDPR. Vid missnöje med hur personuppgifter behandlas har ni rätt att lämna in klagomål till Integritetsskyddsmyndigheten.

Hur får jag information om resultatet av projektet?

Information om resultatet, på gruppnivå, kommer att läggas upp på sociala mediakonton som tillhör Uppsala Barn och BabyLab.

Försäkring och ersättning

Alla deltagande familjer får ett presentkort på 100 kronor för varje besök på labbet (reseersättning). Under deltagande är ni som deltar försäkrade av Kammarkollegiet.

Deltagandet är frivilligt

Ditt deltagande är frivilligt och du kan när som helst välja att avbryta deltagandet. Om du väljer att inte delta eller vill avbryta ditt deltagande behöver du inte uppge varför.

Om du vill avbryta ditt deltagande ska du prata den som genomför studien.

Ansvariga för projektet

Ansvarig för projektet är Gustaf Gredebäck, gustaf.gredeback@psyk.uu.se, 018-4712111

b) Matte, läsning och oro

Information till forskningspersoner
Vi vill fråga dig om du vill delta i ett forskningsprojekt. I det här dokumentet får du information om projektet och om vad det innebär att delta.

Vad är det för ett projekt och varför vill ni att jag ska delta?
Med detta dokument vill vi beskriva en studie om hur barn och vuxna oroar sig för matematik och läsning och hur det relaterar till förmågan att lösa uppgifter som kräver huvudräkning och högläsning. Du blir tillfrågad om deltagande eftersom du är förälder och/eller arbetar på förskola.

Hur går projektet till?
I studien kommer du att få lösa matematiska uppgifter (3*5 = ?) och läsa ord (med olika många bokstäver) och berätta svaret på varje uppgift högt för en försöksledare. Samtidigt kommer dina ögonrörelser och pupillstorlek mätas med en ögonrörelsekamera. Det viktiga är inte att svar rätt utan att göra så gott du kan. Vissa uppgifter är svåra att lösa för de allra fresta personer som deltar. I samband med studien kommer du också få fylla i ett mindre antal frågeformulär som ställer frågor om oro kopplat till matte, läsning och mer generellt i vardagen.

Studien kommer att ta ca 20 minuter att genomföra, samt lite extra tid för frågor och information.

Information från studien kommer att användas för att skriva vetenskapliga artiklar och hjälpa oss förstå hur människor lär sig orsakssamband. När data från studien publiceras kommer all information om deltagarnas identitet vara borttagna.

Forskningshuvudman för projektet är Uppsala universitet. Med forskningshuvudman menas den organisation som är ansvarig för projektet. Ansökan är godkänd av Etikprövningsmyndigheten, diarienummer för prövningen hos Etikprövningsmyndigheten är Dnr 2022-01163-01.

Möjliga följder och risker med att delta i projektet

Vi ser inte några risker med eller följder av projektet.

Vad händer med mina uppgifter?

Projektet kommer att samla in och registrera information om dig.

Data kommer att lagras utan information som kan identifiera dig (vi kommer inte inkludera namn, adress eller annan information som kan användas för att spåra data tillbaka till deltagare). Data (ögonrörelser och svar på frågeformulär) kommer att kopplas till en 6-siffrig kod. Dessa kommer att sparas på en lösenordsskyddadad server på Uppsala universitet och enbart användas av forskare som aktivt deltar i projektet.

Kvantitativa data (datamatriser med siffror) kommer att göras tillgängliga i publikationer men då utan information som kan användas för att identifiera deltagarna.

Uppsala universitet är ansvariga för lagring och hantering av persondata som lagras i Uppsala. Data kommer att sparas i 10 år.

Dina svar och dina resultat kommer att behandlas så att inte obehöriga kan ta del av dem.

Ansvarig för dina personuppgifter är Uppsala universitet. Dataskyddsombud nås på dataskyddsombud@uu.se. Behandling av personuppgifter sker enligt EU:sdataskyddsförordning, GDPR. Vid missnöje med hur personuppgifter behandlas har ni rätt att lämna in klagomål till Integritetsskyddsmyndigheten.

Hur får jag information om resultatet av projektet?

Information om resultatet, på gruppnivå, kommer att läggas upp på sociala mediakonton som tillhör Uppsala Barn och BabyLab.

Försäkring och ersättning

Alla deltagande familjer får ett presentkort på 100 kronor för varje besök på labbet (reseersättning). Under deltagande är ni som deltar försäkrade av Kammarkollegiet.

Deltagandet är frivilligt

Ditt deltagande är frivilligt och du kan när som helst välja att avbryta deltagandet. Om du väljer att inte delta eller vill avbryta ditt deltagande behöver du inte uppge varför.

Om du vill avbryta ditt deltagande ska du prata den som genomför studien.

Ansvariga för projektet

Ansvarig för projektet är Gustaf Gredebäck, gustaf.gredeback@psyk.uu.se, 018-4712111

12.2 Consent Forms a) children; b) parent

a) Samtycke till att mitt barn deltar i projektet

Jag har fått muntlig och/eller skriftlig information om studien och har haft möjlighet att ställa frågor. Jag får behålla den skriftliga informationen.

Jag samtycker till att mitt barn deltar i projektet *Matte, läsning och oro*

Plats och datum	Underskrift
	Namnförtydligande
Plats och datum	Underskrift
	Namnförtydligande

b) Samtycke till att delta i projektet

Jag har fått muntlig och/eller skriftlig information om studien och har haft möjlighet att ställa frågor. Jag får behålla den skriftliga informationen.

Jag samtycker till att delta i projektet *Matte, läsning och oro*

Plats och datum	Underskrift
	Namnförtydligande

Appendix 3. Study III

13.1 Information letter for preschool principal

Ämne: Inbjudan att delta I ett forskningsprojekt om yngre barns matematik-undervisning

Bästa [förskolerektorer namn],

Mitt namn är Laura Galeano, och jag är doktorand i didaktik med fokus på kognitiv utveckling och lärande med ett stort intresse för utbildning av yngre barn i matematik. Jag kontaktar dig idag för att bjuda in [Förskolans namn] att delta i forskningsprojektet *Affekt I förskolans läraktiviteter*.

Kärnan i detta projekt är att undersöka hur barn och förskolorspedagoger engagerar sig i matematik genom lek och social interaktion och vilken roll som känslor/emotioner spelar för detta engagemang. Vi vill belysa hur barn utvecklar matematisk förståelse samtidigt som de deltar i aktiviteter och situationer där gemensamma känslor och emotioner skapar olika förutsättningar för inlärningsresan.

Genom denna forskning hoppas vi kunna bidra med värdefull kunskap om barns och elevers tidiga matematiklärande och stödja utvecklingen av en pedagogik som förbättrar det matematiska lärandet och det emotionella välbefinnandet hos unga elever. Vi tror att din förskolas deltagande avsevärt skulle kunna berika våra resultat och bidra till att främja förskolepedagogiken.

Forskningsprojektet kommer att innebära ett samarbete mellan forskare och förskolepedagoger på din skola. Vi kommer att arbeta nära ditt team för att fånga interaktioner och aktiviteter med matematikinnehåll i den vardagliga verksamheten, samt utforska vilken betydelse som affekt och emotioner spelar för barnens deltagande i aktiviteterna. Projektet är utformat för att vara minimalt störande för verksamhetens dagliga rutiner och kommer att involvera respektfull observation och dokumentation av aktiviteter.

Att delta i projektet kommer att hjälpa oss forskare att få större insikter i de affektiva aspekterna av barns matematiska lärande, och bidra till den bredare kunskapsbasen inom området. Vi förstår betydelsen av din tid och kraven på din förskolas resurser. Därför har vi noggrant utformat projektet för att minimera eventuella besvär. Vi kommer att vara tillgängliga för att ta itu med alla problem eller frågor du kan ha under hela processen, för att säkerställa ett smidigt och ömsesidigt fördelaktigt samarbete.

Om du är intresserad av att delta i detta forskningsprojekt eller vill veta mer om det, skulle jag gärna boka ett möte med dig när det passar dig. Du är välkommen att kontakta mig via e-post eller telefon. Du hittar även bifogade samtyckesformulär och frågeformulär som i en förstudie ska besvaras av de förskollärare och pedagoger som arbetar på din institution med barn 5 år ifall du bestämmer dig för att vara med i projektet.

Tack för att du överväger denna inbjudan, och jag ser fram emot möjligheten att arbeta tillsammans för att främja vår förståelse av matematikundervisning för yngre barn.

Vänliga Hälsningar,

Kontaktperson
Laura Galeano
Doktorand i didaktik med fokus på kognitiv utveckling och lärande
Institutionen för pedagogik, didaktik och utbildningsstudier
Uppsala Universitet
laura.galeano@edu.uu.se,
+46702976938

Projektansvar
Niklas Norén
Docent i pedagogik, Universitetslektor i didaktik
Institutionen för pedagogik, didaktik och utbildningsstudier
Uppsala Universitet
niklas.noren@edu.uu.se,
018-4712490

13.2 Basic Study Information

Affekt i förskolans läraktiviteter

UPPSALA UNIVERSITET

Hej!
Jag heter Laura Galeano och jag är doktorand på Uppsala Universitetsinstitutionen för pedagogik, didaktik och utbildningsstudier.

Min forskning fokuserar på hur barn och förskolepedagoger engagerar sig i matematik och läsning genom lek och social interaktion och vilken roll som känslor/emotioner spelar för detta engagemang.

I samband med (förskola 1) och (förskola 2) förskolors hjälp kommer jag att dokumentera olika spontana interaktioner mellan barn och förskolepedagoger för att öka kunskapen om hur känslor och emotioner påverkar aktiviteter i förskolor dagligen. Jag tycker att det finns mycket att lära oss från förskolors miljö!

På universitetssidan finns mer information om mig och om ni vill ställa frågor om mitt projekt, du kan kontakta mig på: laura.galeano@edu.uu.se; 0702976938

Vänliga hälsingar,

Laura Galeano
Doktorand i Didaktik med focus på kognitiv utveckling och lärande
https://www.katalog.uu.se/profile/?id=N20-2239
Department of Education
https://www.edu.uu.se/research/curriculumstudies/mathmaticseducation/phd-projects/mediators-of-preschool-children-and-teachers--math-anxiety-development-in-sweden/

13.3 Printed Information Sheet About the Project

Informationsbrev till vårdnadshavare

UPPSALA
UNIVERSITET

Vi vill fråga dig om du vill delta i ett forskningsprojekt. I det här dokumentet får du information om projektet och om vad det innebär att delta.

Vad handlar projektet om och varför vill vi att du ska delta?

I projektet vill vi undersöka hur barn och förskolepedagoger visar upp, organiserar och hanterar affekt/känslor i läraktiviteter med ett matematik- eller läsrelaterat innehåll. Vi frågar dig om du vill delta eftersom du är förälder till ett barn i förskolan. Vi fick dina kontaktuppgifter av rektorn och pedagoger på ditt barns förskola.

Hur går projektet till?

I studien kommer forskaren att besöka förskolan under en vecka. Hon tar med sig en videokamera med mikrofon för att spela in olika matematik- och läsrelaterade situationer som regelbundet utspelar sig på förskolan. I samband med studien kommer pedagoger och barn också få svara på frågor om oro kopplat dels till matematik och läsning och dels mer generellt i vardagen.

Information från studien kommer att användas för att skriva och publicera vetenskapliga artiklar. Forsknings huvudman för projektet är Uppsala universitet. Med forskningshuvudman menas den organisation som är ansvarig för projektet. Ansökan är godkänd av Etikprövningsmyndigheten, diarienummer för prövningen hos Etikprövningsmyndigheten är Dnr 2023-03796-01

Möjliga fördelar och positiva följder av att delta i projektet

Genom att delta i detta projekt kommer du att bidra till att öka kunskapen om affekt/känslors roll i förskolepedagogers och barns tidiga möte med olika typer av ämnesinnehåll i förskolans verksamhet. Denna kunskap kommer att användas för att förbättra förskoleundervisningen.

Vad händer med dina uppgifter?

Projektet kommer att samla in material och data där dina barn medverkar. Data (videoinspelningar och svar på frågor) kommer att lagras utan skriftlig information som kan identifiera deltagare. Vi kommer inte inkludera namn, adress eller annan information som kan användas för att spåra data tillbaka till deltagare.

Skriftliga beskrivningar av verksamheten och deltagarnas agerande, tabeller med siffror och bilder ur videomaterialet kommer att göras tillgängliga i publikationer men i avidentifierad form, helt utan information som kan identifiera deltagarna. Data och resultat kommer att behandlas så att obehöriga inte kan ta del av dem. Data kommer att kopplas till en 6-siffrig kod. Data och kod förvaras på en lösenordskyddad server på Uppsala universitet och används enbart av forskare som aktivt deltar i projektet.

Uppsala universitet är ansvariga för lagring och hantering av persondata som lagras i Uppsala. Data kommer att sparas i 10 år efter att studien avslutats. Ansvarig för dina personuppgifter är Uppsala universitet. Dataskyddsombud nås på dataskyddsombud@uu.se. Behandling av personuppgifter sker enligt EU:s dataskyddsförordning, GDPR. Vid synpunkter på hur personuppgifter behandlas har du rätt att lämna in klagomål till Integritetsskyddsmyndigheten.

Hur får jag information om resultatet av projektet?

Information om resultatet, med fokus på gruppen och inte på enskilda individer, kommer att publiceras i en vetenskaplig tidskrift.

Deltagandet är frivilligt

Ditt deltagande är frivilligt och du kan när som helst välja att avbryta deltagandet. Om du väljer att inte delta eller vill avbryta ditt deltagande behöver du inte uppge varför. Om du vill avbryta ditt deltagande ska du prata med den forskare som genomför studien.

Kontaktuppgifter till forskaren som genomför studien

Den forskare som genomför studien på förskolan är Laura Galeano, doktorand i didaktik, laura.galeano@edu.uu.se, 0702976938.

Ansvarig för projektet är Niklas Norén, docent i pedagogik, niklas.noren@edu.uu.se, 018-4712490.

13.4 Information letters for preschool teachers

Information till forskningspersoner

Vi vill fråga dig om du vill delta i ett forskningsprojekt. I det här dokumentet får du information om projektet och om vad det innebär att delta.

Vad handlar projektet om och varför vill vi att du ska delta?

I projektet vill vi undersöka hur barn och förskolepedagoger visar upp, organiserar och hanterar affekt/känslor i läraktiviteter med ett matematik- eller läsrelaterat innehåll. Vi frågar dig om du vill delta eftersom du arbetar vid en förskola. Vi fick tag på dina kontaktuppgifter efter att ha upprättat en dialog med rektorn på din förskola som visat intresse för att delta i projektet.

Hur går projektet till?

I studien kommer forskaren att besöka förskolan under en vecka. Hon tar med sig en videokamera med mikrofon för att spela in olika matematik- och läsrelaterade situationer som regelbundet utspelar sig på förskolan. I samband med studien kommer du också få fylla i ett mindre antal frågeformulär som ställer frågor om oro kopplat dels till matematik och läsning och dels mer generellt i vardagen.

Information från studien kommer att användas för att skriva och publicera vetenskapliga artiklar.

Forskningshuvudman för projektet är Uppsala universitet. Med forskningshuvudman menas den organisation som är ansvarig för projektet. Ansökan är godkänd av Etikprövningsmyndigheten, diarienummer för prövningen hos Etikprövningsmyndigheten är Dnr 2023-03796-01

Möjliga fördelar och positiva följder av att delta i projektet

Genom att delta i detta projekt kommer du att bidra till att öka kunskapen om affektens roll i förskolepedagogers och barns tidiga möte med av olika typer av ämnesinnehåll i förskolans verksamhet. Denna kunskap kommer att användas för att förbättra förskoleundervisningen.

Vad händer med dina uppgifter?

Projektet kommer att samla in material och data där du medverkar.

Data (videoinspelningar och svar på frågor) kommer att lagras utan skriftlig information som kan identifiera deltagare. Vi kommer inte inkludera namn, adress eller annan information som kan användas för att spåra data tillbaka till deltagare. Skriftliga beskrivningar av verksamheten och deltagarnas agerande, tabeller med siffror och bilder ur videomaterialet kommer att göras tillgängliga i publikationer men i avidentifierad form, helt utan information som kan identifiera deltagarna.

Data och resultat kommer att behandlas så att obehöriga inte kan ta del av dem. Data kommer att kopplas till en 6-siffrig kod. Data och kod förvaras på en lösenordskyddad server på Uppsala universitet och används enbart av forskare som aktivt deltar i projektet.

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Hur får jag information om resultatet av projektet?

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Ansvarig för projektet

Ansvarig för projektet är Niklas Norén, docent i pedagogik, niklas.noren@edu.uu.se, 018-4712490.

13.5 Consent Forms a) preschool teachers, b) legal guardians

a) Samtycke till att delta i projektet

Jag har fått muntlig och/eller skriftlig information om studien och har haft möjlighet att ställa frågor. Jag får behålla den skriftliga informationen.

Jag samtycker till att delta i projektet *Affekt i förskolans läraktiviteter*

Plats och datum	Underskrift
	Namnförtydligande

b) Samtycke till att mitt barn deltar i projektet

Jag har fått muntlig och/eller skriftlig information om studien och har haft möjlighet att ställa frågor. Jag får behålla den skriftliga informationen.

Jag samtycker till att mitt barn deltar i projektet *Affekt i förskolans läraktiviteter*

Plats och datum	Underskrift
	Namnförtydligande
Plats och datum	Underskrift
	Namnförtydligande

13.6 Pre-Planned Teacher-Initiated Mathematical Activities

Matematik – mäta och jämföra

Vad: Vi fortsätter arbeta med matematik genom att mäta och jämföra. Denna undervisning utgår från vårt tidigare arbete med våra Väpplarböcker, där barnen fått jobba med matematik på olika sätt bland annat genom att mäta och jämföra sin egen och varandras längd.

Syftet blir att undersöka vad som händer om vi lägger ihop våra längder? Hur långa blir vi tillsammans? Kan vår gemensamma längd nå från den ena väggen till den andra? Hur kan vi visa vår längd i siffror, med måttband samt med kroppen?

Varför:

- Mäta och jämföra med hjälp av olika redskap (mätsticka och med hjälp av kroppens egen längd).
- Sätta ord på matematiska begrepp som t.ex.: meter, centimeter, lång, kort

• förståelse för rum, tid och form, och grundläggande egenskaper hos mängder, mönsöter, antal, ordning, tal, mätning och förändring, samt att resonera matematiskt om detta (Lpfö)

Hur? Gemensam samling där vi skriver upp alla barns längd. Vi adderar allas längd och använder våra kroppar och mätstickor för att mäta, räkna och jämföra. Barnen lägger sig på golvet från vägg till vägg, hur långa blev vi? Var vi längre än rummet?

Bilder från sagans händelseförlopp i rätt ordning (sekvenssaga)

Vad: Sex bilder från en saga läggs ut på golvet framför barnen. Bilderna ligger huller om buller och syftet är att bilderna från sagan ska hamna i rätt ordning.

Varför: Öva på att förstå händelseförloppet, vad händer i vilken ordning och varför? Logiskt tänkande.

•intresse för berättelser, bilder och texter i olika medier, såväl digitala som andra, samt sin förmåga att använda sig av, tolka, ifrågasätta och samtala om dessa (Lpfö)

•förmåga att använda och förstå begrepp, se samband och upptäcka nya sätt att förstå sin omvärld,

Hur och vilka: Vi sitter tillsammans på mattan, en pedagog presenterar bilderna och ger alla barn möjlighet att uttrycka sina tankar och funderingar. Barnen samarbetar för att lägga bilderna i rätt ordning, sedan ”läser” vi sagan och ser om det blir rätt, om inte fortsätter vi för att lösa uppgiften tillsammans.

Appendix 4. Transcription Conventions

This appendix presents the transcription conventions used in the analyses. Jeffersonian conventions (2004) are applied to capture the verbal and prosodic features of talk, while multimodal conventions following Mondada (2018) are used to represent embodied conduct such as gestures, gaze, and body movements. Actions are temporally aligned with speech as closely as possible.

Verbal Transcription (Jefferson, 2004)

Symbol	Meaning
( )	Uncertain or unclear hearing
(word)	Possible hearing
>text<	Talk produced faster than surrounding speech
[	Overlapping talk
:	Sound lengthening
.	Falling intonation (final contour)
↑	Slightly rising or continuing intonation
_	Marked pitch rise

Multimodal Transcription (Mondada, 2018)

Symbol	Meaning
*	Marks onset/offset of teacher’s embodied action
€	Marks onset/offset of child’s embodied action
->	Action continues across subsequent lines
pt	Pointing gesture
bd	Body movement (e.g., wiggling, leaning, posture shifts)
gz	Gaze direction
prs	Prosodic or rhythmic performance (e.g., singing, rapping)
text alignment	Embodied-action tiers are aligned temporally beneath corresponding talk

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