# EXPLORING THE ASSOCIATIONS BETWEEN PARENTAL BELIEFS AND TALK ABOUT MATH WITH THEIR 4-YEAR-OLD CHILDREN


by

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**Exploring the Associations Between Parental Beliefs and Talk about Math with their 4-year-old Children**

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Prior research shows associations between parents' engagement in math-related activities in the home and children's achievement in mathematics. Specifically, the quantity and quality of parental number talk, or number-related verbal input that the child is exposed to is related to children's early math knowledge. There is much individual variation in parents' number talk and less is known about factors that may influence this variation. The present study examines the relation between parents' beliefs regarding the home versus the school in fostering children's mathematics development and the importance of mathematics for their child's future success on parents' use of number talk with their four-year-old child during three semi-structured activities. Parent-child dyads (*n*=150) were video-taped interacting with a picture book, a magnet board, and a set of grocery store toys for 5-10 minutes each. Parents also completed a questionnaire regarding their current beliefs about who is responsible for teaching their child math and how important math is for their child's success. Parents of differing beliefs were compared on their use of number talk with their child. Parents who reported that they believed the home or both the home and the school have the primary responsibility in fostering children's mathematics development engaged in significantly more number talk than parents who reported that the school has this primary responsibility. Parents who reported that they believed mathematics to be of higher importance for their child's success produced more number talk utterances than parents who reported that math is of lower importance, but when controlling for total utterances produced, this correlation became only marginally significant. This study suggests that parents vary in their beliefs regarding math and that these beliefs may have associations with parents' engagement in math-related activities with their child.

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## 1.0 Introduction

In a world of growing demands for science, technology, engineering, and math (STEM), math knowledge is as crucial as ever. The United States Bureau of Labor Statistics projects occupations in STEM to grow faster than average, with more than nine million jobs available by 2022 (Vilorio, 2014). Even outside of jobs in the STEM field, math skills are imperative for success. Math knowledge not only builds reasoning and problem-solving skills, but it is also necessary for many day-to-day tasks including paying bills, managing time effectively, cooking, doing taxes, shopping, and so many others. For these reasons, understanding how mathematics skills and knowledge develop is more important than ever. Mathematics knowledge builds upon foundational skills taught early in life, thus, understanding how mathematics skills develop begins with understanding math learning in early childhood.

While early mathematics learning is important for later mathematics skills and knowledge, mathematical competence early in life has also been found to be related to overall academic achievement for subsequent years of development (DeFlorio & Beliakoff, 2014). A study conducted by Duncan et al. (2007) revealed that school-entry math skills are one of the strongest predictors of later achievement outcomes even above reading skills and attention-related measures. Math concepts such as ordinality, that is, understanding the order of elements, as well as number knowledge, were the most powerful predictors of children's later learning, with early math skills predictive of not only children's later math achievement, but also their later reading achievement. Early math skills, regardless of children's gender and socioeconomic status have been found to be as capable as early reading skills themselves at predicting children's later reading achievement

(Duncan et al., 2007). Thus, the development of early math skills is crucial to study as this early knowledge has potentially long-lasting effects on children's future achievement.

Early math skills such as symbolic number knowledge begin to develop during the preschool years when children learn number words and counting principles. These foundational skills are later built upon when children begin to learn the written number system (Vasilyeva, Veraksa, Weber & Bukhalenkova, 2018). By mastering early concepts of numbers, children build a foundation that will allow them to understand higher-level mathematical problems not only with more ease but also on a deeper level (Duncan et al., 2007).

### 1.1 Parental Report of Home Math Activities and their Influence on Early Math Skills

While prior research demonstrates that early mathematics skills are strong predictors of later academic achievement, this research also shows that not all children have the same early math skills. Prior research on early mathematics development shows that even before entering formal education, children differ in their mathematical skills and knowledge (Susperreguy & Davis-Kean, 2016). Furthermore, at early stages of schooling, children's symbolic number skills vary substantially, giving children different foundations to build their mathematics education upon (Vasilyeva et al., 2018). Since these differences in children's math knowledge are evident at the earliest stages of schooling, it is likely that factors of the home environment as well as parental characteristics contribute to the wide individual variation in children's early math skills and their acquisition of this knowledge.

In the past, this individual variation in academic preparation has been found to be associated with children's experiences with early numeracy and literacy activities (LeFevre, Polyzoi, Skwarchuk, Fast, Sowinksi, 2010; Kleemans, Peeters, Segers, Lerhoeven, 2012). Parents and caregivers take on a large role in childhood development both directly and indirectly as these individuals primarily decide the materials children learn with and the settings their children learn in. Parents are largely responsible for deciding the toys that their children are given to play with which could indirectly impact how, as well as what children learn in the home environment. Parents also have a direct influence on their children's education by deciding what subject matter they will teach in the home (Cannon & Ginsburg, 2008). In fact, a longitudinal study conducted by Skwarchuk, Sowinski, and LeFevre (2014) involving children about to start kindergarten showed that parents' reports of their formal home numeracy practices such as practicing addition at home predicted their children's symbolic number knowledge. In a similar study, formal mathematics activities such as practice with addition and subtraction provided by the parent predicted children's mathematics scores not only at the time of testing, when the child was four years old, but also one year after testing (Huntsinger, Jose, & Luo, 2016). Furthermore, Niklas, Cohrssen, and Taylor (2016) completed a study in which some families participated in a short, two-part intervention. Families in the intervention group were given information on the home numeracy environment and its importance on children's learning as well as a dice game centered on counting principles. Within 20 weeks of implementation, families that did participate in this intervention reported an improvement in their own home numeracy environment. Additionally, children in the intervention group improved on their numerical competency significantly more than children who did not participate in the intervention (Niklas, Cohrssen, & Tayler, 2016). Similarly, when some parents were made aware of the possible impacts of the numeracy environment and instructed to add more math talk during a simple-cooking activity with their child, children produced significantly more correct mathematics responses to their parents than children of parents who had not been instructed to incorporate additional math into to activity (Vandermaas-Peeler, Boomgarden, Finn, Pittard, 2012).

However, the relation between the home numeracy environment and children's math achievement has not been consistent across the board. Other studies have found no relation between parents' reported engagement in math-related activities in the home and children's math knowledge or achievement (Blevins-Knabe, Austin, Musun, Eddy, Jones, 2000). Additionally, Missall, Hoknoski, Caskie and Repasky (2015) found that parents' reported engagement in mathematics activities in the home were not associated with their preschool-aged child's performance on the quantitative subtest of a school readiness exam. Similarly, DeFlorio and Beliakoff (2014) found no association between parents reported at-home activities and 4-year-old children's mathematical ability. Taken together, these studies show the potential importance of the home environment in fostering children's early mathematics development but also highlight the need for further work to address its impact and effects.

## 1.2 Parent Number Talk and Its Influence on Early Math Skills

Another way to measure children's opportunities to learn about math concepts besides parental reports of math-related activities is through measuring children's exposure to number-related verbal input, otherwise known as number talk. Prior research shows that both the quantity as well as the quality of said number talk is positively related to children's mathematical knowledge (Elliott, Braham, & Libertus, 2017). Additionally, specific types of number talk in the home, including counting and labeling of set sizes, have in the past been found to be related to children's later cardinal-number knowledge, i.e., knowing that the final word in a count list refers to the number of objects in the counted set (Gunderson & Levine, 2011). In a longitudinal study attempting to understand the relation between number talk and cardinal-number knowledge, Levine, Suriyakham, Rowe, Huttenlocher, and Gunderson (2010) investigated number talk in the home environment across five different visits between age 14 to 30 months and found large variation in the quantity of number-related input that parents exposed their children to during everyday activities. This variation in number talk was found to be positively correlated with children's understanding of cardinality at 46 months of age (Levine et al., 2010).

When examining preschool-aged children's general mathematical skills, tested with the Test of Early Mathematics Ability (TEMA-3; Ginsburg & Baroody, 2003), Elliott et al. (2017) found that parents' overall number talk was not significantly related to children's math abilities at 5 and 6 years of age, but that parents' use of number words larger than 10 was correlated with children's scores on the mathematics assessment suggesting that quality, in addition to quantity, of number talk can have significant effects on children's math learning. Similarly, Ramani et al. (2015) found that caregivers' engagement in higher quality, or more advanced number talk, including discussion of arithmetic, cardinality and ordinal relations, significantly predicted 3- to 5-year-old ($M$ = 4 years 4 months) children's advanced numerical knowledge.

The above findings strengthen the argument for the home numeracy environment, and more specifically, the potential link between parental use of number talk in the home and children's early math learning. However, though previous research informs us on the possible importance of engaging in number talk in the home and the lasting effects that exposure to number talk may have on children's mathematics development and subsequent academic achievement, it is not yet known what specific factors contribute to the substantial individual variation in number talk across parents.

## 1.3 The Role of Parental Beliefs About Math

Bronfenbrenner's Ecological Systems theory suggests that there are two specific kinds of social processes that influence children's development, proximal and distal, and that these processes are interdependent. Proximal processes include interactions between persons and objects in the immediate environment over an extended period of time. Proximal processes vary based on distal processes which include the characteristics of the person or the environment in which the proximal processes take place, and vary over time (Bronfenbrenner & Morris, 1998). This theory posits one explanation for the mechanisms in which number talk and other math-related activities in the home may affect children's mathematics development. Specifically, parental use of number talk with a child in the home environment reflects the proximal process of development in which children actively learn through interactions with parents or caregivers in their immediate environment. However, proximal processes like the use of number talk may also be influenced by distal processes such as characteristics of an individual. One possible explanation for the large individual variation in parents' number talk may be parents' beliefs regarding mathematics more generally (Tudge, Mokrova, Hatfield, Karnik, 2009).

One factor that may influence parents' use of number talk with their children is their opinions and values about the importance of doing so, or their beliefs regarding their child's educational development more generally. Prior literature demonstrates that parent-child activities such as engagement in number talk may actually mediate the relation between parents' beliefs and child outcomes (Vasilyeva et al., 2018). Strong parental beliefs have been found to predict the experiences that those parents subsequently make available to their children (Sonnenschein, Galindo, Thompson, Huang & Lewis, 2012). For example, prior research shows that parents who reported stronger beliefs regarding the importance of mathematics also reported engaging in more math-related activities with their child (Silver, Elliott & Libertus, 2020). Other research shows that when asked how important it was to parents that they help their child with math, parents who reported higher importance beliefs were more likely to report engaging in math-related activities in the home with their child. In this same study, parents also rated their own enjoyment in mathematics as well as their own mathematical skill level, but neither was subsequently related to the likelihood that the parent reported engaging in math-related activities in the home (Sonnenschein et al., 2012). Both of these findings are consistent with expectancy-value theory which posits that individuals' beliefs regarding the importance and the value of certain tasks influence their choices and persistence in that task (Wigfield & Eccles, 2000). Parents who reported that math was of higher importance, or that they found it important to help their children with math, both reported engaging in more math activities in the home environment showing a possible link between parents' values and their engagements in certain activities with their children (Silver et al., 2020; Sonnenschein et al., 2012).

Similarly, parents' beliefs about the importance of school readiness and academic preparation has been found to be strongly related to the frequency of formal math practices that the parents engaged in with the child in the home. In turn, this frequency of engagement in formal math practices was found to be related to preschoolers' accuracy on a number identification assessment up to a year later when the children were in kindergarten (Vasilyeva et al., 2018). In this instance, parent engagement in numerical activities in the home mediated the relation between parental beliefs and child math performance. While these results show an association between what parents think and what actions parents take part it, parental beliefs extend to children's mathematics skills and knowledge in more ways than one. More positive parental beliefs about math have been found to not only be positively related with home math activities, but also, concurrently, to more positive child beliefs about mathematics as well (Missall, Hojnoski, Caskie & Repasky, 2015). Parental beliefs such as parents' preference for math, as well as their subjective rating of their own mathematics abilities have also been found to be related to parents' reports about engagement in math activities in the home (Missall et al., 2015). Prior research demonstrates that parents who view mathematics in a more positive light, or believe in the importance of mathematics, frequently engage with their child in more math activities in the home. Given what we know from prior literature, this increased engagement in math-related activities in the home may have implications for that child's overall mathematics knowledge and achievement, and parents' beliefs regarding mathematics may also extend to the child in a way that parents who enjoy engaging in math activities may have children who are themselves more likely to enjoy engaging in math activities.

While prior research has examined the association between a few parental beliefs and parents' engagement in math-related activity with their child in the home, the vast majority of these studies have relied on self-report survey data to measure the home numeracy environment which has not been consistently linked to children's math skills (Elliott & Bachman, 2018). Additionally, prior research has examined parents' beliefs regarding the importance of math, but few studies have compared mathematics to other academic and developmental domains. Most research focused on math importance asked parents in a more general, open-ended manner about their beliefs' regarding the importance of mathematics or their importance in engaging in math with their child but it is unknown how parents' beliefs about mathematics may compare to other domains. Moreover, parental beliefs regarding children's mathematics development are not consistent. While some parents feel strongly about the importance of their children doing math at home, others report that doing math at home is either somewhat or not important (Sonnenschein et al., 2012). While it is unknown why some parents possess these beliefs, one assumption that may be made is that some parents may feel that it is simply not their responsibility to teach their child mathematics or that the responsibility of math education lies in the hands of the school.

## 1.4 The Current Study

The gaps in prior literature demonstrate that additional work is needed to further delineate the specific parental beliefs that may influence the home numeracy environment they create for their children. The current study explores the association between parents' beliefs about the importance of mathematics as well as the responsibility of the home and the responsibility of the school in fostering children's mathematics development and home numeracy. While prior research has examined how various parental beliefs relate to parents' engagement in math-related activity in the home, as well as the impact of that engagement on children's mathematics skills and knowledge, to date, no studies have examined the links between parents' beliefs about the responsibility of the school and the home regarding fostering math skill development and home numeracy. In addition, few, if any, of these studies have used observational data to measure children's exposure to math-related input in the home. While much prior research has focused on engagement in mathematics activities in the home through self-reported data from parents, it is possible that parental reports may be biased and thus, the current study measures number talk during semi-structured observations of parents and children as an alternative way to capturing the home numeracy environment. Specifically, we will address three research questions:

Research Question #1 (RQ1): Is there variability in parents' beliefs about the respective roles of parents and teachers in fostering children's development in mathematics and parents' beliefs about the importance of math relative to other academic and developmental domains?

Previous research has shown that parental beliefs regarding the importance surrounding math vary (Sonnenschein et al., 2012) as do their beliefs regarding what type of environment (home vs preschool) contributes the most in preparing children for future mathematics education in kindergarten (DeFlorio and Beliakoff, 2014). Thus, we hypothesized that parents' beliefs regarding the respective roles of parents and teachers in fostering children's development in mathematics as well as their view of the importance of math will vary.

Research Question #2 (RQ2): Are parents' beliefs regarding the responsibility of mathematics education and the importance of mathematics associated with parents' total engagement in number talk with their child?

Based on prior literature that demonstrates that parental beliefs about child development predict the experiences that parents make available to their children (Sonnenschein et al., 2012), it is predicted that parents who believe that the home has the primary responsibility in fostering mathematics education will engage in more number talk with their child than parents who believe that the school has the primary responsibility. Moreover, we predict that the higher parents rank math in terms of importance, the greater their use of number talk.

Research Question #3 (RQ3): Are parents' beliefs regarding the responsibility of mathematics education and the importance of mathematics associated with parents' total engagement in high-level, or more advanced, number talk with their child?

It is predicted that parents who believe that the home has the primary responsibility in fostering mathematics education will engage in more high-level number talk with their child than parents who believe that the school has the primary responsibility, and that the more important parents view math to be, the more high-level number talk they will engage in.

# 2.0 Method

## 2.1 Participants

The data for this project were drawn from the Parents Promoting Early Learning (PPEL) study conducted at the University of Pittsburgh. The overarching goal of this study was to understand how parents help their toddlers and preschool-aged children learn and develop through everyday activities. A total of 178 parent-child dyads participated, but data from 28 participating dyads were excluded because they were missing critical study variables resulting in a final sample of 150 parent-child dyads. Dyads consisted of four-year-old children (*M* = 4 years 5.27 months, *SD* = 3.6 months) who were primarily white (73.9%) as well as one of their parents, or primary caregivers. 142 (94.67%) of these caregivers were mothers, 7 (4.67%) were fathers, and 1 (0.67%) was a grandmother. At the time of data collection, 71 of these children were enrolled in preschool at least 10 hours per week, while 42 were not, and 37 parents did not report this information. Among the parents, 79.9% of parents reported their race as White, 11.9% reported African-American/Black, 3% reported Asian, 1.5% reported Hispanic/Latino and 3.7% reported as other/multiracial. The average annual reported household income was $102,624.90 (*SD* = $77,000). On average, parents were highly educated, with most (79%) having at least a bachelor's degree. The 28 participants identified for exclusion did not differ significantly from the current sample, with a reported average annual household income of $87,301.20 (*SD* = $65,383.40). Additionally, 73.1% of these parents reported having at least a bachelor's degree and 70.6% reported their race as White, 23.5% reported African-American/Black and 5.6% reported Asian. Participants for this study were recruited from a mid-size, urban environment in the Northeast of the United States through flyers at local preschools, community organizations, businesses, and universities as well as online postings. As required by the local Institutional Review Board, all caregivers provided written informed consent to participate prior to engaging in any research-related activities.

## 2.2 Procedure

For this study, researchers visited families' homes on one occasion and video-recorded parent-child interactions during three different semi-structured tasks. Materials for the tasks included a wordless picture book, a magnet board with various puzzle pieces, and a grocery store set with a cash register, plastic credit card and fake money. During each task, the parents were encouraged to play with their child as they normally would with the respective toy for a period of 5-10 minutes. When completing the magnet board puzzle, parents and children were asked to use the magnet shapes provided to complete a design that was shown on a card given to them. During the tasks, the researcher stepped out of the room to encourage naturalistic play between the dyads. Following these activities, parents were instructed to complete a questionnaire.

## 2.3 Measures

### 2.3.1 Semi-Structured Interactions

All conversations during the semi-structured interactions were transcribed verbatim and segmented into utterances by a trained research assistant in the lab and then later checked by a second trained research assistant for reliability. An utterance was defined as a continuous unit of speech from an individual speaker bounded by transition in speaker, grammatical closer or by a pause of more than two seconds (Pan et al., 2004). Following transcriptions, these videos were searched and coded for instances of number talk. Number talk referred to any use of number words (e.g., one, two, three etc.) or talk intended to discuss numbers. Number talk was coded into eight different categories including talk about number symbols, counting, labeling set sizes, ordinal relations, patterns, comparing magnitudes, arithmetic and "other". Examples of each of these number talk categories are described in Table 1. Each utterance was coded with only one hierarchical number talk category. The hierarchy of number talk used when coding was as follows, in order of highest to lowest: arithmetic, patterns, comparing magnitudes, ordinal relations, counting, number symbols, labeling set sizes, other. This hierarchy was created due to instances of combinations of number talk occurring in a typically hierarchical manner. For instance, when engaging in talk about arithmetic, it was necessary for participants to label set sizes by discussing cardinal values (i.e., "How many dollars is 5 dollars plus 10 dollars?"). In these instances, the highest level of number talk used relative to the coding hierarchy took precedence in coding.

The current study also examined a subset of number talk, that is, high-level, or more advanced number talk. Given our hierarchy of coding number talk, we operationalized high-level number talk as the use of number talk about arithmetic, patterns, comparing magnitudes, and ordinal relations.

### 2.3.2 Parent Questionnaire

After completing the semi-structured interactions, parents individually completed an extensive questionnaire including 223 questions. This questionnaire took approximately 60 minutes to complete and asked the parent a variety of questions to gain information about themselves (education level, race, job, marital status, etc.), the child's home environment (living situation, annual household income, income, etc.), the child (health conditions, day care enrollment, etc.), and their joint engagement in various activities (reading books, playing games, watching TV, etc.). This questionnaire also asked the parent about their beliefs on a range of topics including various academic and developmental domains. For the current study, there are two parental beliefs of interest. First is the parents' belief regarding the responsibility of the home relative to the school. On the questionnaire, this question reads as:

"Both home and school may play important roles in fostering children's development in the various skill areas listed below. We would like your view on the **contribution of the home relative to the school.** From the areas listed below, choose the ones that you feel the **HOME** (rather than the school) has the most responsibility for fostering development and the ones you feel the **SCHOOL** (rather than the home) has the most responsibility for fostering development. Choose **EQUAL IMPORTANCE** if you believe home and school share equal responsibility in the areas below."

Parents' responses (home, school, equal) were collected for domains including character and moral development, health and safety awareness, creative activities, effective communication, mathematics, world knowledge (e.g., geography, history, science), literacy (i.e., reading and writing), technological and computer competency, and physical fitness. The current study will examine parents' beliefs regarding the responsibility of the home and the responsibility of the school in fostering their child's mathematics development.

The second parental belief of interest in the current study is the parents' relative ranking of the importance of mathematics in preparing their child for the future. In the questionnaire, this question reads as:

"Please rank the skill areas below according to their importance in best preparing children for the future. To do this, give each skill area a **rank from 1 to 9**. Give a "1" to the area that is most important or first in importance compared to the other skill areas. Give a "9" to the one that is the least important or last in importance. **Remember that you can use each number only once.**"

The areas compared were the same as those asked about in regards to parents' beliefs about the responsibility of the home and the responsibility of the school in fostering development. Using each number only once, parents were asked to rank on a scale of 1 to 9, character and moral development, health and safety awareness, creative activities (e.g., art, music), effective communication, mathematics, global and national awareness (e.g., current events, civic engagement), literacy (reading and writing), technological and computer competency and physical fitness.

## 3.0 Analytic Plan

To address RQ1, descriptive statistics were used to determine how parents' beliefs regarding the responsibility of the home and school, and the importance of mathematics vary. To address RQ2, two different types of analyses were run: First, to examine whether number talk differed by *math responsibility beliefs*, two separate Welch's t-tests were conducted comparing parents' number talk as a function of parental beliefs regarding the responsibility of fostering math education (school vs. home and equal importance). Parents' number talk was measured in two ways: total number of utterances containing number talk summed across the three semi-structured tasks and the proportion of number talk utterances out of the total utterances produced. Second, to examine the relation between parents' beliefs of the importance of mathematics and their engagement in number talk with their child Pearson's correlations were run separately for total number of utterances containing number talk and proportions of number talk out of the total utterances. To address RQ3 and explore the relation between parents' beliefs and their use of high-level number talk, the same analyses were used as in RQ2 for each parental belief using only high-level number talk instead of total number talk as the outcome measures. Specifically, high-level number talk was operationalized as any utterances containing talk about arithmetic, patterns, magnitude comparison, and ordinality, and proportion scores were calculated by dividing the frequency of utterances containing high-level number talk by all utterances that a parent used.

# 4.0 Results

## 4.1 RQ 1: Parents' beliefs about math responsibility and importance

Parents' beliefs regarding responsibility in fostering development for the various academic and developmental domains assessed are shown in Table 2. 86 parents (57%) reported that they believed that the home and school share equal responsibility for fostering their child's math education, while 60 parents (40%) reported that it is the responsibility of the school and 4 parents (3%) indicated the home. Initial analyses were conducted for all 150 parent-child dyads in their respective groups, however, since only 4 parents indicated that they believed the home was primarily responsible for facilitating early math development, these participants were grouped with participants who indicated that both the home and the school share equal responsibility due to both groups of participants expressing the belief that the home plays a large role in children's mathematics development. Further, parents' ranking of the importance of mathematics among a range of academic and developmental domains showed wide individual variation. Parents' average ranking of each of the academic and developmental domains assessed is shown in Table 3. Their beliefs regarding the importance of math in best preparing their child for the future ranged from most important, 1, to least important, 9, with a mean ranking of 5.55 ($SD$ = 1.9).

### 4.2 RQ 2: Relation between parents' beliefs and their use of number talk

In general, parents varied considerably in the amount of talk they engaged in, ranging from 141 to 1005 utterances ($M$ = 386.9, $SD$ = 124.0). Total number talk across tasks ranged from 2 to 120 utterances ($M$ = 34.3, $SD$ = 19.2). To control for the total amount of talk produced by parents, total number talk was calculated as a proportion of total utterances, which ranged from less than 1% to approximately 22.4% of total parent talk across all three tasks ($M$ = 9%, $SD$ = 4.6%). Correlations between variables of interest are depicted in Table 4.

To examine whether number talk differed by math responsibility beliefs, a Welch's t-test was conducted to examine parental beliefs regarding the responsibility of fostering math education (school vs. home and equal importance) and total engagement in number talk. The 60 parents in the school responsibility group engaged in an average of 31.9 utterances of number talk ($SD$ = 17.4), and the 90 participants in the home and equal belief group engaged in an average of 35.9 utterances of number talk ($SD$ = 20.2). However, these differences were not statistically significant ($p$ = 0.20).

In order to control for parents' overall talk, a subsequent Welch's t-test was conducted to examine differences in the *proportion* of utterances containing number talk by parental belief group (school, home and equal importance). Results of this test are shown in Figure 1 and show that parents who reported that they believed either the home, or the home and the school share responsibility in fostering mathematics development engaged in significantly more number talk than parents who reported that the school has the most responsibility in fostering children's' mathematics development ($t$ = 2.01, $p < 0.05$). Parents in the school belief group had an average of 8.2% of their total talk containing number talk ($SD$ = 3.7%), whereas parents in the home or equal belief group had an average 9.6% of their total talk containing number talk ($SD$ = 5.0%).

Furthermore, correlations between parents' beliefs of the importance of mathematics and their engagement in number talk with their child were examined. Parents' ranking of the importance of mathematics and their total engagement in number talk was significantly negatively correlated, $r = -0.18$, $p = 0.02$, in that parents who ranked math as more important, or closer to 1 used more number talk. This correlation is depicted in Figure 2. However, when controlling for overall talk produced by examining number talk as a proportion of total utterances, this correlation became only marginally significant, $r = -0.14$, $p = 0.08$. This correlation is depicted in Figure 3.

### 4.3 RQ 3: Relation between parents' beliefs and their use of high-level number talk

Parents produced a very low number of utterances containing ordinal relations and comparing magnitudes. Because of this, these two codes of number talk were omitted and these instances were included in the number talk category "other." As a result, high-level number talk was operationalized as parents' engagement in number talk about arithmetic and patterns and ranged from 0 to 11 utterances ($M = 1.2$, $SD = 2.2$). To control for the total amount of talk produced by parents, high-level number talk was also calculated as a proportion of total utterances, which ranged from 0% to approximately 3.0% of total talk ($M = 0.3\%$, $SD = 0.6\%$). Descriptive statistics of parents' number talk production are included in Table 5 and distributions of parents' use of high-level number talk are shown in Figure 4 and Figure 5.

While it was originally proposed to examine how parents' beliefs are associated with their engagement in high-level number talk with their child, parents' use of high-level number talk across tasks was minimal. As such we were unable to adequately gauge how parents' math beliefs relate to their engagement in high-level number talk with their child. Thus, analyses between these variables were not included.

## 5.0 Discussion

The present study explored the variability in parental number talk during three semi-structured interactions and the relation between parental beliefs and parents' use of number talk with their child. Specifically, we were interested in exploring parents' beliefs regarding both the responsibility of the school and the home in fostering mathematics development and the importance of mathematics in preparing children for their future. Since few studies have examined what specific beliefs may contribute to parents' variability in number talk, we explored the relation between these beliefs on parents' quantity and quality of number talk with their child. Consistent with our hypothesis and with prior literature, we found large variation in the quantity of number talk that parents produced (Levine et al., 2010; Elliott et al., 2016). While there was also individual variation in parents' engagement in high-level number talk, it occurred too infrequently to adequately analyze how parents' beliefs relate to parents' use of high-level number talk.

Parents' beliefs regarding the home versus the school's responsibility in fostering mathematics development were found to be related to their use of overall number talk when controlling for total utterances produced such that parents who believed that either the home or both the home and school have the primary responsibility in fostering children's math development used a greater proportion of number talk than parents who believed that this was the primary responsibility of the school. This difference between parents of varying beliefs is consistent with the conceptual model of academic socialization. This model suggests that parents' beliefs regarding school influence the practices they implement with their child as the child goes through a period of transition in schooling (Puccioni, 2015). Children in our current sample were 4 years old and likely going to transition into kindergarten within the next year. As such, parents in our sample may have been acting on their beliefs about their role to prepare their child for entrance into kindergarten. These results supplement prior literature on the role of parental beliefs as no prior research had previously examined the association between parents' beliefs regarding the responsibility of the school vs. the home in fostering mathematics development on parents' engagement in math-related activities with their child.

One strength of the current study is the ability to control for the total amount of utterances that parents produced during the semi-structured observations. There was considerable variation in the amount of overall talk that parents engaged in across the three semi-structured activities with the least communicative parents engaging in less than 200 utterances, and the most communicative parent engaging in more than 1000 utterances. This control allowed us to get a more accurate measure of how much *number* input on average that parents are exposing their children to in comparison to how much overall talk, or regular *language* input. This was especially important since total parental talk was significantly correlated with total number talk production.

Additionally, perhaps one of the biggest strengths of the current study, is the use of semi-structured, at-home observations that allowed us to get a view of how parents and children play with each other and how often math, specifically number, is discussed during tasks that are not out of the realm of possible day-to-day activities such as reading a book or engaging in a puzzle with their child. The vast majority of prior research on parents' engagement in math-related activities with their child has been self-report, survey data. Our observations were structured for parents to attempt to engage with their child as they normally would while parents have no knowledge of math activities being observed which is a more reliable measure than self-report data that can be easily biased.

In addition to the association between parents' beliefs about the role of the home vs school, we found a significant correlation between parents' beliefs regarding the importance of mathematics and their use of overall number talk, such that parents who rated math as being higher in importance used more number talk in conversations with their child. Importantly, our measure of math importance compared parents' beliefs regarding mathematics to a relatively large range of academic and developmental domains including character/moral development, health/safety awareness, creative activities, effective communication, mathematics, world knowledge, literacy, technological/computer competency, and physical fitness. This comparison allowed us to get a more holistic representation of parents' prioritization of mathematics by putting their beliefs regarding importance into perspective as a domain outside of just academia or schooling. Our result was consistent with prior literature showing an association between parents' beliefs regarding math importance and their engagement in math-related activities in the home (Sonnenschein et al., 2012; Cannon & Ginsburg, 2008). This finding is also in line with expectancy-value theory in that parents who reported that they believed math to be of higher importance, or higher value, for their child's future produced more number talk with their child, showing higher persistence in this task than parents who expressed less value of mathematics for their child (Wigfield & Eccles, 2000). However, when we controlled for parents' overall talk by comparing the *proportion* of number talk utterances produced, the association was only marginally significant. Thus, these results need to be treated with caution and may warrant replication in a future study.

Overall, our results are consistent with prior literature showing parents' beliefs regarding learning and teaching are associated with their engagement in academic activities in the home as measured via parental report (Sonnenschein et al., 2012; Silver et al., 2020; Vasilyeva et al., 2018;

Missall et al., 2015). Here we expand these findings by showing that parents' beliefs are also related to their number talk directly observed during three different semi-structured interactions. Taken together, these findings suggest that parents' beliefs about mathematics are an important distal factor associated with a proximal process, i.e., the home numeracy environment, which is likely associated with children's math abilities.

Though prior literature suggests the important associations between parents' engagement in quality, or advanced number talk, and their child's mathematics knowledge (Ramani et al., 2015; Elliott et al., 2017), we were unable to explore how parents' math beliefs may relate to this variation in engagement due to the infrequent use of high-level number talk among parents. Despite this inconsistency, we do not interpret this to mean that parents' beliefs regarding mathematics development, or the learning environment that stimulates mathematics development, are not associated with their engagement in high-level math-related activities with their child. Since very little research has focused on more advanced number talk, there is a lack of consensus regarding what types of math talk are considered "basic" or "high-level" and these definitions may also depend on children's actual knowledge. For example, Ramani et al. (2015) defined advanced number talk to consist of talk about arithmetic, magnitude comparison, ordinal relations, and cardinality, while Elliott et al. (2017) defined it as any talk including numbers greater than 10. Thus, an utterance such as "what is one plus one?" might be considered advanced number talk in one definition whereas it would not be in the other. As such, advanced number talk might need to be defined as a combination of the mathematical concept involved in conjunction with the size of the numbers, while possibly also taking the specific skills of the child into account. Future research could try this approach to examine the relation between high-level number talk and parents' beliefs.

## 5.1 Limitations and Future Directions

While we allowed dyads to play with the toys provided in whatever way they felt comfortable and conducted these visits in families' homes to ensure that our observations were naturalistic, it is entirely possible that both parents and children engaged with each other and with the toys provided differently than they would had they not been video-taped for participation in a research study. Similarly, we provided a structured set of toys for the parents and children to play with. It is possible that the semi-structured tasks that parents and children were told to engage in were unfamiliar to some families. Relatedly, our semi-structured tasks may not be activities that parents actually take part in with their children frequently; thus, the observational data may not actually reflect the everyday interactions that parents and children engage in. Instead, these semi-structured observations may have captured the "best case scenario" for these parents and children. We are unaware how often parents and children both have the ability to set aside time to engage in these activities 1-on-1 without any, or with minimal distractions. The toys selected for the free play activities were specifically chosen to stimulate conversation between the parent and child, and it is unknown whether families have access to these types of materials outside of this idealized situation. Thus, children's experiences with number talk and other math-related activities may vary considerably outside of these observations. Future research should attempt to observe number talk between parents and children during more naturalistic observations such as following parents and children during their daily routines to observe how they act under normal, rather than idealized, conditions.

While the results of our study do show a relation between parents' beliefs regarding responsibility in fostering mathematics development and parents' engagement in number talk, future research should take this a step further to explore the specificities of this belief. Our questionnaire item asked parents about their beliefs in a broad sense that may only relate to more general, overall number talk engagement. Parents were asked about their view regarding which location, the home, the school, or both, has the most responsibility for fostering development in mathematics. Future research may consider a more specific exploration of parents' beliefs by asking about their own role compared to the role of the teacher, as well as their beliefs regarding the role of the home environment in pushing children to their next developmental level in math. It is also possible that during activities with their child, parents are adjusting their language input to meet their child's personal needs and abilities, in which case, it may be valuable for future research to consider parents' perception of their child's math abilities as a factor that may influence their engagement in number talk with their child.

Additionally, the current study examined how parental beliefs are related to parents' number talk. This method of quantifying number talk does not acknowledge the active role of the child in these tasks and the possibility that parents may be engaging in more number talk in response to their child's number talk or prompts. For example, a parent whose child repeatedly asks what number is printed on the bills in the grocery store set or how much things cost is likely engaging in more number talk than a parent whose child asks about the parent's favorite food and which foods are healthy. The current number talk coding scheme does not take into account whether this number talk was parent-initiated or child-initiated. Future work should incorporate the active role that the child may play in these interactions by looking at more specific categories of number talk to examine the association between parents' beliefs regarding mathematics and their self-initiated number talk, as well as if parents with stronger beliefs regarding mathematics initiate more number talk during tasks than their child does.

Moreover, the current study focused on parents' production of *number*-related input. While much prior literature demonstrates the importance of early number talk exposure on children's mathematics achievement, this focus leaves out the important category of spatial talk, i.e., talk used to describe the properties of objects (i.e., square, small) and spatial relations between objects (i.e., below, on top of). The current study found minimal number talk production from parents during the magnet board activity. This task is more conducive to spatial talk than the others and parents may have focused on spatial concepts during this task rather than just numerical concepts. Prior research has found links between spatial language, spatial skills, and mathematics performance (Bower, Foster, Zimmermann, Verdine, Mazouk, Islam & Hirsh-Pasek, 2020), demonstrating the need for continued research on factors that may influence production of this type of language. Moreover, future work may examine both overall, and high-level math talk more generally, including both number and spatial language to better understand the implications of these types of math language.

Additionally, while there was some variability in both income and education, parents in our sample were largely highly educated, mostly white, and almost entirely mothers. The latter restricted us from gaining any real understanding of the very important influence on children's early learning that fathers may play in children's math exposure. Fathers' beliefs regarding both responsibility in fostering development of math, and the importance of mathematics, may differ from that of mothers, as could their engagement in number-related input with their child. Very limited research has been done regarding factors that may influence fathers' engagement in math-related activity with their child as well as on the role of this engagement in children's math achievement. However, given prior research demonstrating that math attitudes, such as math anxiety, can vary based upon gender (Wilder, 2012), and other research showing that parents' beliefs predict the experiences that they make available to their children (Sonnenschein et al., 2012), future work should consider the role that fathers' beliefs regarding mathematics have on their engagement in math-related activities with their children. Furthermore, this limited sample restricts us from generalizing the results of our study to a larger, more diversified population. Prior research has shown that there is a relationship between socioeconomic status (SES), typically comprised of parental education, income, or both, parents' beliefs about math development, children's exposure to math-related activities, and their subsequent math achievement (DeFlorio & Beliakoff, 2014). These ties between SES and children's math learning demonstrate the importance of generalization to a larger, more diverse sample as lower-SES populations may benefit the most from this type of work. Future work may examine how parental beliefs regarding math responsibility and math importance vary among parents of differing socioeconomic status, and if that belief has any relation to parents' engagement in both their use of number talk, as well as the quality, or the amount of high-level number talk they use with their child.

Finally, very few parents in our sample (4 out of 150) reported that they believed that the home had the primary responsibility in fostering their child's mathematics development. This result may be in part due to the majority of children already being enrolled in preschool, and all children nearing entrance to kindergarten. It is possible that parents' beliefs about their own responsibility to facilitate learning in the home environment differs for parents who do not send their children to preschool or when children are younger. To explore this further, future research should explore how parental beliefs may change over time such as through a longitudinal study examining the role of parents' beliefs on number talk to gain a better understanding of how language input may change with parents' beliefs across the childhood years.

## 5.2 Conclusion

The home environment and parents' engagement in math-related activities, as well as the quantity and quality of number talk that parents engage in, has been found to be related to children's mathematical abilities. The current study expanded on previous literature to explore factors that may be influencing parents' engagement in these activities by examining their beliefs regarding math importance and math responsibility. We found much individual variation in parents' beliefs regarding mathematics as well as their use of number talk while interacting with their children. Importantly, we found a significant difference in number talk between parents who believed that the school was primarily responsible for fostering children's mathematics development and parents who believed that either the home, or the home and school were equally responsible for fostering this development with the latter engaging in significantly more number talk with their child than the former. We also found that there was a zero-order correlation between parents ranking of math importance and their total production of number talk, but when considering total talk produced, this association dropped to a marginally significant association. Our results provide insight on the variation of parents' beliefs regarding mathematics and add to a growing body of literature that explores the association of parental beliefs and children's exposure to math-related input. This work has broader implications to help inform parents, teachers, and policy makers alike about what factors may and may not be influencing parents' contributions to the home numeracy environment and assist parents in helping their children establish a strong foundation in mathematics for future success.

# 6.0 Figures

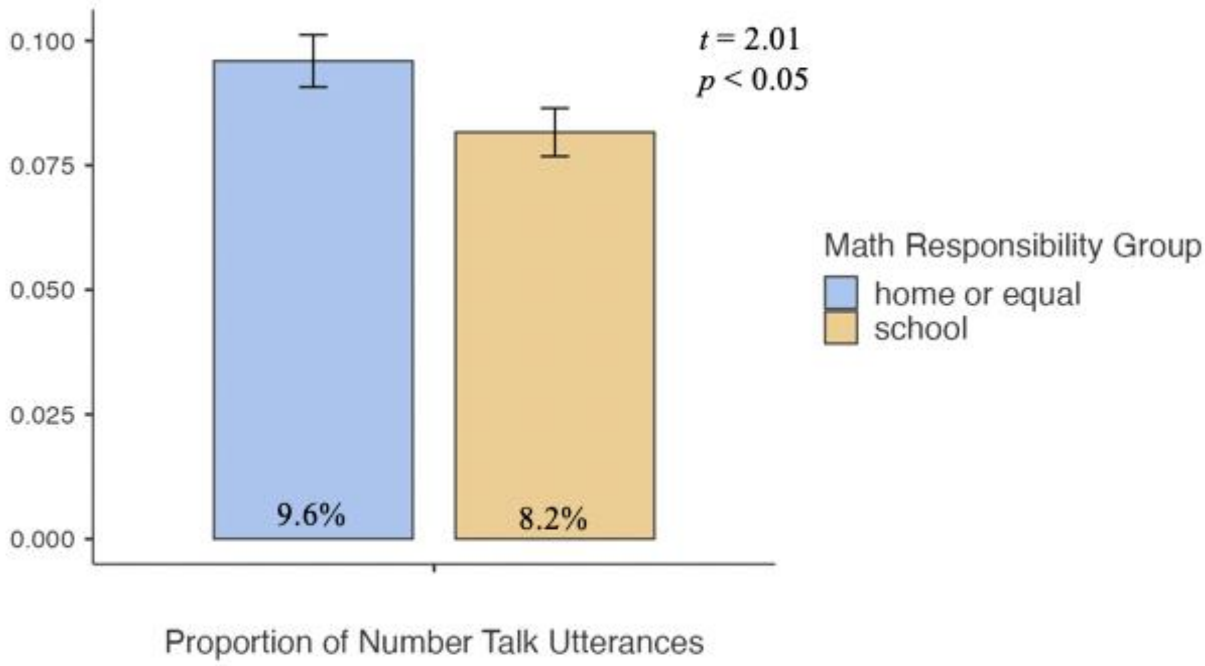


**Figure 1. Proportion of Number Talk Utterances as a Function of Parent Responsibility Group Regarding Fostering Mathematics Development**

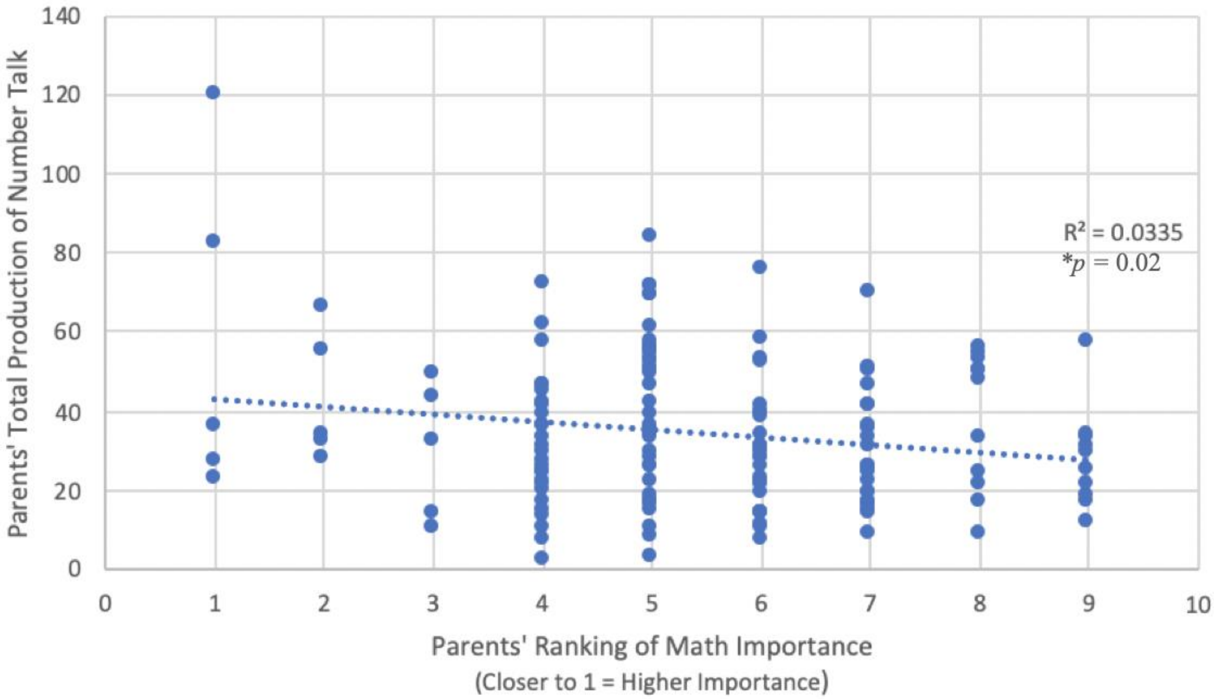


**Figure 2. Correlation Between Math Importance and Parents' Total Production of Number Talk**

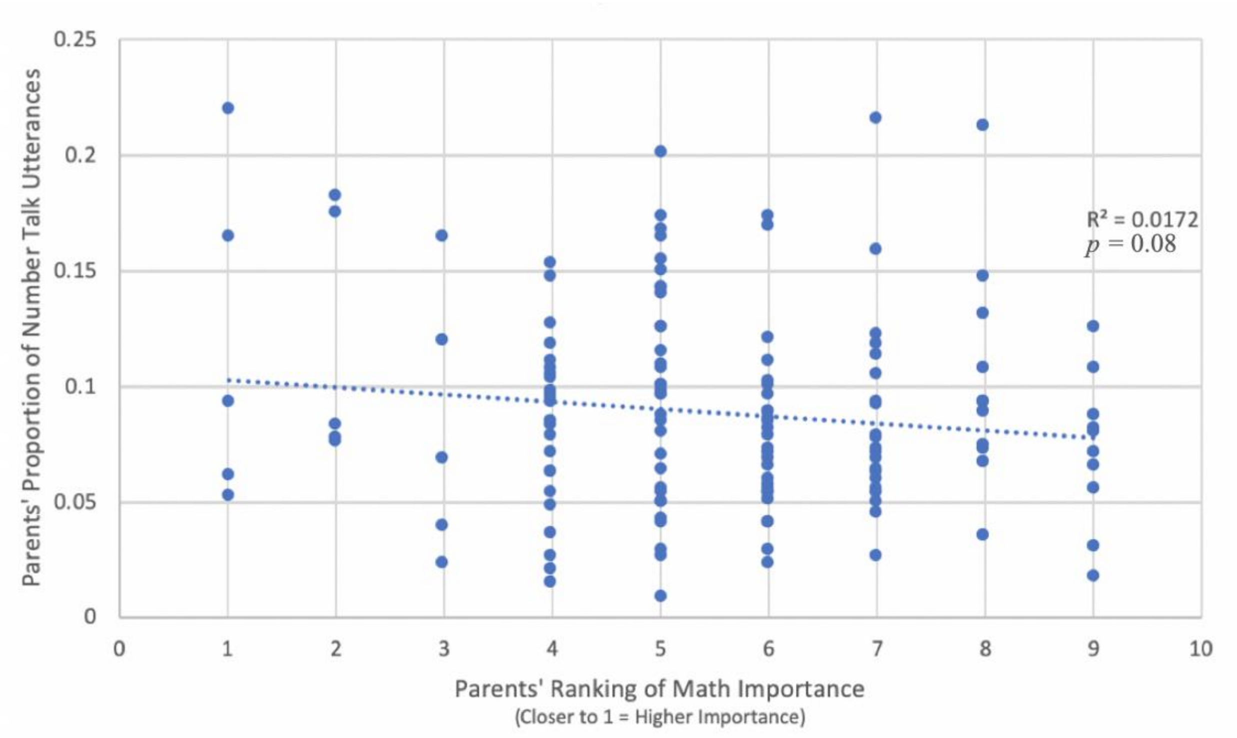


**Figure 3. Correlation Between Math Importance and Proportion of Number Talk Produced**

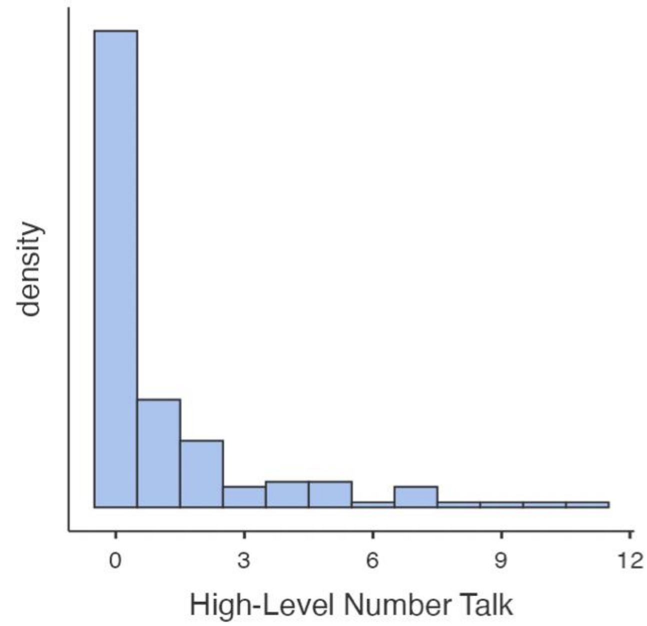


**Figure 4. Parents' Overall Production of High-Level Number Talk**

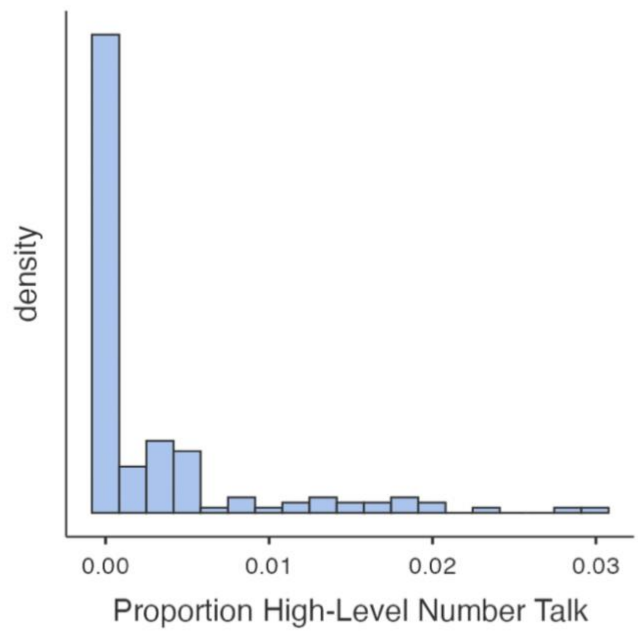


**Figure 5. Parents' Proportion of High-Level Number Talk out of Total Utterances**

# 7.0 Tables

**Table 1. Examples of Each Category of Number Talk**

| Number Talk Coding Category | Example |
|---|---|
| Number Symbols | "Can you point to the number two?" |
| Counting | "There were one, two, three..." |
| Labeling set sizes | "There are three foxes" |
| Ordinal Relations* | "What comes before nine?" |
| Patterns* | "There are two racoons, three birds, four..." |
| Comparing Magnitudes* | "You have four more pizza slices" |
| Arithmetic* | "One plus one is two" |
| Other | "Pass me the five-dollar bill" |

***High Level Number Talk**

**Table 2. Number of Parents Reporting that it is the Responsibility of the Home, School or Both to Teach their Children Certain Skills**

| | Home | School | Equal |
|---|---|---|---|
| Mathematics | 4 | 60 | 86 |
| Character/Moral Development | 88 | 2 | 60 |
| Health/Safety Awareness | 47 | 9 | 94 |
| Creative Activities | 19 | 19 | 111 |
| Effective Communication | 36 | 5 | 108 |
| Global/National Awareness | 12 | 50 | 88 |
| Literacy | 15 | 23 | 112 |
| Technological/ Computer Competency | 8 | 47 | 95 |
| Physical Fitness | 34 | 8 | 107 |

**Table 3. Parents' Average Importance Ranking for Different Domains**

| | Mean | Std. Dev. |
|---|---|---|
| Mathematics | 5.5 | 1.9 |
| Character/Moral Development | 1.9 | 1.5 |
| Health/Safety Awareness | 4.2 | 2.3 |
| Creative Activities | 6.2 | 1.8 |
| Effective Communication | 3.2 | 1.7 |
| Global/National Awareness | 7.3 | 1.8 |
| Literacy | 3.3 | 1.6 |
| Technological/ Computer Competency | 6.7 | 1.8 |
| Physical Fitness | 7.1 | 2.0 |

**Table 4. Correlations Between Variables of Interest**

| Measure | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1. Parent utterances | | | | | | |
| 2. Total number talk | .41** | | | | | |
| 3. Proportion of number talk | -.10 | 0.81** | | | | |
| 4. Total high-level number talk | .35** | 0.88** | .75** | | | |
| 5. Proportion of high-level number talk | -.19* | 0.63** | .87** | .81** | | |
| 6. Parent's rankings of the importance of math | <-.01 | -.18* | -.14 | -.10 | -.05 | |

***p<.05, **p<.001**

**Table 5. Parents' Production of Number Talk Across Tasks**

| Number Talk Category | Minimum | Maximum | Mean | Std. Dev. |
|---|---|---|---|---|
| Number Symbols | 0 | 29 | 2.4 | 4.7 |
| Counting | 0 | 44 | 4.6 | 6.9 |
| Labeling set sizes | 1 | 65 | 24.1 | 12.2 |
| Patterns | 0 | 8 | 0.2 | 1.1 |
| Arithmetic | 0 | 11 | 1.0 | 1.9 |
| Other | 0 | 14 | 2.1 | 2.2 |

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