LENA Grow Evaluation

Evaluation of LENA Grow in Milwaukee Head Start Classrooms

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Executive Summary

Prepared by John Heilmann[a] and Maura Moyle[b]

[a] University of Wisconsin-Milwaukee

[b] Marquette University

Statement of the Problem

The World Health Organization has identified poverty as the strongest social determinant of health. Nearly 40% of households in Wisconsin are from low socioeconomic status (SES) backgrounds and struggle to meet basic needs (United Way, 2016). Despite decades of research and billions of dollars in investments, there continues to be a significant achievement gap for children from disadvantaged backgrounds (Ferrer et al., 2015). The roots of this achievement gap start early. By the time children from low SES backgrounds reach 3 years of age, they have heard 30 million fewer words than their higher SES peers (Hart & Risley, 1995). As a result, children from low SES homes tend to enter school with smaller vocabularies and are at risk for delays in language acquisition and challenges in long-term reading, academic, and social success (Kurdek & Sinclair, 2001). Children from low-income households are less likely to receive high-quality childcare (Carlson et al., 2008). The importance of early language experience and the power of caregiver talk has led public health experts to recommend that caregivers provide adequate ***language nutrition,*** defined as high quantity and quality of talk directed toward young children (Zauche et al., 2016). The goal of our project is to empower early childhood teachers to promote language nutrition with children from low-SES backgrounds.

Efficacy research has demonstrated that high-intensity coaching programs can be effective in empowering parents and teachers to enhance their language nutrition and promote young children's language skills (Powell et al., 2010; Tosh et al., 2017). Effective coaching programs require frequent, unobtrusive, and valid feedback (Duchaine et al., 2011). The LENA (Language ENvironment Analysis) system is an innovative technology that provides automated feedback. Children wear digital recorders to capture the full language environment during a typical day. LENA software automatically summarizes the quantity of adult-child interactions. This objective data is used in conjunction with a 10-week coaching curriculum focused on increasing children's language input from their caregivers and the number of conversational turns between adults and children. Preliminary studies have demonstrated that LENA feedback can promote caregivers' ability to provide language nutrition (Suskind et al., 2016). However,

there are limited data on the use of the LENA feedback system within a childcare environment, where many children spend the majority of their waking hours.

The ***LENA Grow*** program incorporates classroom-level LENA data with a coaching curriculum to promote language nutrition for early educators. Through LENA Grow, teachers complete a 10-week curriculum, where they receive LENA data from their classrooms, discuss strategies to increase their language nutrition, and develop goals to increase the quantity and quality of language used with children in their classrooms. LENA summarizes the overall amount of talking within the classroom environment (Total Words), as well as the amount of interaction with individual students (Conversational Turns). To date, LENA Grow has been used in over 2,000 center-based classrooms, serving more than 18,000 children. However, the efficacy has not been well studied. The goal of this project was to test the impact of LENA Grow teachers serving at-risk children and compare the outcomes to teachers receiving business-as-usual coaching. We achieved this goal by addressing the following research questions:

1) Do teachers who completed LENA Grow substantially increase the quantity and quality of the language used in their classrooms?
2) Do teachers who completed LENA Grow rate themselves as being more effective teachers when compared to teachers completing business-as-usual coaching?
3) Do children whose teachers completed LENA Grow experience substantially greater academic and language gains when compared to children whose teachers completed business-as-usual coaching?

Context for the Study

The Next Door Foundation is a gold-standard early childhood agency that serves children and families in Milwaukee. Next Door provides center-based early childhood education through its direct administration of Early Head Start, Head Start, and Kindergarten classrooms. Next Door has strong administrative leadership, excellent funding, an established teacher coaching program, and highly skilled teachers. Next Door had been implementing LENA Grow in its on-site Early Head Start classrooms with good success. Recently, Next Door started the *Childcare Partnership Program* (CPP), where Next Door staff provide administrative support and coaching services to non-Next Door preschools throughout Milwaukee. The goal of the CCP is to leverage the strong supports of Next Door to improve the educational workforce throughout the region. The most tangible impact of the CCP is the provision of coaching to the educational workforce at community preschools. For the past three years, the Next Door CCP has provided intensive, practice-based coaching to early childhood teachers in Head Starts throughout Milwaukee. The coaching is delivered by professional teaching coaches, whose full-time jobs are staying up to date on the latest coaching practices and delivering individualized coaching to early childhood teachers.

In the spring of 2022, the CCP chose to add LENA Grow to their coaching curriculum. CCP coaches implemented the LENA Grow curriculum with teachers from 10 Early Head Start and Head Start classrooms (i.e., *Treatment Classrooms*). In addition, the CCP team collected data from 10 additional CCP classrooms that did not receive LENA Grow, but rather completed business-as-usual practice-based coaching (i.e., *Control Classrooms*). As observed in Table 1, the groups were well matched on the number of students participating and student age. All children were in Head Start or Early Head Start classrooms, meeting the state's eligibility

criteria (e.g., children from families with low income, children in foster care, children from families receiving public assistance, etc.). The treatment group had a higher percentage of African American children and the control group had a higher percentage of Hispanic children. Additional demographic information is available in Appendix A.

Table 1. Demographic Characteristics of Children Participating in the Study

Treatment Group					**Control Group**				
Center	Classroom	*n*	Mean Age (Mths)	%African American %Hispanic	Center	Classroom	*n*	Mean Age (Mths)	Race/Ethnicity
3250	14937	4	8.9	100% Af. Amer.	3326	14927	6	25.0	17% Af. Amer. 67% Hispanic 17% White
	14938	6	18.7	83% Af. Amer. 17% Other		14928	3	18.2	33% Af. Amer. 33% Hispanic 33% White
	14939	6	34.5	83% Af. Amer. 17% Other		14929	5	29.6	60% Af. Amer. 40% Hispanic
	14940	10	47.4	80% Af. Amer. 10% Other 10% No Report		14930	13	40.7	15% Af. Amer. 62% Hispanic 8% White 15% Multiracial
3251	14941	17	43.2	24% Af. Amer. 47% Hispanic 12% White 18% Multiracial	3325	14931	4	22.9	50% Af. Amer. 25% Asian 25% Multiracial
	14942	8	18.1	25% Af. Amer. 50% Hispanic 13% White 13% Multiracial		14932	7	33.0	43% Af. Amer. 14% White 14% Other 29% Multiracial
	14943	7	28.0	14% Af. Amer. 57% Hispanic 29% Multiracial	3324	14933	6	27.9	17% Af. Amer. 67% Hispanic 17% White
	14944	7	32.5	14% Af. Amer. 43% White 14% Other 29% Multiracial		14934	19	45.2	11% Af Amer. 79% Hispanic 11% White
3252	14945	5	20.0	60% Af. Amer. 40% White		14935	7	28.5	14% Af. Amer 86% Hispanic
	14946	9	28.0	89% Af. Amer.		14936	7	19.8	43% Af. Amer.

				11% Multiracial				57% Hispanic
Total		***79***	***31.4***	***52% Af. Amer.*** ***20% Hispanic*** ***10% White*** ***4% Other*** ***13% Multiracial*** ***1% No Report***	***Total***		***77***	***33.3***	***25% Af. Amer.*** ***57% Hispanic*** ***10% White*** ***0% Asian*** ***1% Other*** ***6% Multiracial***

We next summarize the characteristics of the teaching workforce participating in the study. As observed in the following table, the teachers in the treatment and control groups were roughly equivalent. The teachers in the treatment group had more total college experience, yet fewer 4-year degrees than the control teachers. Substantially more of the teachers in the treatment group had credentialing completed or in progress from the Child Development Association. The teachers in the control group had notably more experience than the teachers in the treatment group. The race and ethnicity of the groups varied slightly, with the treatment group having notably more teachers who were African American and fewer teachers who were White.

Table 2. Demographic Information of Teachers Participating in the Study

		Treatment Teachers (*n* = 18)	**Control Teachers (*n* = 18)**
Education	High School/GED	6%	11%
	Some College	33%	28%
	Associates	39%	28%
	4-year degree	22%	33%
Child Development Association (CDA) Credential	No	28%	56%
	In progress	22%	6%
	Yes	44%	39%
	Prefer no answer	6%	0%
Experience Teaching	< 1 year	17%	11%
	1 – 4 years	17%	11%
	5 – 9 years	17%	22%
	10 – 14 years	11%	6%
	15+ years	39%	50%
Race/Ethnicity	African American	39%	11%
	Hispanic	50%	39%
	White	11%	33%
	Asian	0%	6%
	Multiracial	0%	11%
Dominant Language	English	61%	67%
	Spanish	39%	33%
Second Language Fluency	None	67%	50%
	English	17%	22%

	Spanish	6%	22%
	Hmong	0%	6%
	Prefer no answer	11%	0%
Gender Identity	Female	100%	94%
	Male	0%	6%

Intervention

The LENA Grow curriculum was implemented in 10 classrooms. Most of the classrooms had a teacher and teaching assistant complete the LENA program, with a total of 18 teachers participating. Prior to the start of the program, their coaches completed 5 hours of training on the LENA curriculum. In March of 2022, each child in the 10 treatment classrooms wore the LENA devices for two full days, which provided baseline LENA data. LENA data were then collected each week for the entire duration of the coaching program. The coaches and teachers then met weekly for small group coaching sessions, where they reviewed the past week's LENA data, discussed strategies for promoting language use in the classroom, and developed individualized goals.

Outcome Measures

We evaluated the program's overall effectiveness at three levels: (1) Direct impact on teacher talking, (2) Impact on teacher self-perceptions, and (3) Impact on child outcomes. We used the LENA data to document the teachers' language use in the classroom, which was only available for teachers in the treatment group. All other data were available for both the treatment and control group.

The LENA data comes directly from the LENA recorders, worn by the children for entire school days. The baseline data were averaged from two separate recording days, before teachers started the LENA Grow coaching sessions. The post-coaching data were averaged from the two last weeks of the LENA Grow program. Specialized software automatically calculated the following measures:

Adult Word Count (AWC) – estimates the number of adult words spoken near the child (within 6-10 feet). Words are not recognized per se, they are estimated based on acoustic information like duration, syllable counts and consonant distributions.

Child Vocalization Count (CVC) – estimates the frequency with which the key child vocalizes. Vocalizations represent any sound generated from the child's vocal tract except fixed signals (cries, screams) and sounds related to respiration or digestion (breath, burps). A child vocalization can be a word, a babble or a sentence of any length, separated by at least 300 milliseconds of silence or other sounds.

Conversational Turn Count (CTC) – estimates the number of back-and-forth alternations between key child vocalizations and adult vocalizations. It is a proxy for serve-and-return interaction and is LENA's most predictive measure for language/cognitive outcomes (Gilkerson et al., 2018) as well as brain structure and function (Romeo et al., 2018). Turns must contain at most one initiation and one response within 5 seconds. For example, if a child says something and an adult response within 5 seconds, that is one conversational turn. Same goes vice versa, if an adult vocalizes and a children responds within 5 second, that is counted as one turn.

Figure 1. Summary of Outcome Data and Predictions

Teacher Talking — LENA Data

- LENA data collected in classrooms and shared with teachers during coaching sessions
- Main measures include Total Words and Conversational Turns produced in the classroom
- Analyzed data from baseline and during the last two weeks of coaching
- Predicted strong growth because these skills were directly addressed in the intervention

Teacher Self Ratings — Teacher Perception Survey

- 14 questions asking teachers to rate their overall effectiveness as a teacher
- 3 Domains: Beliefs & Actions, Job Satisfaction, and Self Efficacy
- Predicted that that teachers in the treatment group would have stronger self-ratings because of the objective feedback provided by the LENA data and the positive coaching experiences

Child Outcomes — Teaching Strategies Gold

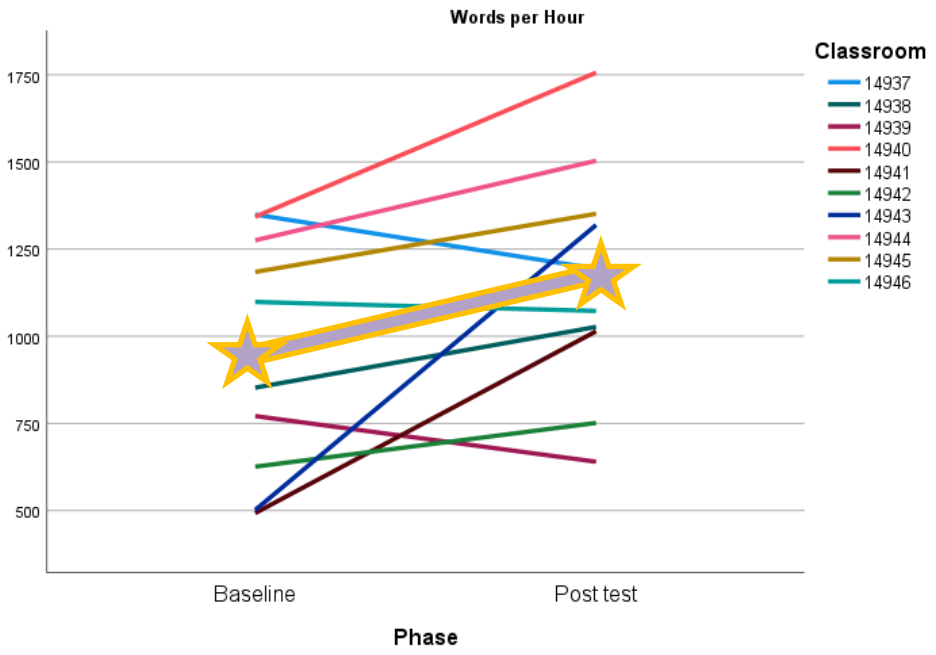
- Formative assessment data collected from all children in the 20 classrooms
- Includes language and academic subtests (Language, Cognition, & Literacy)
- Predict that all children make growth with age, but children in treatment group grow faster than control group children in language and academic domains

R***esults***

LENA Data

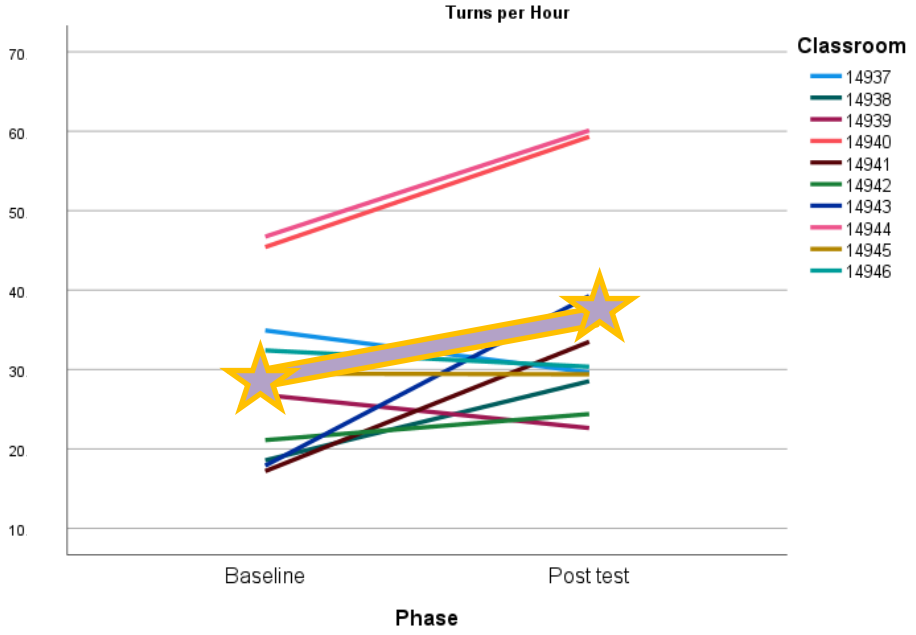
Total Words. At the end of the 10-week coaching program, children in the 10 classrooms were exposed to adult talk at a much higher frequency. They went, on average, from producing 950 words per hour to producing 1,163 words per hour, which was an ***22% increase in words produced***. Figure 2 depicts the changes in words produced by teachers per hour, with the gold bar showing the average for all classrooms and the individual lines showing growth for each individual classroom.

Figure 2. Total Word Produced at the Beginning and End of the LENA Grow Program



Conversational Turns. The teachers, as a group, notably increased conversational turns with the children in their classrooms. At baseline, teachers were producing, on average, 29 turns per hour. At the end of the LENA Grow program, teachers were producing an average of 36 turns per hour, which was a ***24% increase in conversational turns over a 10-week period***. This increase was noteworthy, as the teachers in these 10 classrooms started the LENA Grow program with conversational turns at an unusually high level. In non-Head Start classrooms nationwide, teachers start, on average, at 18 turns per hour. The teachers in our sample began with conversational turns at a 56% higher rate than nationwide averages.

Figure 3. Use of Conversational Turns at the Beginning and End of the LENA Grow Program



Individual Differences in Rooms. To explore different patterns of growth in the LENA data, we examined changes in Total Words and Conversational Turns for each classroom. Table 2 summarizes the baseline performance for these two measures and the percent change from baseline to the end of the coaching program for each classroom. The six classrooms in the top of the table had positive growth for both Total Words and Conversational Turns. The four classrooms in the bottom of the table had no growth or decreases in at least one measure over the course of the training.

Table 3. Individual Profiles for Growth in Words Produced and Conversational Turns

Faster Growth

Classroom ID	Words at Baseline	% Increase Words	Turns at Baseline	% Increase Turns
14943[a]	502	163%	17.9	119%
14941 [a]	493	106%	17.2	95%
14938[b]	853	20%	18.6	54%
14940 [b]	1343	31%	45.4	31%
14944 [a]	1276	18%	46.7	29%
14942 [a]	626	20%	21.1	16%
Average	***849***	***60%***	***27.8***	***57%***

Slower Growth

Classroom ID	Words at Baseline	% Increase Words	Turns at Baseline	% increase Turns
14945[c]	1185	14%	29.5	0%
14946 [c]	1099	-2%	32.4	-6%
14937 [b]	1349	-12%	34.9	-15%
14939 [b]	771	-17%	26.8	-16%
Average	***1101***	***-4%***	***30.9***	***-9%***

[a] Center 3251
[b] Center 3250
[c] Center 3252

Summary of Table 3

- The two classrooms that had the fewest words and turns at the beginning of the program had the greatest increase (classrooms 14943 & 14941)
- Similarly, classrooms that started with more words and turns tended to have slower growth. Of the 5 classrooms that started with more than 1,000 words and more than 30 turns, 60% were in the slower growth group
- All classrooms from Center 3251 were in the faster growth group. Center 3251 had the highest percentage of Hispanic children in the treatment group
- The classrooms with the oldest children (classrooms 14940 & 14941; $M_{age} >$ 40 months) had some of the largest increases in scores
- The classroom with the youngest children (classroom 1437; M_{age} = 8.9 months) had some of the largest declines in scores at the end of the program

Individual Differences between Children. The prior analyses examined changes over time for each of the 10 classrooms. To refine our understanding of children's individual experiences during the LENA training, we examined responses for each of the 80 children who provided baseline and follow-up data. The following analyses are based on all children, irrespective of the center or classroom that they were enrolled in.

In our experience, children who talk less tend to get more attention from their teachers throughout the 10-week LENA Grow program. In fact, the program is designed for this purpose, as children are ranked lowest to highest for teacher/child interaction in each report and coaching sessions focus on these children to increase classroom equity. We looked at the children who had some of the fewest conversational turns at the beginning of the program – those who were in the bottom 1/3 of their classrooms in use of conversational turns at baseline. We compared their growth in the LENA measures to children whose turns were in the top 2/3 of the classroom. As observed in the following table, children who started with the fewest turns had dramatic growth in their use of turns and in their own vocalizations. This growth was far greater than observed for children who started with a higher conversational

turn rate and indicates that the teachers gave these most vulnerable children extra attention and helped to boost their communication, providing more equitable language interaction in the classroom.

Table 4. Growth in Turns and Vocalizations for Children who Started with Lower versus Higher Conversational Turn Rates

Baseline use of Conversational Turns	Increase in Turns	Increase in Child Vocalizations
Bottom 1/3 of classroom	68%	49%
Top 2/3 of classroom	25%	2%

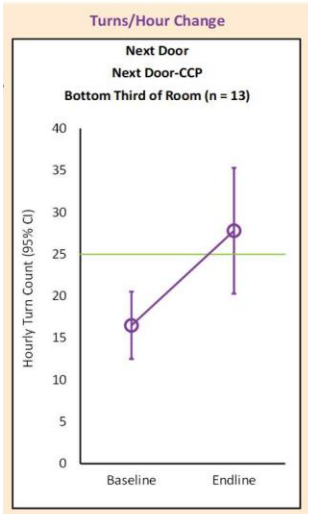


Figure 4. Growth in Use of Conversational Turns for Children who Started the LENA Grow Program with the Lowest Conversational Turn Rates

To better understand the differences in the growth in conversational turns across the children, we completed a series of correlations between growth in turns, age, and baseline LENA measures. As observed in the table below, there was a significant positive correlation between age and growth in turns, meaning that older children tended to have greater growth in conversational turns. We also observed a significant negative correlation between growth in conversational turns and two of the baseline LENA measures (turns and number of words produced by the teachers), meaning that greater growth was observed in conversational turns when children started with teachers who used fewer turns and produced fewer words. The children's vocalizations at baseline did not significantly relate to growth in conversational turns.

Table 5. Correlations between Growth in Conversational Turns, Age, and Baseline LENA Measures

	Age (in months)	Turns at Baseline	Teacher Words at Baseline	Child Vocalizations at Baseline
Growth in Turns	.30**	-.38**	-.31**	.09

The following figures illustrate these differences across children with the lowest (<25th percentile) and highest (>75th percentile) growth in conversational turns.

Figure 5: Children who had Greater Growth in Conversational Turns were Older at Baseline

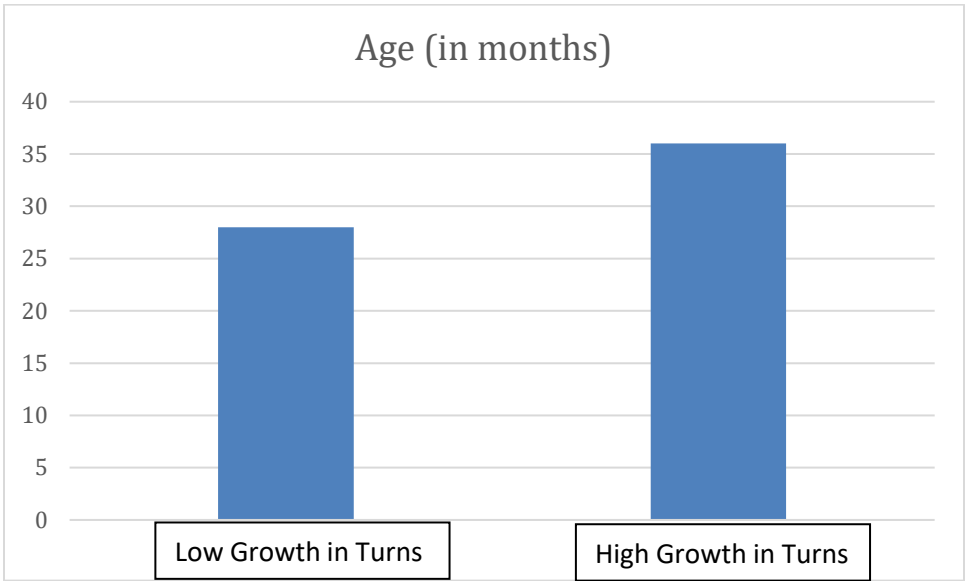


Figure 6: Children who had Greater Growth in Conversational Turns had Fewer Conversational Turns at Baseline

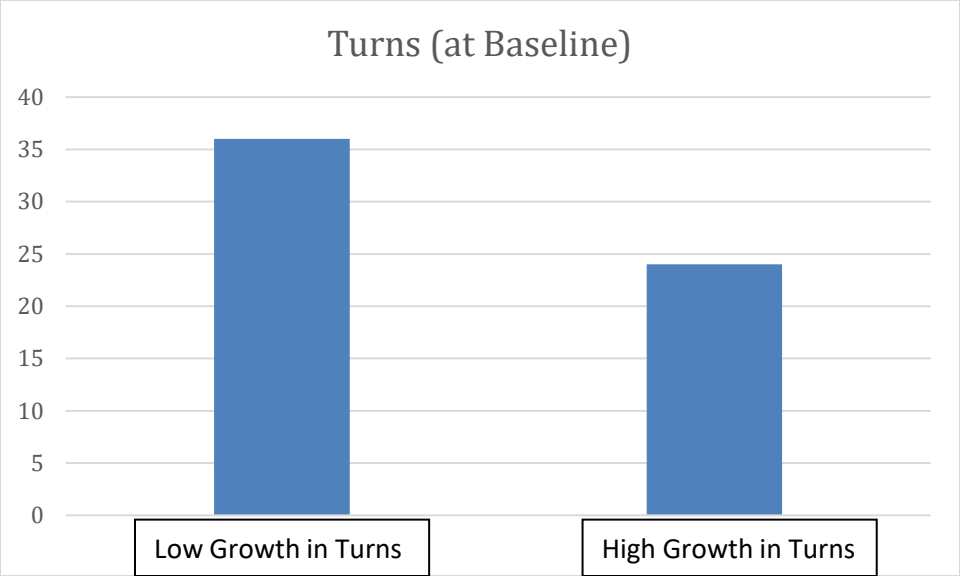
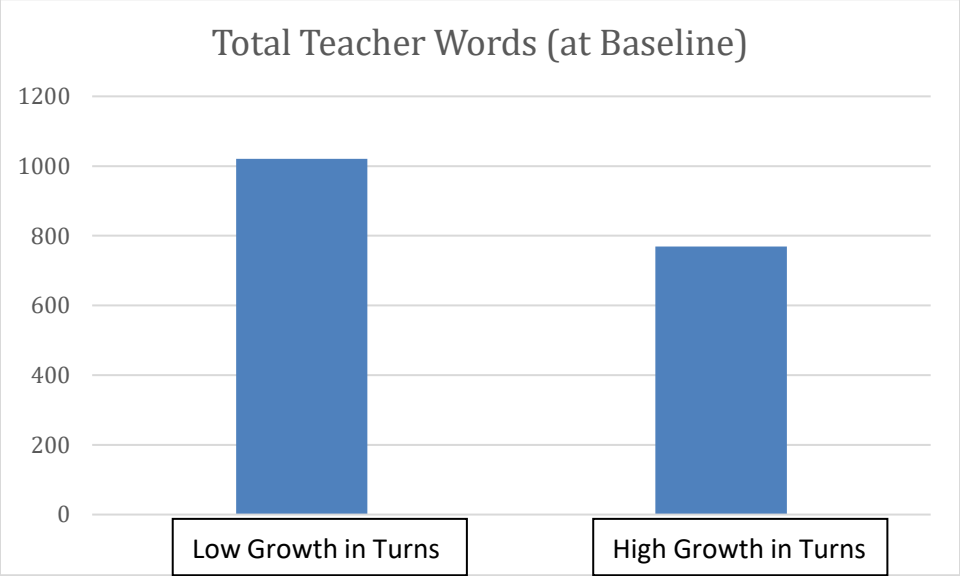


Figure 7: Children who had Greater Growth in Turns had Teachers who used Fewer Words at Baseline



_____Finally, we examined how children's growth in conversational turns related to their growth in the other two LENA measures. As observed in the following table, growth in turns had a significant positive relationship with growth in teacher words and child vocalizations. We further observed that growth in teacher words and child vocalizations had a weak, nonsignificant relationship.

Table 6. Relationship between Growth in LENA Measures

	Growth in Turns	Growth in Teacher Words
Growth in Teacher Words	.75**	
Growth in Child Vocalizations	.60**	.14

We may be tempted to conclude that the growth in turns is driven by growth in teacher talking (given the stronger correlation). To determine if growth in child vocalizations also uniquely predicted growth in turns, we completed a hierarchical regression equation, where we first compared the growth in teacher words with conversational turns ($r^2 = .56$, $F = 97.3$, $p < .001$). We then entered growth in child vocalizations to the equation, which uniquely predicted the growth in conversational turns (r^2 change $= .25$, $F = 100.1$, $p < .001$). This shows that the growth in turns is uniquely impacted by *both* teacher *and* child talking. In other words, growth in conversational turns is optimized when teachers talk more *and* when children become more vocal.

Teacher Perception Survey

At the beginning and end of the 10-week LENA coaching program, participants completed the Teacher Perception Survey, a 14-question survey that asked about teachers' **(a) Beliefs & Actions** surrounding education (e.g., how often they read to children in their classroom, how much talk there is in the classroom, how connected teachers are with children), **(b) Job Satisfaction** (e.g., tell friends they like their job, perception of stress, feel valued as an educator), and **(c) Self Efficacy** (e.g., confident in abilities, strong knowledge of child development). The treatment group, as a whole, reported increases for their Beliefs & Actions, Job Satisfaction, and Self Efficacy, scoring an average of 52.0 at baseline and 55.8 at the end of LENA Grow (a 7.5% increase in scores). The control group stayed largely the same, scoring an average of 52.4 at baseline and 52.3 at the end of the 10-week period.

To further describe these changes, we examined the percentage of teachers whose self-ratings increased, stayed the same, or decreased over the 10 weeks. These changes were summarized for the total survey score and each of the three domains, and further evaluated across the treatment and control group.

Table 7. Percent Change from Baseline to Post Test for Teacher Self-Ratings

	Treatment Group			Control Group		
	Increase	Same	Decrease	Increase	Same	Decrease
Beliefs & Actions	69%	13%	18%	44%	12%	44%
Job Satisfaction	50%	12%	38%	22%	45%	33%
Self Efficacy	81%	13%	6%	33%	33%	33%
Total Score	**81%**	**0%**	**19%**	**22%**	**33%**	**44%**

As observed in Table 7, most teachers in the treatment group increased their overall ratings, with increased Total Scores observed for the majority of the teachers (81%). For the control group, most teachers' ratings either stayed the same or decreased (77%). We completed a series of Wilcoxon Z statistical analyses to determine if these changes in total scores were significant and, furthermore, if changes within the individual domains were also significant. A larger Z-score and a p-value <.05 shows that the differences were statistically significant.

Table 8. Results from the Paired Samples t-test

	Treatment Group (n = 9)		Control Group (n = 16)	
	t	p	t	p
Beliefs & Actions*	-2.2	.02	0.4	.37
Job Satisfaction	-0.8	.23	0.5	.50
Self Efficacy*	-2.5	.01	-0.3	.41
Total Score*	**-3.1**	**<.01**	**0.1**	**.47**

* Significant increase for control group (p < .05)

As observed in Table 8, the changes in total scores were significant for the treatment group and not significant for the control group. In fact, none of the changes within the three domains were significant for the control group. Looking at the treatment group, we see that the changes in Beliefs & Actions and Self Efficacy were clearly significant, while the changes in Job Satisfaction were not significant. These differences can be further visualized in Appendix B.

Teaching Strategies Gold

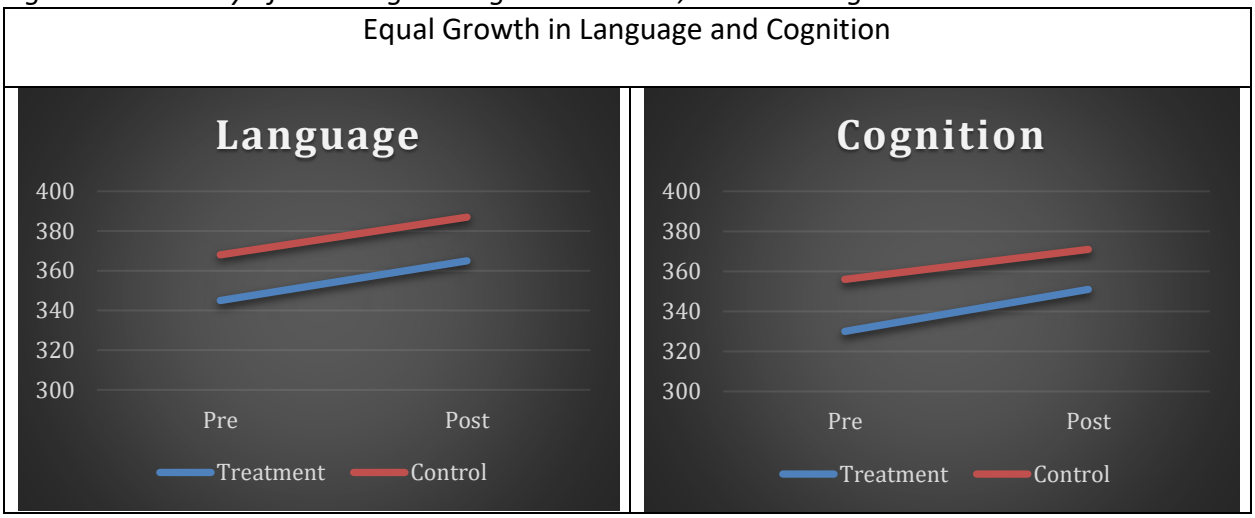
At Next Door, the educational team regularly collects child-level data using Teaching Strategies Gold. Three subtests within Teaching Strategies Gold examine a range of children's language and academic skills, including **(a) Language Skills** (e.g., following directions, expanding vocabulary, engaging in conversations), **(b) Cognitive Skills** (e.g., solving problems, flexibility in thinking, making connections), and **(c) Literacy Skills** (e.g., rhyming, using books, interacting during reading experiences).

Figure 4 illustrates the children's performance at baseline and after the 10-week session. As observed in the figure, the children in the control group generally had stronger skills than children in the treatment group, at both the beginning and end of the 10-week session. We also observed that children in both groups made notable gains across the 10 weeks. To determine if one of the groups made significantly greater gains over time, we look for an interaction of effects across time and groups. Visually, an interaction is depicted by a steeper slope with one of the lines for one of the groups. In addition, we can test an interaction for statistical significance using an Analysis of Variance. Just as with the Wilcoxon test, we seek p-values <.05 to indicate statistical significance.

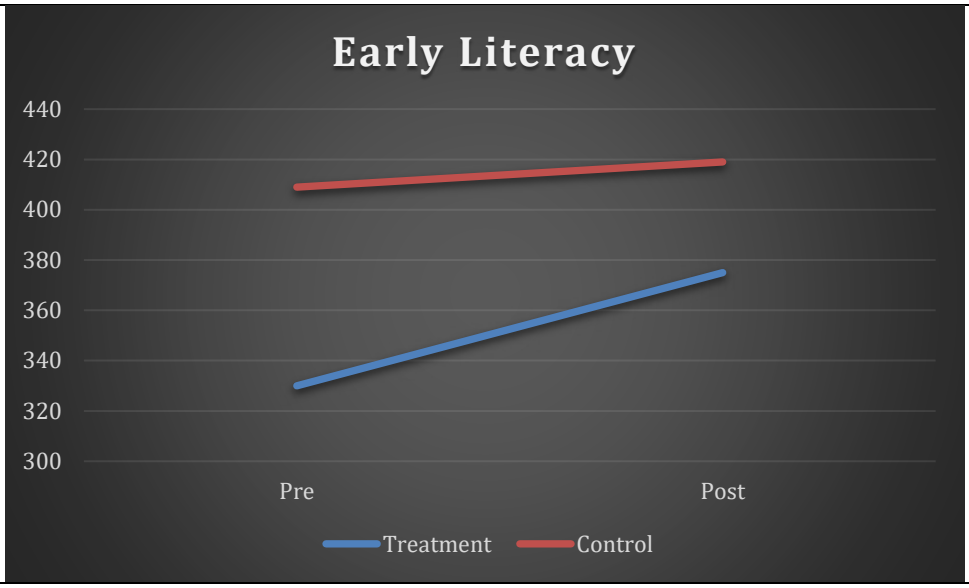
Looking at the figures, there does not appear to be an interaction of time and group for the domains of Language and Cognition, which is confirmed with our statistical analysis (p = .84 and .47, respectively). Early literacy skills do appear to grow faster for the treatment group

relative to the gains experienced by the control group, which was confirmed with our statistical analysis (p = .007).

Figure 4. Summary of Teaching Strategies Gold Data, Summarizing Children's Outcomes



Treatment Group Significantly Faster Growth in Early Literacy



Summary

Through this study, we made the following discoveries:

- Teachers completing LENA Grow, as a group, increased their use of Total Words and Conversational Turns
    - More talking and more turns means that students are getting greater language nutrition after their teachers complete LENA Grow
    - While most teachers increased their use of words and turns, some teachers had slower growth
        - Teachers of older children were more likely to make gains than teachers of infants
        - Teachers from a school serving a high percentage of Hispanic students had the greatest gains. It is unclear if these differences could be due to the school, instructional/coaching staff, student demographics, or some type of complex interaction of factors
- Teachers who completed LENA Grow rated themselves as being more effective than teachers who did not go through the coaching program
    - Impact of LENA Grow was most pronounced for self efficacy
    - LENA Grow's use of objective feedback and positive, practice-based coaching techniques likely responsible for teachers' improved self perceptions
- Children whose teachers received coaching through LENA Grow made substantial gains
    - Notable gains noted for in child vocalizations, and conversational turns
    - Gains most pronounced for children who talked less than their peers at the beginning of the LENA Grow program

Based on these findings, we make the following recommendations:

- Early childhood centers strongly consider incorporating LENA Grow into their coaching programs
- Further funding to provide support for teachers and students most in need of language nutrition
- Further study of the contextual factors influencing the success of LENA Grow, such as
    - Younger versus older children
    - Children from different cultural, linguistic, and ethnic backgrounds
    - Teacher characteristics
    - Educational centers with varying levels of administrative support

Appendix A. Additional Demographic Characteristics of Treatment and Control Classrooms

		Treatment (n = 79)	Control (n = 77)
Primary Caregiver's Highest degree	Unsure	5%	0%
	No High School	4%	3%
	GED/High School	30%	35%
	Some college	30%	22%
	Associate's	11%	15%
	4-yr Undergrad	13%	21%
	Masters	5%	4%
Language Spoken at Home	English	71%	75%
	Spanish	21%	23%
	Other	1%	1%

Appendix B. Group Differences on Teacher Perception Survey

Note: Green markers indicate the distribution of individual teachers' scores in the pre and post periods. Stars indicate the average pre and post scores by subsample.