

## **Quantifying Engagement in Preschool Classrooms - Conversational Turn-Taking & Topic Initiations**

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As an Associate Research Professor at the University of Kansas, Dr. Buzhardt's research interests focus on developing and testing technology solutions to support data-driven intervention decision making in early childhood education. At Juniper Gardens Children's Project (JGCP), he leads the Technology Innovation Development & Research (TIDR) Lab, which is a hybrid of onsite fulltime application developers and externally contracted developers, where online and mobile applications are designed, developed, tested, and maintained for nearly all JGCP interventions that utilize technology. Through grants funded through OSEP and IES and led by Dr. Buzhardt, the TIDR Lab developed and currently maintains the MOD and IGDI platform where it is hosted. Additionally, Dr. Buzhardt has led or co-led 10 federal grants from the Department of Education (5 from Office of Special Education Programs, 5 from Institute of Education Sciences) and four from the National Institute on Disability, Independent Living, and Rehabilitation Research. He currently directs a project funded by the Institute of Education Sciences to develop a web application that guides educators' data-driven intervention decision making. He also leads a \$2.5M project funded by the Office of Special Education Programs to develop and test strategies and applications grounded in Implementation Science to scale-up sustained use of data-driven decision-making practices by infant-toddler service providers. He recently completed a 2nd successful RCT of the MOD across four states to test web-based decision-making support vs. self-guided decision making in Early Head Start home visiting settings. Other relevant projects include investigations of the construct and predictive validity of infant-toddler IGDI assessments, development of web-based professional development for elementary educators, and a current NSF-funded project to develop technology to automatically measure child and adult language in preschool and informal learning contexts.

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## Quantifying Engagement in Preschool Classrooms: Conversational Turn-Taking & Topic Initiations

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### Abstract

Adult-child interaction is an important component for language development in young children. Teachers responsible for the language acquisition of their students have a vested interest in improving such conversation in their classrooms. Advancements in speech technology and natural language processing can be used as an effective tool by teachers in pre-school classrooms to acquire large amounts of conversational data, receive feedback from automated conversational analysis, and amend their teaching methods. Measuring engagement among pre-school children and teachers is a challenging task and not well defined. In this study, we focus on developing criteria to measure conversational turn-taking and topic initiation during adult-child interactions in preschool environments. However, counting conversational turns, conversation initiations, or vocabulary alone is not enough to judge the quality of a conversation and track language acquisition. It is necessary to use a combination of the three and include a measurement of the complexity of vocabulary. The next iterative of this problem is to deploy various solutions from speech and language processing technology to automate these measurements.

### Introduction

Pre-school and elementary years are formative years in language development<sup>1</sup>. Educators of young children with tools to track language acquisition in the classroom can improve child learning outcomes and support implementation of education standards. In this study, we analyzed the pre-school adult-child conversations using conversation initiation, conversational turn count, and target Phonological Mean Length of Utterance (PMLU). The effectiveness and practice of using these measurements to track Common Core education standards by teachers was considered and discussed. Tracking these measurements highlights extremes in conversations, allowing educators to adjust their teaching methods to improve turn counts and vocabulary use. Advancements in speech technology and natural language processing can be used to automate this process by acquiring large amounts of conversational data and providing feedback from conversational analysis. For all analysis in this study, we referred to both text transcripts and speech/audio data of recording sessions. Trends were observed between topic initiations, turn rate, and target PMLU scores.

### Conversational Turn-taking

A conversational turn in adult-child interactions is when an adult speaks and a child follows, or vice versa, with no longer than 5 seconds in between. Any sound is counted as a response, including babbling or one-word responses. Adult-child conversations have been found to have a more significant

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impact on language development when compared to adult language input alone<sup>2</sup>. Conversational turn taking is cognitively demanding, requiring the addressed to interpret the conversation initiation as well as encode a response<sup>3</sup>. Higher numbers of conversational turns have also been linked to increased brain activity<sup>2</sup>. This suggests that a higher number of conversational turns is beneficial to language acquisition.

### Topic/Conversational Initiations

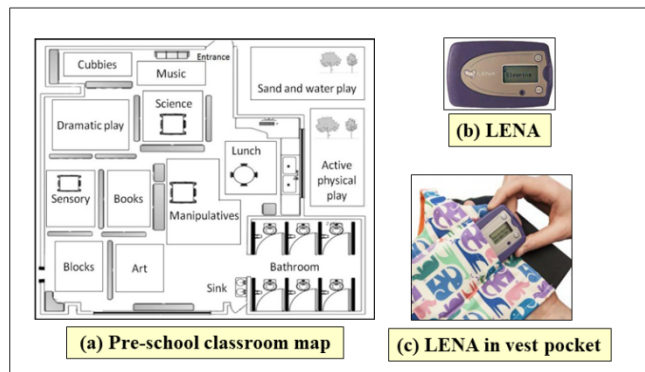
A topic/conversational initiation refers to the statement that prompts the first conversational turn in an adult-child verbal exchange on a certain subject. If the topic spoken about changed, or more than 5 seconds went by without a response, a new topic initiation was noted. Child initiations refer to a child beginning a conversation while adult initiations refer to an adult beginning a conversation.

### Vocabulary Count

Vocabulary count refers to the number of words spoken by or directed to a child. Vocabulary exposure and its importance in language acquisition is commonly studied<sup>2</sup>. However, counting vocabulary does not distinguish between repeated use of words and does not measure the spoken word complexity. In this study, vocabulary count is considered as a measure of nouns spoken by a child.

### PMLU: Phonological Mean Length of Utterance

Phonological Mean Length of Utterance<sup>4</sup> (PMLU) measures the length of a child's words and the number of correct consonants uttered. Ingram<sup>4</sup> established a set of rules to apply PMLU dealing with sample size, word selection, and assigning points for the occurrence of consonants and vowels. For example, the word 'cat' has a target PMLU of 5, but a child pronouncing the word as 'at' would only score 3. The total PMLU value is a ratio of the child's pronunciation accuracy to target PMLU. In this study, the final PMLU was not calculated since the purpose was not to diagnose children with speech/language delays. Instead, the target PMLU was used to give a numerical measure of complexity to words attempted. It is assumed that the child understands the meaning of the word attempted. Therefore, the target PMLU score used refers to the highest possible scoring a child could receive if a word is pronounced correctly. Words with higher target PMLU values have higher phonetic complexity and tend to be longer.



**Figure 1: (a) Pre-school classroom map,  
(b, c) LENA and its location**

Standards CCSS.ELA-LITERACY.SL.K.1.B<sup>5</sup> and CCSS.ELA-LITERACY.SL.K.4<sup>5</sup> were tracked using conversational turn counts and the target PMLU of nouns.

### Educational Language Standards

Considering the use of conversational data in classroom scenarios, the **Texas Common Core English Language Arts Speaking and Listening Standards for Kindergarten** were used in making data analysis decisions.

## Dataset: Adult-child interactions in Pre-school Classrooms

The dataset used for this paper was collected at a pre-school facility (Fig. 1(a)) in the US using Language Environment Analysis (LENA) audio recorders (Fig. 1(b,c)) for developing automatic adult-child speech and language processing systems<sup>6</sup>. The subjects included adults (pre-school teachers and researchers) and children. All children were English speakers and 3 to 5 years old. The speech data were transcribed by our transcription team at CRSS UT-Dallas. Thirty-minute random samples were taken from 5 different sessions – each session denoting a separate child. Two of these sessions included children with speech challenges receiving speech-language therapy services.

## Analysis, Results & Discussion

### Topic Initiations and Turn Rates

Topic/conversational initiations made by children versus adult teachers were analyzed separately. Turn rates were calculated by dividing the total number of conversational turns by the total number of conversation initiations. Turn rates for adult-initiated conversations were higher than turn rates for child-initiated conversations (Fig. 2). On average, conversational turns per adult-initiated conversation was greater than the number of turns per child-initiated conversation. Most conversations, initiated by children or adults, were ended by adults. This suggests that in child-teacher conversational engagement, the adult has dominant control over conversation duration vs. a child. Since higher turn counts have been shown to improve language acquisition<sup>3</sup>, this suggests adult initiated conversations are more beneficial for children in such learning spaces.

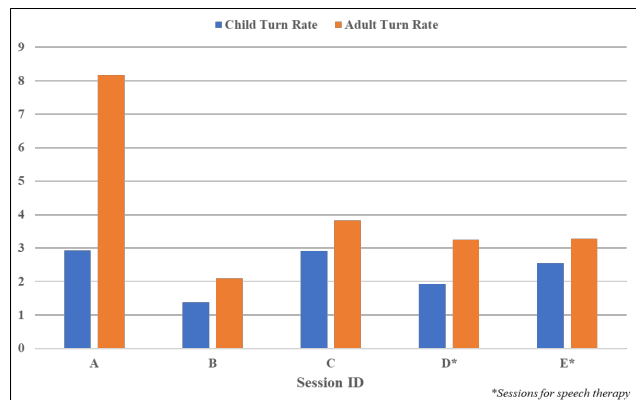


Figure 2: Child vs Adult Turn Rate

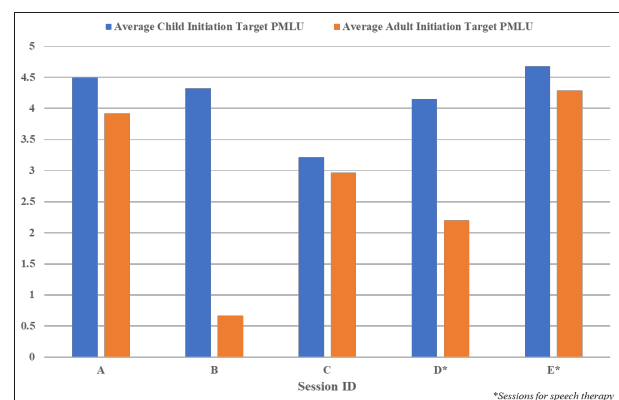


Figure 3: Child vs Adult Target PMLU

### Topic Initiations and Target PMLU (Phonological Length of Utterance)

Although adult-initiated conversations were observed to have a higher turn count, these conversations had lower target PMLU scores for child responses (Fig. 3). The target PMLU scores for child-initiated conversations were higher than adult-initiated conversations. Children used more complex vocabulary when they initiated conversation than when they responded to adult-initiated conversation. This was largely because initiating a conversation required the child to produce a complete coherent sentence. When responding to adult initiations, one-word responses or sounds were acceptable. This brings into question the high turn count found with adult-initiated conversations. Although a high turn count is

beneficial, if the resulting child responses are minimal, it is possible that the full cognitive benefit of a turn is not being experienced by the child.

## Examples of Application

Using target PMLU and conversational turn count can call attention to challenges in children's language acquisition. Scenario 1 (Fig. 4) shows a conversation with a high turn count, but a low target PMLU. The child is responding at a low level of complexity and uses only one noun. If only conversational turns are considered, the low engagement of response will be missed. Scenario 2 (Fig 4) shows a conversation with a high vocabulary count, but a low target PMLU. The vocabulary count here is the total number of nouns said by the child. Because target PMLU is an average, the score is decreased when a word is repeated. If only the amount of vocabulary words used was considered, the response might be considered more complex than it was.

Scenario 1	Scenario 2
<b>Target PMLU = 3</b> <b>Turn Count = 7</b> <b>Conversation:</b> Adult: What do you want to play with? Child: Uh. Adult: What do you think you want to do? Child: Here. Adult: Okay. I'll come play with you. Child: Yeah. Adult: Ok. Child: Thank you. Off here.	<b>Target PMLU = 2.9</b> <b>Vocabulary Count = 18</b> <b>Conversation:</b> Child: Oh nay! guess what? [gasp] in the morning in the night I saw my elf. Adult: In the morn in the night what are you doing? Child: And I got I got I got her. Adult: Did you? Child: I and I caught her [gasp] and I caught her and and then [gasp] and then and then when she got in bed I take I didn't go in in and got her and that got on the bed right.

**Figure 4: Conversations with Low Target PMLU Scores**

Scenario 3 (Fig. 5) shows two conversations with a low turn count and a high PMLU score. This pairing suggests that a child spoke few words but used complex nouns and/or complete sentences. Scenario 4 (Fig. 6) shows a conversation with higher turn counts and higher target PMLU scores. Increasing both the number of turns and the complexity of nouns used in conversations with children ensures that conversations keep going and that children are using people, places, and things in their conversations, as the two Common Core Standards being considered require. The values for target PMLU in conversations ranged from 0 - 16 and the turn counts varied from 1 - 34. These wide ranges make it difficult to assign specific grade-level expectations for target PMLU or conversational turns. PMLU measures have grade-level values, but these are for final PMLU scores, a ratio of accurate pronunciation to target PMLU and are used to diagnose speech delays.

<b>Target PMLU = 7.2</b> <b>Turn Count = 3</b> <b>Conversation:</b> Child: These cups have why do the cups have lines? Adult: They're just different cups. They're the ones that the kitchen gave us today. Child: The babies get red cups. Adult: Oh! Not the babies but the toddlers.	<b>Target PMLU = 8.5</b> <b>Turn Count = 2</b> <b>Conversation:</b> Adult: Do you know what I saw a picture of this weekend [name]? You at the movie last night, what movie did you go see? Child: Dinosaur movie. Adult: The good dinosaur?
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**Figure 5: Conversations with High Target PMLU Scores**

<b>Target PMLU = 10</b> <b>Turn Count = 7</b> <b>Conversation:</b> Child: Powers going through this whole thing to make it light light up and to make the sound. Adult: Makes it work? Child: Electricity. Adult: Where's the power of it? Child: Outside. Adult: Oh [name] [name] knows where the powers at? Child: The battery. Adult: Because wait a minute now try.
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**Figure 6: Conversation with High Turn Counts and High Target PMLU Scores**

## Conclusion

In this study, conversational speech analysis was explored for child-adult interactions in preschool classrooms. Target PMLU scores for nouns and conversational turn counts can track language acquisition standards and highlight potential blind spots in language acquisition. Standardized vocabulary lists exist for reading and writing in the Common Core Language Standards<sup>5</sup>, but not for speaking. This observation suggests it would be useful for teachers to use the target PMLU measure to track student's language, highlight trends, and identify student outliers. Indicators of problems would include regular target PMLU scores of zero (e.g., word perplexity), and/or low counts for conversational turns. Ideally, as children develop language, their target PMLU scores would increase, as well as their conversational turn rates. For next steps/future work, we will explore the use of speech and language processing technology to automate measurement of target PMLU and conversational turn analysis. Conversational interactions of adults and children in naturalistic environments can be analyzed to provide tracking data for teachers to consider when writing lesson plans and adapting teaching methods for diverse students.

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