Prince George's County Public Schools

RESEARCH REPORT

Early Literacy Acquisition in PGCPS: Developmental Trajectory Patterns

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September 2015 © Prince George's County Public Schools

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EXECUTIVE SUMMARY

A. Background

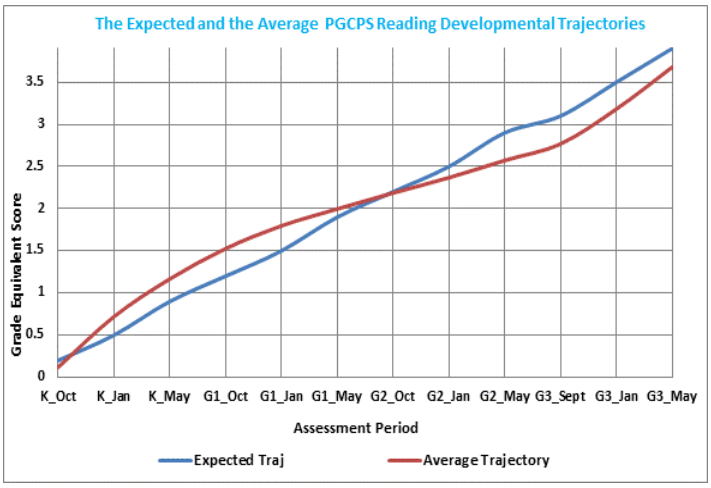
Early literacy skills are crucial building blocks for reading readiness in high school and beyond. The learning that takes place from kindergarten through third grade is an important stage in the developmental trajectory of reading. These grades are critical years for developing mastery of the sounds, structure and functions of language. During this period, children need to learn important skills that become the building blocks for long-term proficiency in reading. An examination of the relationship between where students start in kindergarten and how they progress through the third grade provides insight into the characteristics of students that are ready to transition from 'learning to read' to 'reading to learn' at the end of third grade.

The study used longitudinal data to identify the typical pattern of growth in reading skills from kindergarten to third grade and to examine any differential patterns of growth among subgroups of students. The study employed Developmental Reading Assessment (DRA) and the Scholastic Reading Inventory (SRI) assessment scores and standardized them into a grade-equivalent metric to create a consistent measure of the typical developmental reading trajectory for the average PGCPS student in reference to the expected path of proficient reading. In this study, trajectories are modeled for 8,939 students who entered PGCPS in SY2010. The study also investigated how this typical reading trajectory varied by selected socio-demographic characteristics of students, the readiness gap at school entry and preschool experience.

B. Key Findings

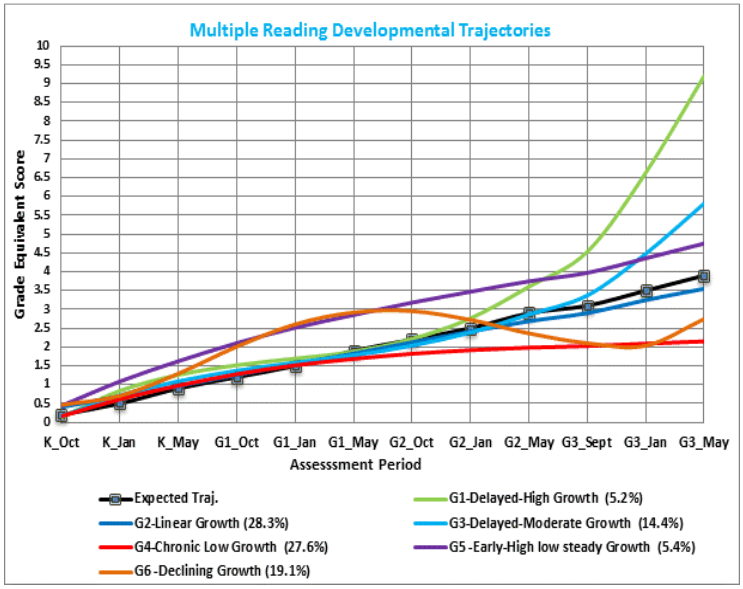
To conduct this research, a cohort was followed through administrative data from kindergarten (2009-10) through the end of third grade (2012-13). Six key findings, outlined below, highlight the findings of the trajectory analysis.

1. The reading trajectory for the average PGCPS student was characterized by rate of growth more than would be expected in kindergarten but the rate of growth started slowing down in the first grade. The slowing down of the rate of growth resulted in the average student falling below-grade expectation in second grade. Despite the recovery made in the third grade, the average student's reading was slightly below expectation at the end of the school year in third grade. Put in terms of the developmental skills of reading, the stages of emergent



reader (kindergarten) and early reader (beginning to mid first grade) are characterized by growth that is higher than is needed to be on the expected path of proficiency. However, as a transitional reader (from the middle of the first grade through end of second grade) the average student seems to struggle to gain the necessary skills.

2. The study identified six unique developmental groups in reading. The six developmental trajectories resemble each other in early grades/assessments but the gap among them widened overtime. The widening of the gap among developmental groups was not a result of differences in initial reading levels at kindergarten entry. While some groups that read below-grade at kindergarten entry were reading at above-grade expectation at the end of third grade, others that read above-grade expectation at kindergarten entry finished third grade reading below-grade expectation. The important predictors of end of third grade underperformance were falling below the expected path of proficiency early in the trajectory and delayed recovery that started late in third grade. Alternatively, those that finished third grade reading above-grade expectation experienced early recovery at higher rates from the deceleration in growth in the first and second grade.



3. Students who came to PGCPS ready for school in the domains of language and literacy experienced smaller rate of deceleration in the first and second grade. The results demonstrate that students who were school ready in language and literacy read at higher levels than their classmates that were not school ready at kindergarten entry and had different growth pattern through the end of the third grade. School ready students enjoyed substantively more net growth in the first and second grades and maintained grade proficiency longer than their peers who were not school ready.

4. Results of the analysis show that attending a PGCPS program (Pre-K or Head Start) was not associated with reading at higher levels at school entry or different rate of growth from kindergarten to early first grade. The average growth rate in subsequent grades was higher for PGCPS preschoolers than for those who did not attend preschool in PGCPS; however, this did not result in significant performance gap between the two groups at the end of the third grade.

5. The reading growth for at-risk groups of children (ELL or SPED) was characterized by bigger rate of deceleration in the first and second grade. Whereas both groups grew at rates that are similar to their peers in kindergarten, the subsequent slowing down of the rates of growth resulted in wider gaps between the groups and their peers. In the third grade, SPED students recovered at the same rate with their non-SPED peers, while ELL students grew at a higher rate than their non-ELL peers did. As a result, the reading gap between SPED and non-SPED students remained intact as the

reading trajectories of ELL students converged with those of their non-ELL peers at the end of the third grade.

6. Finally, the average developmental reading trajectory was applicable to all students irrespective of the quality of instruction in reading. The results of the analysis demonstrated that the typical reading developmental trajectory for the average student was not associated with the quality of instruction in reading the student received, as measured by the number of years of instruction in reading by a highly qualified teacher.

C. Conclusion

This study employed two assessments that capture different skills at different levels of reading development, and standardized them for easy comparison. The trajectory approach used identified the early acceleration in kindergarten, the slowing down of growth in first and second grades and the recovery in the third grade. The pattern of growth shows a rapid acquisition of the basic skills during the stages of emergent and early reader followed by a decline in the rate of progress during the transitional reader stage and some recovery of the rate of progress in the third grade. This result is similar to previous studies that found that children learning to read English seem to undergo a longer lasting growth spurt in kindergarten and first grade and a slumping of the rate of growth in subsequent grades. The slumping of growth in this study for the average student occurred from the middle of the first grade through end of second grade, with slight variations in the onset and degree of the slump for various groups of students. A common characteristic of students who read proficiently by the end of the third grade was that they recovered earlier and at higher rates from the observed slump of growth. Because of this early recovery, they made significant gains in reading skills in the second grade. In contrast, an important predictor of end of third grade underperformance was falling below the expected path of proficiency early in the developmental trajectory and delayed recovery in the third grade.

The results of the analysis clearly indicate that late first grade through the end of the second grade is a challenge for the majority of students. This period of the developmental trajectory is characterized by a slowing down of the growth in reading. PGCPS should focus on these grades and identify the students' characteristics and learning environments that help or facilitate learning during this time. It is also important that there is focus on literacy skills prior to these grades as reading difficulties that may appear later when students are learning to read in the transitional stage originate early in kindergarten.

I. INTRODUCTION

A. Background

Early literacy skills are crucial building blocks for reading readiness in high school and beyond. Growth in secondary reading is driven by what happens in the early primary grades because once a child's early reading pattern is established there is a high degree of longitudinal stability in the rate of growth later. If students lag behind the expected trajectory of growth in the early grades, they can be expected to experience a further widening of the gap between their reading skills and the grade level expectations in future grades. The learning that takes place from prekindergarten through third grade is the cornerstone of a successful education (Lesaux, 2013; NAESP, 2010). As such, reading on-grade level by the end of third grade is a critical step to subsequent academic achievements.

The kindergarten to third grade period of reading development is an important stage in the acquisition of reading skills. These grades are critical years for developing mastery of the sounds, structure and functions of language. During this period, children need to learn important skills that become the building blocks for long-term proficiency in reading. Several aspects of children's language skills become important at different points in this process of early literacy acquisition (Whitehurst & Lonigan, 1998). Whereas decoding letters into corresponding sounds and linking those sounds to single words is important in the earliest grades, a child's semantic and syntactic abilities assume greater importance later in the sequence of learning to read when the child is reading for meaning. A variety of possible academic growth patterns or learning trajectories can be expected to occur during this period. There may be different patterns of growth when students move from the emergent reader (Kindergarten), early reader (beginning to mid first grade), transitional reader (through end of second grade) and to the extending reader (third grade) stages of development in reading. The acquisition of these skills thus follows a developmental pattern; students who lag behind in reading skills at the early grades will have difficulty with reading in subsequent grades.

Students with different reading abilities and social characteristics grow differently. Increasingly, readiness for school for young children before they enter school has become the focus of early literacy as gaps in children's learning and development appear well before they start kindergarten. To this end, the Maryland State Department of Education (MSDE) developed a framework for school readiness and a formalized process to assess kindergarten readiness. The Maryland Model of School Readiness (MMSR) assessment of emergent reading skills started in 2001. According to MMSR data in 2011 thirty-five percent (35%) more children were rated as "fully ready" for school in language and literacy compared to children who entered kindergarten in 2001. In Prince George's County Public Schools (PGCPS), the number of students rated as

"fully ready" in language and literacy in 2011 also increased by 41% from 2001(MSDE, 2012). The upward trend reflected the statewide efforts of improving early learning opportunities. In order to align the school readiness assessment with the common core standards, MSDE replaced the MMSR with the new Kindergarten Readiness Assessment (KRA). According to data of the Kindergarten Readiness Assessment (KRA) in 2014, 47% of children in the state of Maryland and 35% of PGCPS incoming kindergarteners were respectively rated as "fully ready" in language and literacy. These differences in school readiness among kindergarten children are associated with the speed at which students acquire reading skills during formal schooling.

A growing body of evidence shows that early childhood day-care programs and preschool environments have positive effects on children's emergent literacy skills. Specifically, continuity between emergent literacy skills from preschool into the early school years is very helpful in the acquisition of reading skills. Whereas many children transition from culturally familiar childcare programs or family environments into programs that do not reflect their home culture or language, experience with public school preschool environment makes it easier to transition into kindergarten programs. PGCPS is expanding early childhood programs intended to enhance school readiness of incoming kindergarteners.

Students with disabilities and English Language Learners (ELL) need specialized instruction and support in their language development. Both groups have been associated with achievement gap at kindergarten entry and delayed developmental growth in reading skills (Snow, Burns, and Griffin, 1998). These gaps in reading developmental growth, however, can be eliminated with appropriate kindergarten to end of third grade instructional practices that target the needs of these populations. For instance, research has shown that systematic and deliberate exposure to English during early childhood results in the highest achievement in English by the end of third grade for English Language Learners (Espinosa, 2008). As is the case for all students, reading proficiency at the end of the third grade will increase the likelihood that SPED and ELL children will do well during the rest of their academic careers.

As aforementioned, student performance in reading is highly associated with instructional practices. Research confirms that an effective teacher can do more to improve achievement than any other factor in education (NAESP, 2010). A major national problem highlighted by the National Association of Elementary School Principals is the lack of teachers with the necessary qualification and certification in early childhood teaching, particularly in Kindergarten. Maryland State Department of Education implemented procedures and policies to assure that all teachers in core academic areas are highly qualified in the core academic subjects they teach. Though Maryland has not yet reached its goal of 100% highly qualified teachers (HQT), local school districts have demonstrated significant progress toward this goal. PGCPS has made significant gains in increasing the percentage of highly qualified teachers but remains among the

school districts in the state of Maryland that have challenges in ensuring that highly qualified teachers teach all classes.

To prepare students to be reading on grade proficiently, PGCPS is pursuing strategies that include increasing the number of pre-Kindergarten programs and school readiness at kindergarten entry, improving the chronic underperformance of SPED and ELL students and increasing the quality of early literacy instruction. PGCPS has adopted a new strategic plan (SY16-SY20) to improve reading and close the achievement gap in reading among groups of students. As expectations are raised with the common core standards, the closing of the achievement gap will greatly depend on the ability of the district to increase the speed of growth in reading. An examination of the relationship between where students start in kindergarten and how they progress through the third grade will provide insight into the characteristics of students that are ready to transition from 'learning to read' to 'reading to learn' at the end of third grade. A study of the typical reading growth pattern and any differences among groups of students in PGCPS would immensely contribute to improving the teaching and learning of early literacy.

B. Scope and Purpose of the Study

The project is a study of the developmental trajectory of PGCPS students' Kindergarten through third grade acquisition of reading skills. The purpose of the present study is to examine patterns of growth in reading skills from kindergarten to third grade and to examine any differential patterns of growth among subgroups of students. More specifically, the study identifies the typical PGCPS K-3rd grade reading developmental trajectory and the grade and/or semester at which the average student deviates from the expected path, that is , the grade(semester) the typical student performs below-grade level expectation. This will assist the district in identifying the point at which varying student subgroups deviate from the path that will result in acquiring benchmarked levels of reading at the end of third grade.

As PGCPS seeks to see improvements in reading proficiency and the closing of achievement gaps within a short timeframe, longitudinal analyses of reading data from previous years provides the appropriate context in making decisions about expectations of growth goals to meet the strategic plan's 2020 promise. The study will help identify any deficiencies in early reading through the empirical analysis of Kindergarten to end of third grade reading developmental trajectory in a PGCPS cohort. The findings from the study will yield several important clues to understanding the development of early reading among PGCPS students.

C. Research Questions

The study answers the following questions:

1. What is the nature of PGCPS Kindergarten to end of third grade reading developmental trajectory?
    a. What is the average kindergarten to end of third grade reading developmental trajectory? In addition, how does the average trajectory differ from the expected K-3rd grade trajectory?

    b. How many unique reading developmental trajectories are available in the sample?

2. Are school readiness gap at kindergarten entry and preschool experience associated with distinct kindergarten to end of third grade reading developmental trajectory?

    a. Do 'ready for school' kindergarteners have an average reading developmental trajectory that is different from those who were 'not ready for school' in language and literacy?

    b. Do students who attend PGCPS preschool programs have an average reading developmental trajectory that is different from those who do not attend PGCPS Preschool programs?

3. Are student characteristics in kindergarten associated with distinct kindergarten to end of third grade reading developmental trajectory?

    a. Do Special Education (SPED) students have an average reading developmental trajectory that is different from students who are not Special Education students?

    b. Do English Language Learners (ELL) have an average reading developmental trajectory that is different from those who are non-ELL students?

4. To what extent does the quality of instruction from kindergarten to end of third grade instruction change the average developmental reading trajectory?

Research Question 1a attempts to map out the average kindergarten to end of third grade reading developmental trajectory of the typical PGCPS student. Results from analysis to answer the question will identify the average initial kindergarten reading ability of the average student and the growth in reading in successive grades until third grade. The question also attempts to

investigate the extent to which the observed developmental trajectory is similar or different from the expected path of growth in early reading. In doing so, the study will identify points in time where students demonstrate growth above or below the expected path of grade level proficiency. Further, results from the analysis will inform if the gap in reading performance between the typical PGCPS student and the typical proficient student nationally widens or closes at end of third grade.

Research Question 1b focuses on different reading trajectories that exist in PGCPS. The question addresses the variations in the growth of reading that are not captured by the average reading trajectory. The question will help us separate the overall student population into groups that follow similar trajectories and represent heterogeneous patterns of the average process of developmental growth in reading. Whereas the answers to Research Question 1a provide description of the pattern of growth represented by the most typical PGCPS student, the patterns that are not represented by this typical trajectory will be identified by the findings that answer Research Question 1b.

The purpose of Research Question 2 is to document the association between pre-kindergarten experiences and the reading developmental trajectory. First, Research Question 2a attempts to answer if students who were ready for school at kindergarten entry have a growth pattern that is different from students who were not ready for school. Results from the analysis will provide insight into the role school readiness plays at the beginning of kindergarten and in K-3rd grade growth pattern. Second, Research Question 2b assesses if students who attended preschool programs in PGCPS grow differently from those who did not attend PGCPS preschool programs. The findings for this question will provide answers if prekindergarten experiences plays any role in determining initial reading levels at the beginning of kindergarten and the growth patterns through the end of the third grade.

Research Question 3 focuses on the association between student characteristics and the typical developmental reading trajectory. More specifically, the question will focus on two student characteristics. They are Special Education (SPED) or Limited English Proficiency (LEP) status of students. Research Question 3a compares the reading developmental trajectory of SPED students with non-SPED students while Research Question 3b compares the reading developmental trajectory of English Language Learner (ELL) students with those who are not ELL students. Both questions will provide answers to whether English language learners and Special education students become more similar or dissimilar in their reading achievement to students not facing these challenges.

Research Question 4 focuses on whether an increase in the number of years of reading instruction by highly qualified teachers is associated with a different trajectory of reading than the average developmental reading trajectory. The question will also address if receiving all four

years of instruction in reading by a highly qualified teacher results in reading trajectory that is significantly different from instruction by highly qualified teacher in fewer academic years.

D. Organization of Report

This report is organized into four major sections. Following this introductory section, the sampling method and measures used and the analysis plan adopted to answer the aforementioned research questions are described in Section II. Section III contains the research findings, which provides the answers to the research questions, while Section IV contains a discussion of the findings, which includes the conclusions that can be drawn from the findings and the limitations of the study.

II. DATA, MEASURES AND METHODS

A. Data and Sample

The purpose of this study is to examine students' reading achievement longitudinally from kindergarten through third grade. Kindergarten students who entered PGCPS in SY2010 were selected as the sample for the study. A retrospective longitudinal panel data for 8939 students was created. This kindergarten cohort was selected because it provides us with the necessary data needed to construct a longitudinal panel data for the study of the developmental trajectory of reading. Students were included in the analysis if they were enrolled in the expected grade level in a given year. The social characteristic of the sample in kindergarten is as follows: 60% received free and reduced lunch (FARM), 26% English Language Learner (ELL) and 7% Special education (SPED). While 61% of the sample attended PGCPS preschool programs, 57% of them were ready for school in language and literacy at kindergarten entry.

Reading achievement data for this study was collected from various data sources. Two sources of reading assessment data were used to construct the panel data. A database was constructed using reading ability on each student in the sample. The Developmental Reading Assessment (DRA) and the Scholastic Reading Inventory (SRI) assessment data were used to construct the database. Students in the sample were assessed three times a year from kindergarten through third grade. These reading assessments occurred at 5-month intervals during each school year (See Table 1). As can be seen in table 1, this produces 12 measurement points that were used to develop a growth trajectory model.

Table 1*:* Description assessment data by Grade and Source, on the sample for the study

Grade	Measurement Period	Measurement Time	Source of Measure
Kindergarten	1	Oct 2009	DRA
	2	Jan 2010	DRA
	3	May 2010	DRA
First grade	4	Oct 2010	DRA
	5	Jan 2011	DRA
	6	May 2011	DRA
Second grade	7	Oct 2011	DRA
	8	Jan 2012	SRI
	9	May 2012	SRI
Third grade	10	Sept 2012	SRI
	11	Jan 2013	SRI
	12	May 2013	SRI

In answering questions 2 and 3, groups of students based on school readiness at kindergarten entry and preschool experience as well as social characteristics were constructed. The source of data to create these groups was the Maryland Model for School Readiness (MMSR) dataset. The MMSR is a state mandate assessment administered to all kindergarten students, by their teachers, during the first eight weeks of school. The school readiness data on language and literacy and MMSR data regarding childcare services the year prior to kindergarten were the source of data for Research Question 2. MMSR data on the type of specialized services a student received in kindergarten were also used to develop indicators of whether a student was a special education or English language learner student. Finally, data on student-teacher alignment and class-level membership files from MSDE were used to match students to classrooms and the qualification of teachers who taught a reading class to a given student from kindergarten to third grade.

B. Measures

Reading Ability. As aforementioned, the panel data of reading ability comes from two separate assessments that capture grade appropriate reading skills. These two assessments use different scales of reading ability; therefore, it was necessary to have a consistency of scale between the two measures. Reading achievement was thus measured using a grade- equivalent score. This consistent equal-interval scale was used to perform mathematical operations and model growth over time. The reading ability score was obtained by converting the text score of DRA assessment (kindergarten to October of second grade) and the SRI Lexile score (January of second grade to the end of third grade) to grade-equivalent score. The trajectory of reading from Kindergarten to the end of third grade was standardized with this conversion.[i]

The grade-equivalent measure also reflects a benchmark or criterion-referenced score, as it captures the specific content and skills students are required to master by the assessment time during a particular grade. These grade-equivalent scores provide information about proficiency at each assessment period and on how much a student is growing in relation to the expected scores on the growth curve. Grade-equivalents provide a rough estimate of grade-level performance and assume that the typical student will grow one grade equivalent each school year. A way to interpret the expected grade-equivalent score is to view it as a benchmark score where a student is expected to be reading at the time of assessment. For example, at the end of third grade a Lexile score of 300 was converted to 3.9 to imply the level of proficiency after 9 months of instruction in third grade. If a student's score was 3.7 at the end of third grade, the student's reading performance was 2 months behind the expected level of reading.

School Readiness in language and literacy. Data from the Maryland Model for School Readiness (MMSR) assessment was used to develop a measure of school readiness in language and literacy. The language and literacy development assessment captures a student's level of

readiness in six areas: phonemic awareness, listening, phonics, vocabulary, comprehension and writing.[ii] The MMSR used the following specific steps to create scoring scales for readiness in language and literacy. Each of the six indicators was given a score of 3 (Proficient), 2 (In Process) or 1 (Needs Development). The sum of the six indicator values were then divided into three readiness levels. The MMSR identified three levels of school readiness: fully ready, approaching readiness, and developing readiness. A total score 15 to 18 is 'Full Readiness', a score of 10 to 14 is 'Approaching Readiness' and a score between 6 and 9 is 'Developing Readiness' in language and literacy. In practical terms, 'Full Readiness' represents a student who scored proficient in at least three of the indicators and is in process of achieving proficiency in the other three indicators. For purposes of this study, 'approaching readiness' and 'developing readiness' were recoded to make up one group that is renamed as 'not ready for school". A variable of school readiness in language and literacy was thus created with two values: a 'school ready' and 'not ready for school' at the start of kindergarten. This indicator was then used to develop separate reading developmental trajectories for students who were 'school ready' and 'not ready for school' at kindergarten entry.

Preschool Status. Using the MMSR data, an indicator of the type of childcare students experienced the year preceding kindergarten entry was created. For purposes of this study, two groups were constructed: those who attended Preschool in PGCPS (both pre-Kindergarten and head start programs) and everybody else. This indicator was then used to develop separate reading developmental trajectories for students who attended PGCPS preschool programs and those who did not.

Special Education status. An indicator of whether a student was categorized as in need of special instructional need in Kindergarten was developed. The indicator distinguished students who were Special Education (SPED) students from students who were not. This indicator was used to develop separate reading developmental trajectories for SPED and non-SPED groups.

***English proficiency status in Kindergarten*.** An indicator of students with differing levels of initial English proficiency at kindergarten was obtained from the MMSR data. The indicator classified students who were English Language Learners (ELL) from students who were not. This indicator was used to develop separate reading growth curves for the ELL and non-ELL groups.

Quality of Instruction. A measure of quality of instruction was captured by whether the student was taught in a classroom with a teacher that was classified as highly qualified by the Maryland State Department of Education (MSDE). Highly qualified teacher (HQT) designation is shorthand for the combination of three components: whether a teacher possesses accurate certification in the relevant academic subject, is teaching the appropriate grade, and is teaching a

course in the content area for which he or she holds a MSDE certification. For purposes of this study, an indicator of whether or not each student in the sample attended a reading class that was taught by HQT for each of the four years of instruction from kindergarten to the third grade was developed. A composite score of the total number of reading instruction by HQT was also constructed.

C. Methods of Analysis

The developmental growth model is the analytical technique used in this study. There is a growing interest in employing developmental growth models or trajectories to track student progress in academic achievement as well as develop measures of system and school accountability. Trajectories are longitudinal models that examine how outcomes change as a function of time and generate a growth curve for each individual. Developmental Trajectory model allows us to study achievement status (a starting or endpoint), change in achievement over time (rate or magnitude of growth), and the functional form of growth (acceleration or deceleration) (Kenny, Kashy and Cook, 2006; Williamson, 2010). Developmental Trajectory model is the method of analysis adopted for this study. A Developmental Trajectory model captures change in individual student performance over time and provides the most concise picture of progress as the student moves along grades. In this study, the observed progress made by students in the sample is compared to the expected path of consistent grade proficiency. That is, the growth trajectory in reading is presented in relation to the expected trajectory of consistent on-or-above grade performance at each point of reading assessment. Using the expected trajectory of proficient reading pathway as a reference point enables us to compare and contrast different groups of students and determine the extent to which groups deviated from the expected path in reading.

The Average Reading Developmental Trajectory

This section provides a description of the particular Trajectory model adopted for the study. The average PGCPS Reading Developmental Trajectory, the focus of Research Question 1a, provides a measure of the rate and the form of the collective growth for all PGCPS students. The shape of the growth was determined using the grade-equivalent reading scores. Multiple functional forms were defined and then fit to the observed data. The functional form that best captured the pattern of change observed in the data was chosen. The choice for the best fitting model was determined using model selection indices known as Information Criteria- Bayesian Information Criteria (BIC) and Akaike Information Criteria (AIC). The form of growth resulting in the lowest BIC was selected (See Appendix A).

Reading Developmental Trajectories

Research Question 1b seeks to capture the various reading developmental trajectories that may exist in the student population. To identify these multiple developmental trajectories of reading within the sample, a form of mixture modeling known as Groups-Based Trajectory Model (Nagin, 1999; Jones and Nagin, 2012) was used. In this model, each student in the sample was assumed to adhere to a particular group-specific trajectory of reading. The analysis selected the number of groups and the form of growth for each trajectory group. The number of trajectory groups and the functional forms of the groups were determined using the same model selection indices above. Once the ideal number of groups and shapes were identified, in the third step, model adequacy was also tested using the average posterior probabilities (APP) of group membership. The accuracy of assignment for each trajectory (that is, students are well assigned to their trajectories) was established following Nagin's (2005) recommendation that the average posterior probabilities should exceed a minimum of .70 for each trajectory group and that each group should include at least 5% of the sample (See Appendix B for further details).

Differences in the Average Reading Developmental Trajectory

The focus of Research Questions 2, 3, and 4 was the extent to which the average reading developmental trajectory varied by students' characteristics or learning experiences. Using the same method used to create the average developmental trajectory for all PGCPS students, separate reading trajectories for each indicator of the variable of interest were estimated. In addition to producing the same parameters of growth as the average PGCPS growth curve, tests of differences of the parameters of growth were used to determine if any of the differences were statistically significantly different from each other. These tests of difference include comparison of the initial status at the beginning of kindergarten, the initial growth rate, and the rates of acceleration and deceleration along the reading developmental trajectory.

III. FINDINGS

The results of the analyses are presented in this section. The presentation in each sub-section is organized in the sequence of the research questions.

A. Average Reading Developmental Trajectory

Research Question 1a: What is the average kindergarten to end of third grade reading developmental trajectory? In addition, how does the average trajectory differ from the expected K-3rd grade trajectory?

As can be expected in a study of a developmental issue such as the acquisition of reading skills, the average student in the sample experienced growth in reading during the four years of elementary education studied. The analysis here provides answers to what form of growth best describes the average reading developmental trajectory for the sample. Several trajectories of reading with different forms of growth were estimated and the form of growth that best described the average PGCPS reading trajectory (Red Curve) is presented in Figure 1 (See appendix A for more details on the analysis and determination of the best fit). Figure 1 also presents the expected trajectory of reading (Blue Curve), the growth path where students are meeting the expected reading levels at each assessment period. The form of growth that best described the average PGCPS reading developmental trajectory suggested that the reading increased rapidly at the beginning and then decelerated or slowed down but such deceleration gradually diminished over time.

During the first assessment in kindergarten, the average grade-equivalent reading score for the sample was 0.12, which was slightly below the expected on-grade score of 0.2 for the period. The average reading trajectory was characterized by growth in reading that sharply increased from kindergarten to early first grade and then the rate of growth slowed down from the middle of first grade to the end of second grade, and partially recovered in the third grade. The average student experienced growth (about 1.68 grade-equivalent score) from Kindergarten to the middle of first grade. Growth in reading began to decelerate in the middle of first grade until the end of the second grade, as the average student experienced a growth of about 0.78 grade-equivalent score or 46% of the initial growth. The slowing down of growth in reading resulted in the average student falling below-grade expectation in second grade. However, the rate of growth recovered or accelerated in the third grade as the average student grew by about 1.1 grade-equivalent score (or 66% of initial growth) between the end of the second and third grades. Put in terms of growth during a school year, the average student had a growth of 1.31 grade-equivalent score during kindergarten. The average yearly growth for first grade, second grade and third grade were 0.59, 0.48, and 1.01 grade-equivalent scores, respectively. Compared

to the fastest growth in kindergarten, the growth achieved in subsequent grades were equal to 45%, 37% and 77% respectively of what it was at kindergarten.

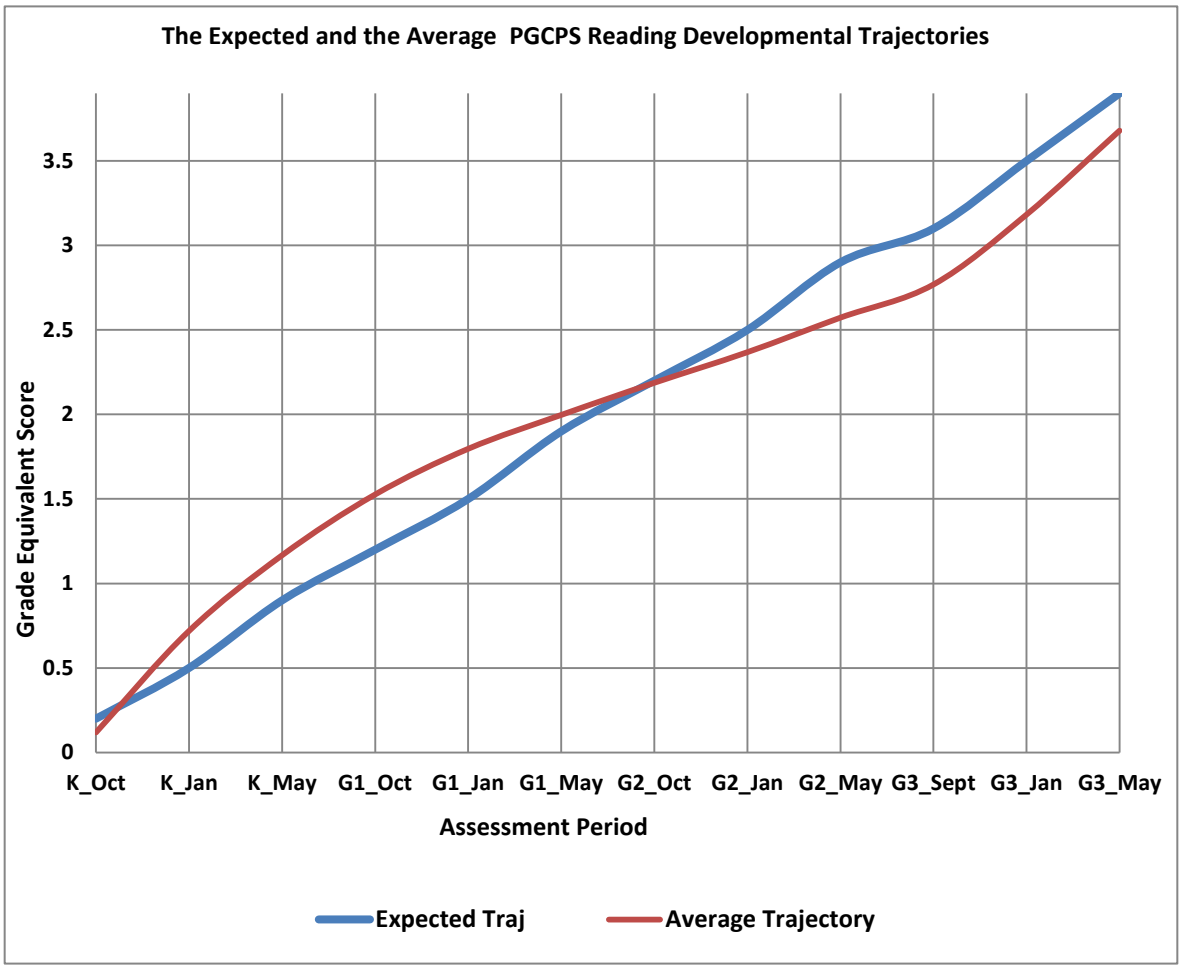


Figure 1 : The Expected and the Average PGCPS Reading Developmental Trajectories

In sum, the slowing down of growth in the first grade resulted in the average student falling below-grade expectations in second grade as is evident from the crossing over of the average trajectory below the expected trajectory in Figure 1. The average path of growth for the average PGCPS student deviated from the expected path of growth during second grade but the gap between the actual and the expected levels of reading was narrowed by the end of third grade. Despite the recovery made in the third grade, the average student's reading was slightly below expectation at the end of the school year in third grade.

B. Reading Developmental Trajectories

Research Question 1b: How many unique reading developmental trajectories are available in the sample?

The analysis above identified that the average student in the sample grew more than would be expected in kindergarten but grew less than expected in the first and second grades. While the growth rate in third grade was higher than expected, it was not sufficient to compensate for the low growth rate in first and second grades. Thus, the average student performed below expectation through the end of the third grade. When the requirement to have only one developmental trajectory was relaxed, six unique developmental trajectories emerged. These six trajectories are presented in Figure 2 (coefficients can be found in Table 5 in the appendix B). These groups are named as the 'Delayed-High Growth' (Group 1 Light Green), 'Linear Growth' (Group 2 Blue), 'Delayed-Moderate Growth' (Group 3 Light Blue), 'Chronic Low Growth' (Group 4 Red), the 'Early-High Low Steady Growth' (Group 5 purple), and 'Declining Growth' (Group 6 Orange). The expected trajectory of consistent grade proficiency is represented with a black curve. In the next section, brief discussion of the six trajectories and their growth profile is offered.

The 'Delayed-High' growth group. The 'Delayed-High' growth group comprised of 5.2% of the sample. The group started kindergarten with the very lowest initial reading level of all the trajectories and was characterized by a growth pattern that was accelerated at the start of schooling and in the second and third grades. It started growing at the fastest rate by the beginning of second grade and ended third grade reading at a level that was significantly above-grade proficiency.

The 'Linear Growth' group. The 'Linear Growth' group is the largest subgroup in the sample (group 2, 28.3%). The group started kindergarten reading significantly above-grade expectation. The group was characterized by a stable growth pattern. It maintained grade proficiency until January of second grade, when it dropped below-grade expectation. This trend of below-grade level reading status continued until the end of the third grade. Similar to the average growth pattern, the group had a slightly below the expected reading performance at the end of the school year in third grade.

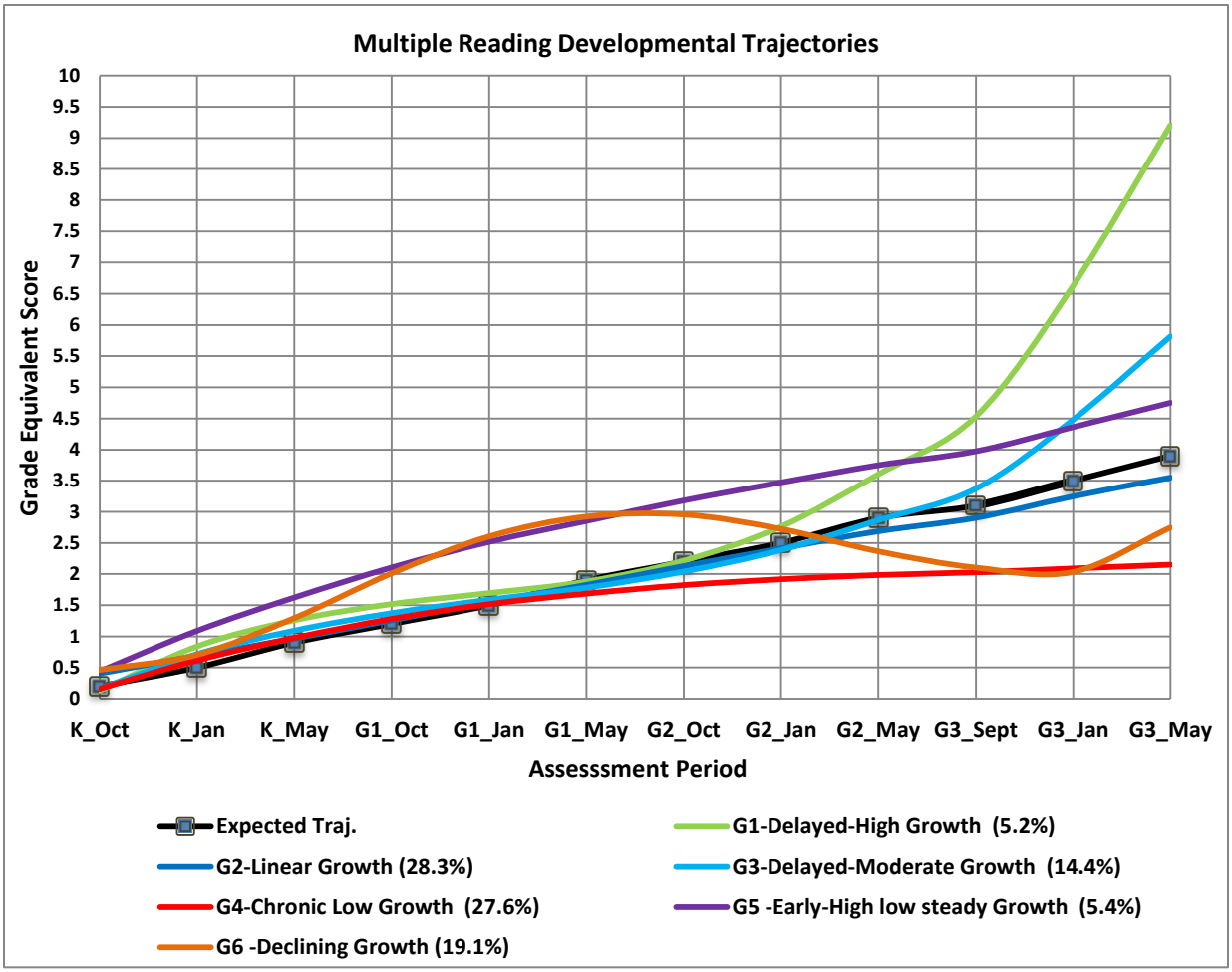


Figure 2: Reading Developmental Trajectories

The 'Delayed-Moderate Growth' group. The 'Delayed-Moderate Growth' group (group 3) comprised 16% of the sample. This group began kindergarten reading below-grade level and it had similar pattern with the delayed high growth group; that is, accelerated growth at the start of schooling, followed by deceleration and again accelerated in second grade. However, the rate at which the moderate growth group accelerated in second grade was smaller than the rate of growth for the 'delayed-high growth' group. This group also experienced above-grade expectation reading score by the end of the third grade.

The 'Chronic Low Growth' group. The 'Chronic Low Growth' group (group 4, 27.6 %) began kindergarten reading below-grade expectation but did not have the same growth pattern as the delayed growth groups. Its trajectory started with a slow growth rate in kindergarten, a short lasting growth spurt in first grade, followed by fast deceleration in second grade and slow recovery in third grade. By the end of the first grade, the group was reading at below-grade expectation and continued on this path through the end of the third grade.

The 'Early-High Low-Steady Growth' group. The 'Early-High Low-Steady Growth' group (group 5) comprised 19% of the sample. Like the linear growth group, this group started kindergarten reading significantly above-grade expectation. Its trajectory was characterized by a rapid growth spurt in Kindergarten followed by deceleration in first grade that was replaced by increasingly steady but low rates of growth in the second and third grades. The group displayed a growth rate that was higher than the expected growth at the beginning of the trajectory and finished with above-grade proficiency by the end of the third grade.

The 'Declining Growth' group. The 'Declining Growth' group (group 6) consists of 19.1% of the sample. The group started kindergarten reading significantly above-grade expectation. However, it showed a roller-coaster pattern of growth. The group did not experience the early growth in reading that all other groups enjoyed during kindergarten but exhibited a steep increase in first grade. The rate of this growth declined precipitously in the second grade and the group registered loss in reading in the second grade. In addition, the group did not experience growth early in the third grade that was characteristics of most other groups. The group, however, slightly started to recover towards the end of the third grade. The group finished third grade reading significantly below-grade expectation.

The following general observations are made from the analysis in this section. First, the trajectories described above reveal patterns of growth that diverged from each other and the expected path as students moved from kindergarten to third grade. That is, the trajectories appear to resemble each other in early grades/assessment periods but the gap among them widened overtime. As the gap widened between the groups, the gap between the expected level of on-grade reading at the end of third grade and the above-grade and below-grade reading trajectories also widened. Second, the widening of the gap among groups was not a result of differences in initial reading levels at kindergarten entry. Two of the three groups that read below-grade at kindergarten entry were reading at above-grade expectation at the end of third grade. On the other hand, of the three groups that read above-grade expectation at kindergarten entry only one group finished third grade reading above-grade expectation. Third, groups that had fallen below the expected path of proficiency early in the trajectory also had bigger performance gaps from the expected path by the end of the third grade. Fourth, the groups that that read above-grade expectation by the end of the third grade had experienced early recovery, and at higher rates, from the deceleration in the rate of growth that occurred between the first and second grades. That is, they experienced significant growth in second grade in contrast to the acceleration that started in the third grade for the average student. Last, groups that read significantly below-grade expectation by the end of the third grade had experienced significant deceleration in the early grades and did not start recovery in their rates of growth until after the second semester in the third grade.

C. Average Reading Developmental trajectory and readiness gap at school entry and preschool experiences

Research Question 2a: Do 'ready for school' kindergarteners have an average reading developmental trajectory that is different from those who were 'not ready for school' in language and literacy?

A trajectory of reading with the same form of growth as the average trajectory of reading in subsection A was estimated separately for students who are 'school ready' at kindergarten entry (57% of the sample) and their classmates who were 'not ready for school' (43% of the sample) at kindergarten entry. Figure 3 presents these two trajectories as well as the expected trajectory of consistent grade proficiency.

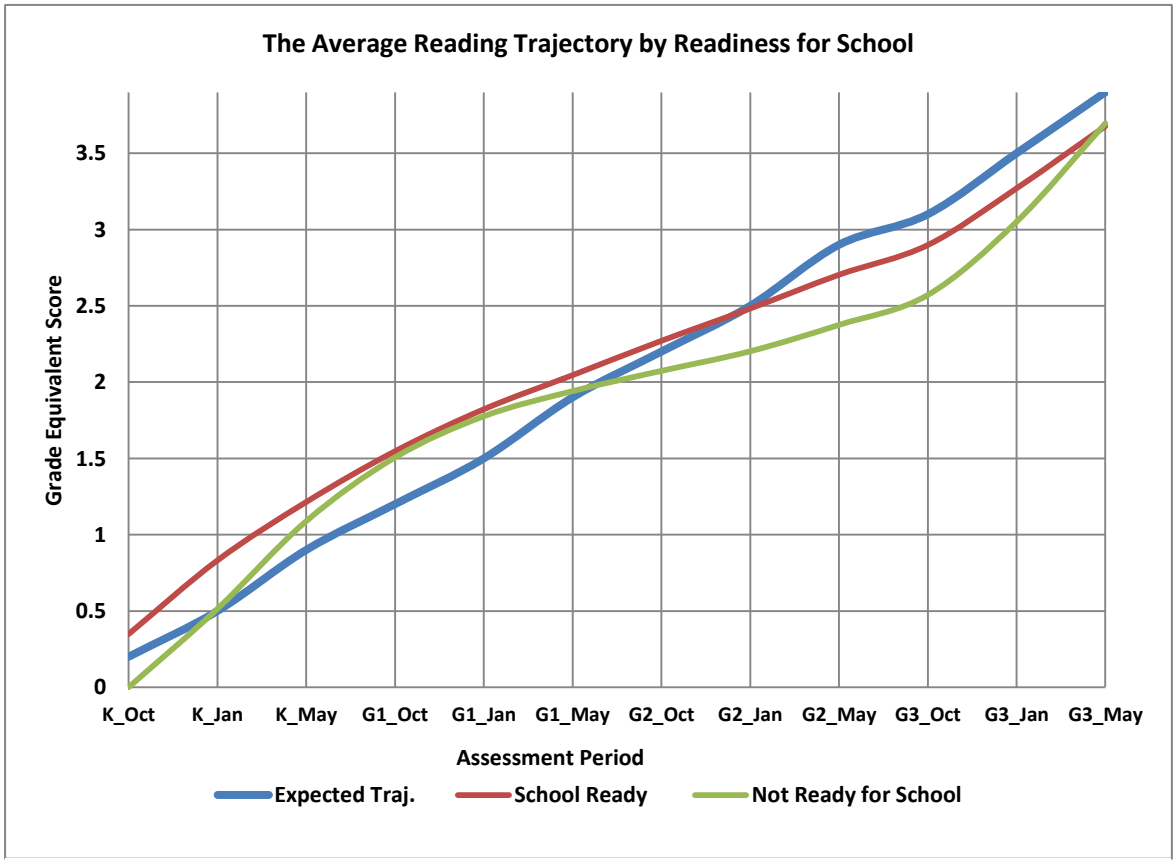


Figure 3: The Average Reading Trajectory by Readiness for School

Results of the analysis shows that students who are school ready were statistically significantly different ($p < 0.05$) from their classmates that were not school ready on (a) the initial reading level at kindergarten entry and (b) the kindergarten to third grade growth pattern. During the first assessment period in kindergarten, students who are school ready were already reading at a higher level than their classmates that were not school ready. While both groups

experienced higher than expected growth in reading from kindergarten to early first grade, the students that were not school ready grew faster and appeared to close the gap between the two groups. The students that were not ready for school, however, did not maintain the initial rate of growth in subsequent semesters and grades. They experienced a slowing down of growth in reading at a higher rate and as early as the beginning of the first grade. In contrast, growth in reading for school ready students slowed down at a smaller rate and a semester later. As a result, students who were school ready at kindergarten entry enjoyed substantively more net growth in the first and second grades and maintained grade proficiency until the middle of second grade, compared to classmates who were not ready for school hat were reading at below-grade expectation by the end of the first grade. As the rate of growth recovered or accelerated in the third grade for both groups, students who were not ready for school had slightly better growth than school ready students did. In sum, school ready students experienced a smaller deceleration of growth in reading in first and second grade.

Research Question 2b: Do students who attend PGCPS preschool programs have an average reading developmental trajectory that is different from those who do not attend PGCPS Preschool programs?

Separate trajectories of reading for students who attended preschool in PGCPS (61% of the sample) and those who did not attend preschool in PGCPS (39% of the sample) were estimated. Figure 4 compares these trajectories.

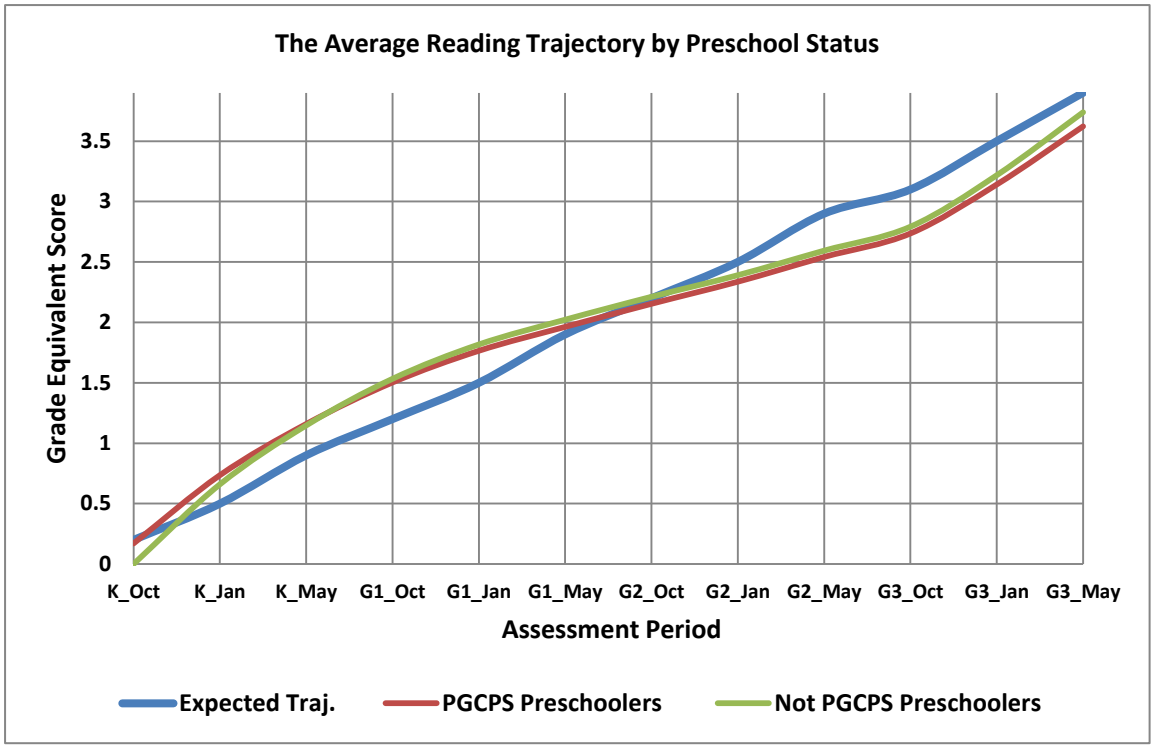


Figure 4: The Average Reading Trajectory by Preschool Status

Results of the analysis show that attending a PGCPS program (Pre-K or head Start) was associated with higher rates of growth in reading in the second and third grades ($p < 0.05$); however, it was not associated with any statistically significant differences in (a) the initial reading level at kindergarten entry and (b) the kindergarten to first grade growth pattern ($p > 0.05$). At kindergarten entry, both PGCPS preschoolers and students who did not attend PGCPS preschool programs had similar reading ability. Both also experienced higher than expected growth in reading, at the same rate, from kindergarten to early first grade. Subsequently, the initial rate of growth slowed down through the end of second grade. The average growth rate from early first grade through the end of second grade was higher for PGCPS preschoolers than for those who did not attend preschool in PGCPS. The rate of growth recovered or accelerated in the third grade slightly more for PGCPS preschoolers than for non-PGCPS preschoolers. However, the differences in the rates of growth did not translate into a significant gap between the two groups at the end of the third–grade as both groups started with similar initial level and initial rate of growth.

D. Average Reading Developmental Trajectory and Student Characteristics

Research Question 3a: Do Special Education (SPED) students have an average reading developmental trajectory that is different from students who are not SPED students?

Separate trajectories of reading for students who entered kindergarten as Special Education (SPED) students (6.8% of the sample) and students who were not special education (93.2% of the sample) were estimated. Figure 5 compares these trajectories.

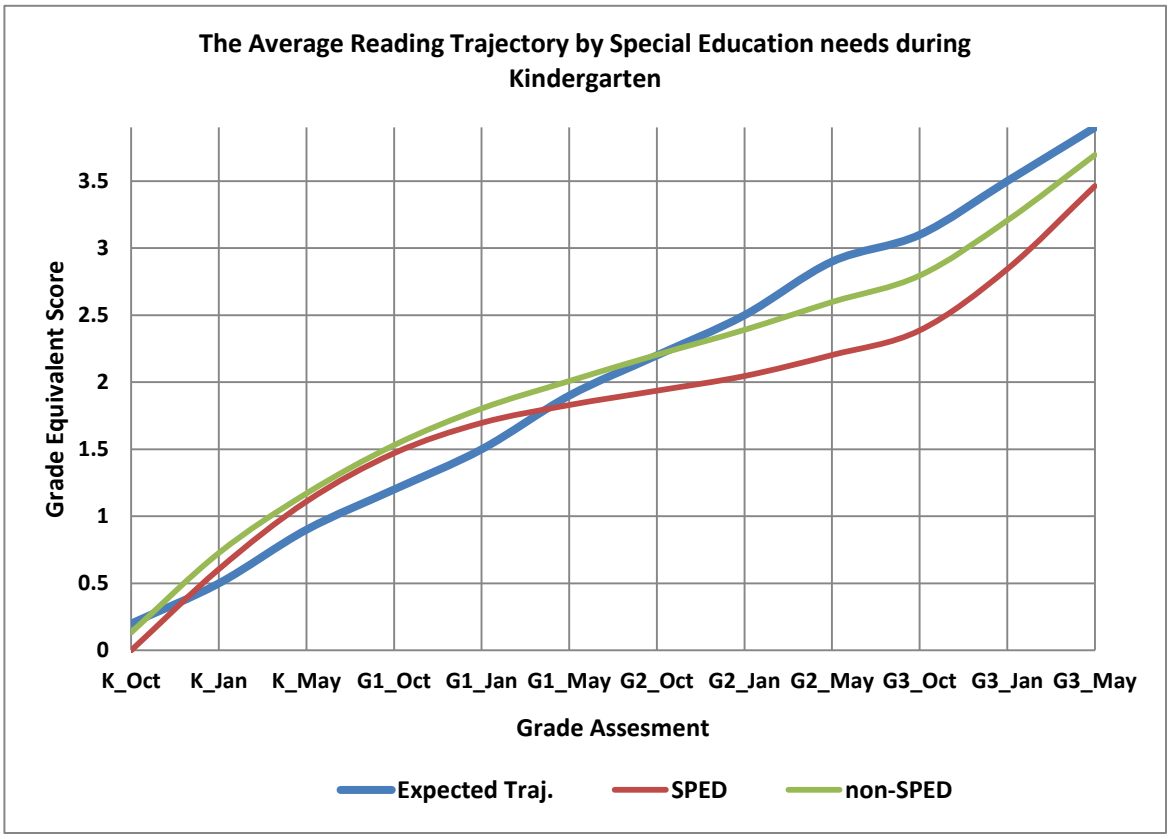


Figure 5: The Average Reading Trajectory by Special Education needs during Kindergarten

Results of the analysis show that the average Special Education student (SPED) had lower rates of growth in reading in first and second grade ($p < 0.05$); however, they did not have statistically significant difference in (a) the initial reading level at kindergarten entry, (b) the kindergarten to early first grade and (c) third grade growth pattern ($p > 0.05$). In other words, the average special education students grew at rates similar to the average classmate that was not special education from kindergarten to the middle of first grade. As students experienced the slowing of growth in reading, the rate of deceleration was significantly higher for the average special education student. As a result, the average SPED student gained less reading skills than the average non-SPED classmate did in first and second grade. By the end of the first grade, the average SPED student was reading at below-grade expectation in comparison to the average non-SPED classmate who read below-grade in the middle of the second grade. In third grade, however, the rate of growth for the average SPED and non-SPED student recovered or accelerated at similar rates. In sum, the average SPED student experienced slower rate of growth between first and second grade but had a growth rate similar with the average non-SPED classmate in the third grade. However, the reading performance gap that emerged in the first grade between the special education student and his/her classmates remained at the end of the third grade.

Research Question 3b: Do English Language Learners (ELL) have an average reading developmental trajectory that is different from those who are not ELL students?

Separate trajectories for students who entered kindergarten as English Language Learners (ELL, 26.3% of the sample) and their classmates who were not ELL students (73.7% of the sample) were estimated. Figure 6 compares these trajectories.

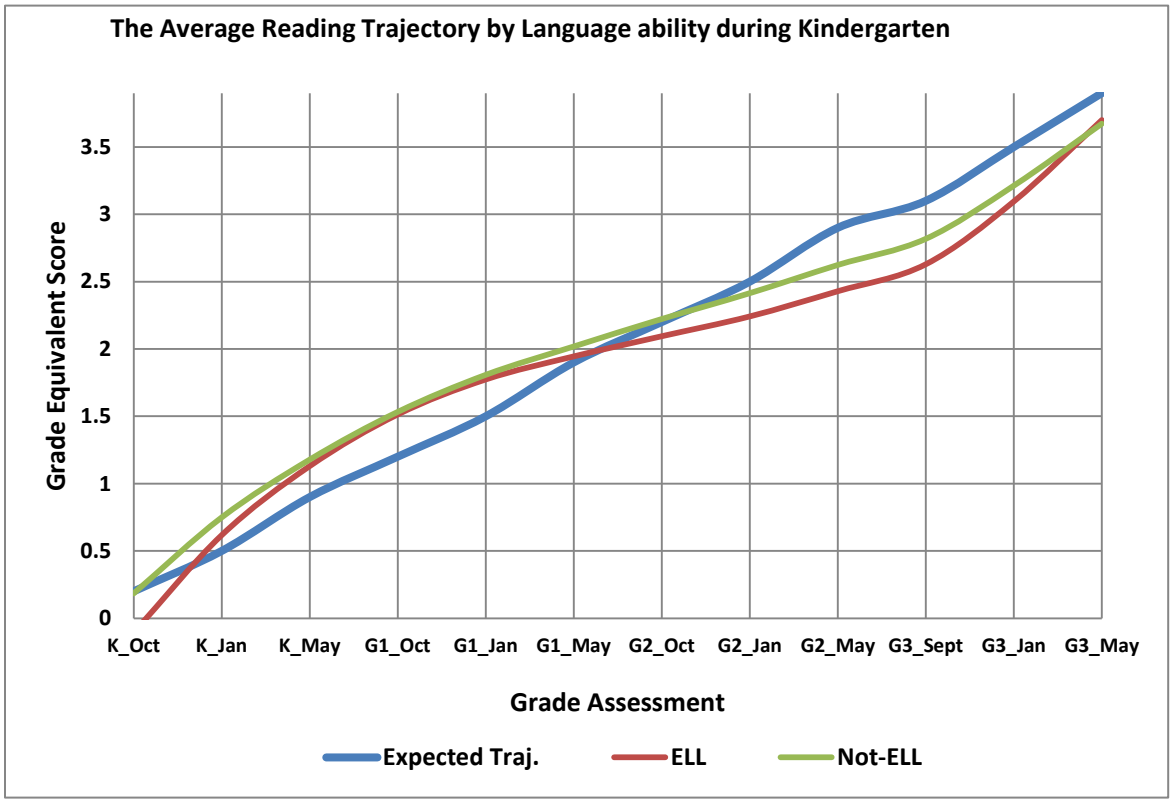


Figure 6: The Average Reading Trajectory by Language ability during Kindergarten

Results suggest that English language learner (ELL) status was associated with lower rates of growth in reading relative to non-ELLs in first and second grade and higher rate of growth in the third grade ($p < 0.05$). However, ELL was not associated with any statistically significant differences in (a) the initial reading level at kindergarten entry and (b) the kindergarten to early first grade ($p > 0.05$). That is, English language learners had similar growth rates with their classmates from kindergarten to the middle of first grade and both were on-grade proficiency at the end of the first grade. As growth slowed in the first grade, the rate of deceleration was higher for the ELL group. The average ELL student was reading at below-grade expectation by the beginning of second grade in comparison to his/her non-ELL average classmate who was reading on-grade at the beginning of the second grade. However, the rate of growth accelerated in the third grade slightly more for the average ELL student. In sum, the

average English language learner grew at slower rate in the first and second grade and at a higher rate in the third grade, thereby closing the gap that had occurred in the second grade.

E. Average Reading Developmental trajectory and Quality of Instruction

Research Question 4: To what extent does the quality of instruction from kindergarten to end of third grade instruction change the average developmental reading trajectory?

The quality of instruction, measured by a whether a student attended a reading class taught by a highly qualified teacher (HQT) in a given grade, was used to develop separate trajectories. The objective of the analysis was to test whether the average developmental trajectory described earlier varied based on the number of school years instruction in reading was given by a highly quality teacher. As a context, the average number of years taught by highly qualified teacher for the whole sample was 2.9 years, with half of the students receiving at least three years of instruction by a highly qualified teacher. In the sample, 7.7% did not receive any instruction by highly qualified teacher while 10.3% received only a year of instruction by a highly qualified teacher. The remaining breakdown of the frequency of instruction by highly qualified teacher was 20.2% had two years, 22.3% had three years and 46.6% had four years of instruction by HQT. Figure 7 displays comparison of the trajectories along with the trajectory of the expected path and the average PGCPS trajectory that was reported in Figure 1.

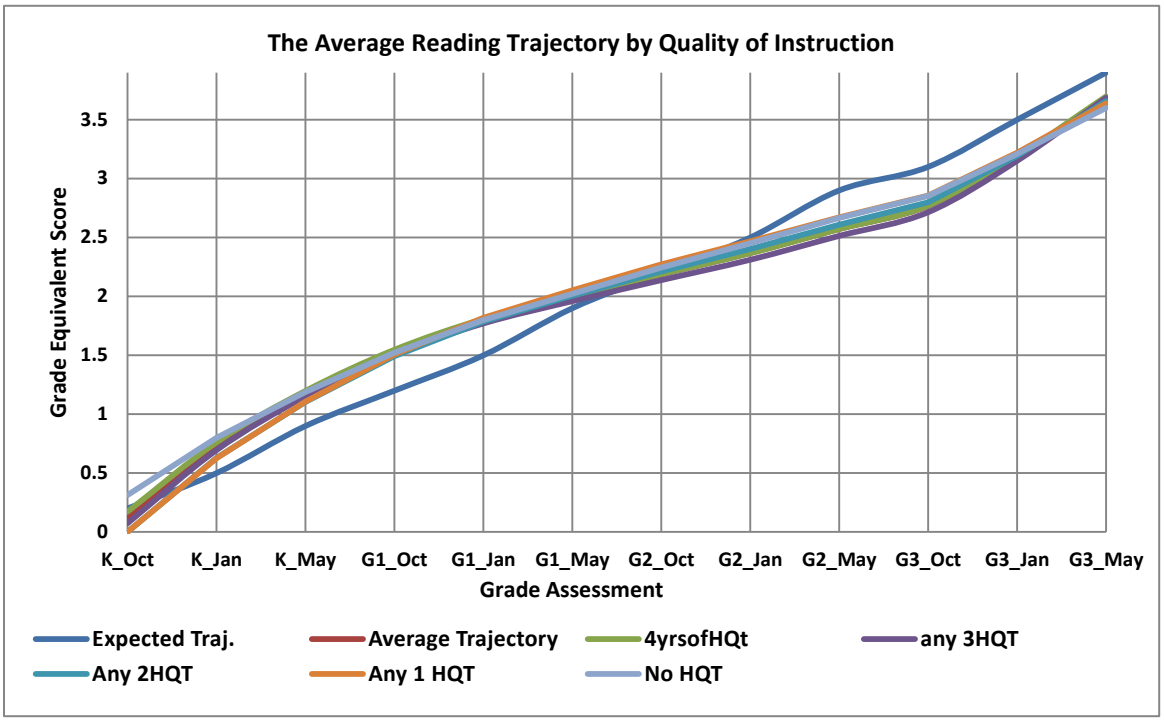


Figure 7: The Average Reading Trajectory by Quality of Instruction

The results demonstrate that the average reading developmental trajectory for the sample described earlier was equally descriptive of the growth of pattern of all students irrespective of the years of instruction by highly qualified teacher. All trajectories had similar pattern of growth. All were similar with the average path of growth in (a) sharp increase from kindergarten to early first grade, (b) the way they deviated from the expected path of growth during second grade and (c) finished third grade reading slightly below-grade expectation despite the recovery made in the third grade.

IV. DISCUSSION AND CONCLUSIONS

The purpose of the present study was to identify the typical kindergarten to third grade reading developmental trajectory in PGCPS and to examine variations of the typical reading trajectory. In doing so, we investigated the typical trajectory in reference to the expected path of proficient reading, and how the typical path varied by selected characteristics of students, the readiness gap at school entry and preschool experience. We also identified multiple trajectories of reading development that result in proficiency or underperformance in reading by the end of the third grade. A discussion of the findings presented in the previous section along with conclusions is presented here.

The results of the analyses for the first research question, Research Question 1a, indicate that the average student does not grow in a linear fashion. Instead, the average student in the sample grew more than would be expected in kindergarten but the rate of growth started slowing down in the first grade. The slowing down of the rate of growth resulted in the average student falling below-grade expectation in second grade. In the third grade, however, the rate of growth recovered slightly and the gap between the observed and the expected levels of reading was narrowed by the end of third grade. Nevertheless, the average student's reading ability was slightly below expectation at the end of the school year in third grade. Overall, the transition into the second grade seems to be the grade at which the average student deviates from the expected path of proficient reading and performs below-grade expectation. Put in terms of the developmental skills of reading, when the average student is an emergent reader (kindergarten) and early reader (beginning to mid first grade) he acquires reading skills at a higher rate than is needed to attain grade level proficiency. However, the skills level (or the grades) at which the average student seems to struggle is when the student is a transitional reader (from the middle of the first grade through end of second grade).

The results from Research Question 1b revealed that multiple trajectories, rather than one typical or normative trajectory, were prevalent in the sample. Though the above description represented the most typical pattern of growth for the average PGCPS student, the study ascertained that there were six unique developmental groups in the sample. Three of the six groups were reading above-grade level by the end of the third grade. As the three groups followed different pathways in their progress toward reading proficiently, a common characteristic of them was that they all recovered early and substantively more from the slowing of growth that occurred between first and second grade. These groups enjoyed above average growth in reading in the second grade, in contrast to the acceleration of growth that occurred in the third grade for the rest of the sample. The results of the analysis also show that the groups that were not proficient readers by the end of the third grade followed different paths to underperformance. These groups either experienced low rates of growth or had a negative net gain in the second grade. The linear growth group enjoyed consistent rate of growth in reading

but the rate of its growth was too low to compensate for the observed deviation from the expected path in second grade experienced. As a result, the group fell below the expected level in the second semester of second grade and finished third grade reading slightly below-grade expectation. The low-chronic growth group experienced much smaller rate of overall growth that declined overtime. Its rate of growth plateaued in the second grade and did not demonstrate any sizeable growth since then. The 'Declining Growth' group is different in that it had the most precipitous decline in its rate of growth in the second grade and finished the third grade reading below its own reading level at the beginning of the second grade. This group had a net negative gain in reading in second grade and did not start recovering from the low growth or decline until the winter of third grade.

Results from the analysis of the second set of research questions revealed that there were few variations in the average reading developmental trajectory based on two status variables during kindergarten. The study focused on two factors: school readiness in language and literacy at school entry and type of preschool attended. The results demonstrate that students who were school ready in language and literacy read at higher levels than their classmates that were not school ready at kindergarten entry and had different growth pattern through the end of the third grade. Students who came to PGCPS ready for school in the domains of language and literacy experienced smaller rate of deceleration between first and second grade. As a result, school ready students enjoyed substantively more net growth in the first and second grades and maintained grade proficiency longer than their peers who were not school ready. In other words, the average students fell below the expected path of proficiency but a school ready student enjoyed two more semesters of proficiency in the second grade. On the other hand, PGCPS preschoolers were not reading at higher levels at school entry and do not have a rate of growth hat were different from that of non-PGCPS preschoolers in kindergarten to early first grade.. Even though the average growth rate in subsequent grades was higher for PGCPS preschoolers than for those who did not attend preschool in PGCPS, it did not result in significant performance gap at the end of the third grade.

The results of the analysis also investigated how the reading trajectory for the average student varied by student characteristics during kindergarten. We specifically focused on comparing the average trajectory of two groups of students often categorized as having a high risk of delayed growth in reading: SPED and ELL. We wanted to know how the average trajectory of these two groups compares with their peers who do not have those risk factors. The growth pattern of these at-risk groups followed similar path of the average student but was characterized by bigger rate of deceleration of growth between first and second grades. Whereas both groups grew at rates that are similar to their peers in kindergarten, the subsequent slowing down of the rates of growth resulted in wider gaps between the groups and their peers. While SPED students recovered at the same rate with their non-SPED peers in the third grade, ELL students grew at a higher rate than their non-ELL peers did. As a result, the reading trajectories

of ELL students converged with those of their non-ELL peers at the end of the third grade as the reading gap between SPED and non-SPED students remained intact.

Finally, the results of the analysis demonstrated that the typical reading developmental trajectory for the average student was not associated with the quality of instruction in reading. The fact that quality of instruction, measured by frequency of instruction by a highly qualified teacher, did not result in variations in the typical trajectory does not lead us to conclude that the quality of instruction is not important. Our measure of instructional quality only captures the teacher's qualifications and the match between the teacher's qualifications and the class taught. It does not measure the instructional approaches and strategies employed by the highly qualified teacher in a given classroom. A future study should expand on the results of this study by focusing educational programs and classroom instruction that students receive and the role they play in altering reading trajectories of K-3 students. The current data set was limited for it did not account for the differences in the educational programs and classroom instruction that students received, raising valuable questions for future research about what instructional and programmatic factors accelerate the reading growth of students in kindergarten to third grades.

In conclusion, this study employed two different measures that capture different skills at different levels of reading development, and standardized them for easy comparison. This made it possible to profile the kindergarten to end of third grade developmental trajectory where word reading and reading comprehension are studied simultaneously. Moreover, the study used multiple measurement points in a given academic year to understand the dynamics of reading development from the beginning of formal instruction until students are expected to start to read to learn. The trajectory approach used in the study enabled us to identify the early acceleration in kindergarten, the slowing down of growth in first and second grades and the recovery in the third grade. The pattern of growth shows a rapid acquisition of the basic skills during the stages of emergent and early reader followed by a decline in the rate of progress during the transitional reader stage and some recovery of the rate of progress in the third grade. This result is similar to previous studies that found that children learning to read English seem to undergo a longer lasting growth spurt in kindergarten and Grade 1 (Hill, Bloom, Black, & Lipsey, 2008; Skibbe et al., 2012) and a slumping of the rate of growth in subsequent grades (Snow, Burns, and Griffin, 1998). The slumping of growth in this study for the average student occurred from the middle of the first grade through end of second grade, with slight variations in the onset and degree of the slump for various groups of students. Future research and interventions should seek to identify the correlates of improving the acquisition of reading skills in the transitional stage (late first grade through the end of second grade).

The literature offers two possible explanations for the slump in growth. One possible explanation for the slowing down of growth is that the slump is an artifact; that is, the tasks in school and the tasks in assessment instrument may change so much between grades that it is not

sensible to compare progress and success on such different tasks and measures. In this study, however, the slowing of progress for the average student started much earlier than the change of assessment instrument from the DRA to the SRI in the middle of the second grade. Moreover, the standardization of the assessment into grade-equivalent measure and the identification of multiple trajectories that experienced various levels of growth during the typical slump period demonstrate that the trend is not just an artifact. A second possible explanation is that it is not so much of a second grade slump but a "primary-grade streak," (Snow, Burns, and Griffin, 1998) that is, that some children have problems in the earlier assessments/grade that are hidden while so much else is being learned. It may be that there had been less need for certain knowledge and abilities until second grade and failure to thrive in those areas might not be noticed until then (Snow, Burns, and Griffin, 1998). This possibility is the likeliest explanation because students who were ready for school at kindergarten entry experienced smaller degree of the slump in growth. As previous studies have indicated the reason that emergent literacy skills are important for children entering elementary school is not that children with low levels of those skills cannot succeed in the task of learning to read. Rather, the reason is that schools provide an age-graded rather than skills-graded curriculum in which early delays are magnified at each additional step as the gap increases between what children bring to the curriculum and what the curriculum demands (Whitehurst and Lonigan, 1998). It is, therefore, important that there is focus on skills in the early stages of literacy development for preventing reading difficulties that may appear later when students are learning to read in the transitional stage.

REFERENCES

Espinosa, Linda. 2012. Assessment of Young English-Language Learners. The Encyclopedia of Applied Linguistics,, Blackwell Publishing Ltd.

Hill, Carolyn J., Howard S. Bloom, Alison Rebeck Black, and Mark W. Lipsey. 2008. Empirical Benchmarks for Interpreting Effect Sizes in Research. Child Development Perspectives, Volume 2, Issue 3, pp. 172-177, December 2008.

Jones, B. L., and D. Nagin,. 2012. A Stata Plugin for Estimating Group-Based Trajectory Models

Kenny, David A. , Deborah A. Kashy, and William L. Cook. 2006. *Dyadic Data Analysis*. New York, NY: Guilford.

Lesaux, Nonie K. 2013. PreK-3rd: Getting Literacy Instruction Right. The Foundation for Child Development, Policy to Action Brief, No. 9, may 2013.

Maryland State Department of Education. 2012. The 2012-2013 Maryland School Readiness Report. Baltimore, Maryland.

Maryland State Department of Education. 2009. Maryland Model for School Readiness (MMSR)-Framework and Standards for Kindergarten. Baltimore, Maryland, Fifth edition, Summer 2009.

Nagin, D. S. 2005. Group-Based Modeling of Development. Cambridge, MA: Harvard Univ Press.

Nagin, D. 1999. Analyzing Developmental Trajectories: Semi-Parametric, Group-Based Approach. Psychological Methods 4:39-177

National Reading Panel. 2000. Report of the National Reading Panel-Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for Reading instruction. Washington, D.C.: National Institute of Child Health and Human Development (NICHHD).

PGCPS. 2015. Strategic Plan, 2016-2020, March 2015.

Skibbe, L. E., Bindman, S. W., Hindman, A. H., Aram, D., & Morrison, F. J. 2012. Longitudinal Relations between Parental Writing Support and Preschoolers' Language and Literacy Skills. *Reading Research Quarterly*, *48*(4), 387–401.

Smith, Malbert. 2011. Bending the Reading Growth Trajectory: Instructional Strategies to Promote Reading Skills and Close the Readiness Gap. MetaMetrics Policy Brief #2, March 2011.

Snow, Catherine E, M. Susan Burns, and Peg Griffin. 1998. Preventing Reading Difficulties in Young Children. National academy press, Washington DC.

The NAESP Foundation Task Force on Early Learning. 2010. Building and Supporting an Aligned System: A Vision for Transforming Education Across the Pre-K-Grade Three Years."

Whitehurst, G. J., & Lonigan, C. J. 1998. Child development and emergent literacy. Child Development, 69, 848–872.

Williamson, Gary. 2010. What is Expected Growth? A White Paper from Metametrics.

Appendices

Appendix A: Outputs for the Average Reading Trajectory Model

Table 2: Coefficients for the Average Trajectory Model

	Intercept	Linear	Quadratic	Cubic	AIC	BIC
Full Sample (N=8939)	***0.118 (0.0144)******	***2.062 (0.032)******	***-.775 (0.020)******	***0.131 (0.003)******	***-138444.7***	***-138462.5***
Reading Trajectory by Readiness for School						
School Ready (N=5097)	***0.34875 (0.01794)******	***1.61 (0.041)******	***-0.49073 (0.02556)******	***0.8160 (0.00044)******	***-80996.9***	***-81013.3***
Not ready for school (N=3842)	***-0.30829 (0.0244)******	***2.89295 (0.053269)******	***-1.28609 (0.03223)******	***0.21755 (0.00555)******	***-56958.9***	***-56974.5***
Reading Trajectory by Preschool Status						
PGCPS preschoolers (N=5459)	***0.17079 (0.01786)******	***1.96281 (0.04037)******	***-.71327 (0.02494)******	***0.12131 (0.00338)******	***-84324.6***	***-84341.1***
Not PGCPS Preschoolers (N=3480)	***0.02989 (0.02453)***	***2.27198 (0.05445)******	***-.87532 (0.03345)******	***0.14616 (0.00581)******	***-54009.1***	***-54024.5***
Reading Trajectory by Special Education needs during Kindergarten						
SPED (N= 609)	***-0.12696 (0.05884)****	***2.59116 (0.13119)******	***-1.19083 (0.08016)******	***0.20559 (0.01385)******	***-8914.1***	***-8925.1***
Not SPED (N=8330)	***0.13423 (0.01491)******	***2.02778 (0.03348)******	***-.74837 (0.02066)******	***0.12606 (0.00360)******	***-129394.2***	***-129411.7***
Average Reading Trajectory by Language Ability during Kindergarten						
ELL (N=2352)	***-0.10603 (0.023)******	***2.52988 (0.06538)******	***-1.08736 (0.0396)******	***0.18628 (0.00682)******	***-35973.6***	***-35988***
Not ELL (N= 6587)	***0.18477 (0.01658)******	***1.92 (0.03746)******	***-.67719 (0.02324)******	***0. 11308 (0.00406)******	***-102342.2***	***-102359.2***
Average Reading Trajectory by Quality of Instruction						
No HQT (N=685)	***.31287 (.0593)******	***1.63326 (.13647)****	***-.49519 (.08569)******	***.08072 (.0622)******	***-8961.3***	***-8972.6***
Any 1 Year of HQT (N=918)	***-.01209 (.0479)***	***2.12371 (.10904)****	***-.718036 (.06960)******	***.11217 (.01235)******	***-105.1***	***-105.3***
Any 2 Years of HQT (N=1810)	***.01246 (.03950)***	***2.14693 (.08980)******	***-.77037 (.05625)******	***.12515 (.00988)******	***-176519***	***-17671.6***
Any 3 Years of HQT (1994)	***.074185 (.0304)****	***2.14603 (.06784)******	***-.84809 (.04142)******	***.14556 (.00716)******	***-31959.3***	***-31973.3***
4 years of HQT (N=4162)	**0.17299 (0.02071)*****	**2.02254 (0.04645)*****	**-.77151 (0.02846)*****	**0.13201 (0.00493)*****	**- 67672.7**	**- 67688.5**

*** $p < .01$; ** $p < .05$; * $p < .10$ (p = probability that result is not statistically different from 0.)

Appendix B: Methodology and Outputs for Groups-based Trajectory Model

To identify discrete developmental trajectories of reading within the sample, the study employed a form of mixture modeling known as the Groups-Based Trajectory Model (Nagin, 1999). In this model, each student in the sample is assumed to adhere to a particular group-specific trajectory of change over time in his/her reading. The process that generates individual differences in these trajectories is unobserved. By separating the overall student population into groups that follow similar trajectories, it identifies heterogeneous patterns in the underlying processes of developmental change in early reading. The TRAJ command in STATA was used to perform the analysis for the groups-based trajectory model (Jones and Nagin, 2012). The TRAJ command calculates the probability of each student belonging to each trajectory group and assigns each student to the trajectory group with the largest probability. Each trajectory group has its own intercept and growth parameters to indicate the trajectory of reading as a function of duration from baseline (Kindergarten- October).

Number of Trajectory Groups.

The first step in this analysis was to fit students' repeated reading scores in order to select the number (j) and form (linear, quadratic, cubic, etc…) of the trajectory groups. The number of trajectory groups that best accommodate the data were determined using a flexible nonlinear functional form. After the number of trajectory groups was identified, the functional forms of the groups were selected. In both cases, the best fitting model was determined using model selection indices known as Information Criteria, including Bayesian Information Criteria (BIC), sample-size adjusted BIC, and Akaike Information Criteria (AIC). The number and form of groups resulting in the lowest BIC were selected. The BIC[iii] was used primarily to determine the appropriate number of trajectories. The statistic extracts a penalty for adding additional parameters (e.g., trajectories or higher-order terms), and thus tends to favor more parsimonious model specifications. A BIC factor of more than 20 represents "strong evidence" that model Mj+1 is preferable to model Mj.

As shown in Table 1 below, K=6 groups yielded the lowest BIC for reading trajectories Other models were estimated but rejected based on the results of the BIC. This finding implies that the subtypes of the average reading trajectory or heterogeneity in learning patterns among PGCPS students is sufficiently accommodated by splitting the students into six groups for analysis.

Table 3: Determination of Number of Trajectories

	BIC	Change in BIC with addition of +1 group	AIC
1 Trajectory	-138462.5		-138444.7
2 Trajectories	-128347.7	10114.8	-128312.2
3 Trajectories	-125378.5	2969.2	-125325.3
4 Trajectories	-124130.7	1247.8	-124059.7
5 Trajectories	-123416.3	7144	-123327.5
6 Trajectories	**-123439**	**22.7**	**-123332.5**
7 Trajectories	-123461.7	-22.7	-123337.5

All tested with cubic function of groups first

Shape of the Trajectories

After selecting the number of groups, BIC was used to determine whether a different functional would improve fit, holding the number of groups constant at six. The selection of best functional form of growth was also informed by the desire to identify at least one group that followed a linear path of growth in reading. As shows in table 2, the best-fitting group trajectory model had four trajectories with cubic shape, a linear trajectory and a trajectory with a quartic shape. Table 3 reports the coefficients that describe the shape of the trajectory for each group along with their statistical significance.

Table 4: Identifying the Functional Form of the Six Group Trajectories

	BIC	Change in BIC with addition of +1 group	AIC
Six cubic growth groups	-123439		-123332.5
1 Linear and 5 Cubic growth Groups	-123655.3	-216.3	-123555.9
1inearL, 1 Quartic, and 4 Cubic growth groups	**-122458.2**	**1197.1**	**-122355.28**

Table 5: Coefficients Parameters for each Trajectory-group

	Intercept	Linear	Quadratic	Cubic	Quartic
Group 1 (N=465)	0.129 (0.0483)**	2.67 (0.115)***	-1.741 (0.074)***	0.463 (0.013)***	
Group 2 *(N=2617)*	0.404 (0.014)***	.862 (0.008)***			
Group 3 *(N=1271)*	0.159 (0.033)***	1.99 (0.082)***	-1.01 (0.051)***	0.245 (0.009)***	
Group 4 *(N=2513)*	0.16 (0.024)***	1.52 (0.059)***	-.44 (0.035)***	0.046 (0.006)***	
Group 5 *(N=450)*	0.44 (0.056)***	2. 13 (0.18)***	-.53 (0.13)***	0.073 (0.023)**	
Group 6 *(N= =1623)*	0.46 (0.031)**	-.172 (0.117)	3.33 (0.125)***	-1.865 (0.0518)***	.277 (.007)***

*** $p < .01$; ** $p < .05$; * $p < .10$ (*p = probability that result is not statistically different from 0.*)

Group Description and Assignment Accuracy

Once the number of groups and shapes of the trajectories were identified, in the third step, model adequacy was tested using the average posterior probabilities (APP) of group membership. After estimating the discrete trajectories in reading, each student was assigned to the trajectory for which s/he had the highest probability of membership. The accuracy of assignment for each trajectory (that is, students are well assigned to their trajectories) was established following Nagin's (2005) recommendation that the average posterior probabilities should exceed a minimum of .70 for each trajectory group.

Table 6: Group Size and Probability of Membership of Trajectory Groups

N=8939	Probability of membership in the group	Group Size	Percent
Group 1 – Delayed-High Growth	.95	465	5.2%
Group 2 – Linear Growth	.76	2617	28.3%
Group 3 – Delayed-Moderate Growth	.84	1271	14.4%
Group 4 - Chronic Low Growth	.82	2513	27.6%
Group 5- Early-High low steady Growth	.81	450	5.4%
Group 6 - Declining Growth	.81	1623	19.1%

Group assignment accuracy was calculated based on average probabilities of belonging in each group, and is summarized in Table 4. The mean probability was 0.95, 0.76, 0.84, 0.82, 0.81 and 0.81 for those assigned to trajectories 1–6, respectively. The selection of six trajectories was also informed by the recommended criteria that suggested that each identified group should at least contain 5% of the population. All six-groups fulfilled this criterion of minimum of 5 percent of the sample.

Table 7: Student Characteristics of Trajectory Groups

Variable	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	*Whole Sample*
SPED	6.0%	5.2%	5.5%	10.7%	0.4%	8.4%	6.8%
ELL	25%	25%	28.1%	30.2%	16.7%	24.2%	26.3%
School Ready in Language	61%	59%	55%	50.5%	76%	59%	57%
Preschool in PGCPS	56.8%	52%	59.2%	64.3%	56.7%	58.3%	61%

[i] The DRA text score and SRI Lexile score use an approach that looks at typical texts used in each grade, and tests what level of reading ability students must exhibit to be able to comprehend the typical grade level texts. Thus, they provide the expected test scores for a particular grade and period of assessment that correspond to having proficiency of corresponding reading material. This provides a curricular-based rather than a performance-based perspective that might be used for defining "normal" growth (Williamson, 2010).

[ii] Phonemic Awareness (that students discriminate sounds and words, and produce rhyming words); Listening (that students gain meaning by listening, and demonstrate beginning phonemic awareness); Phonics (that students recognize that letters have corresponding sounds); Vocabulary (that students Use expanded vocabulary and language for a variety of purposes, and show beginning understanding of concepts about print); Comprehension (that students demonstrate an understanding of concepts of print to determine how print is organized and read, comprehend and respond to fiction and non-fiction text); and Writing (that students Use letter-like shapes, symbols, letters and words to convey meaning).

[iii] The TRAJ command in STAT calculates the BIC as the value of the model's maximized likelihood minus one-half the number of parameters in the model multiplied by the log of the sample size (Nagin 2005).