Supporting the Development of Early Mathematical Knowledge Among Dual-Language-Learners with Varying English-Proficiency from Preschool through Kindergarten

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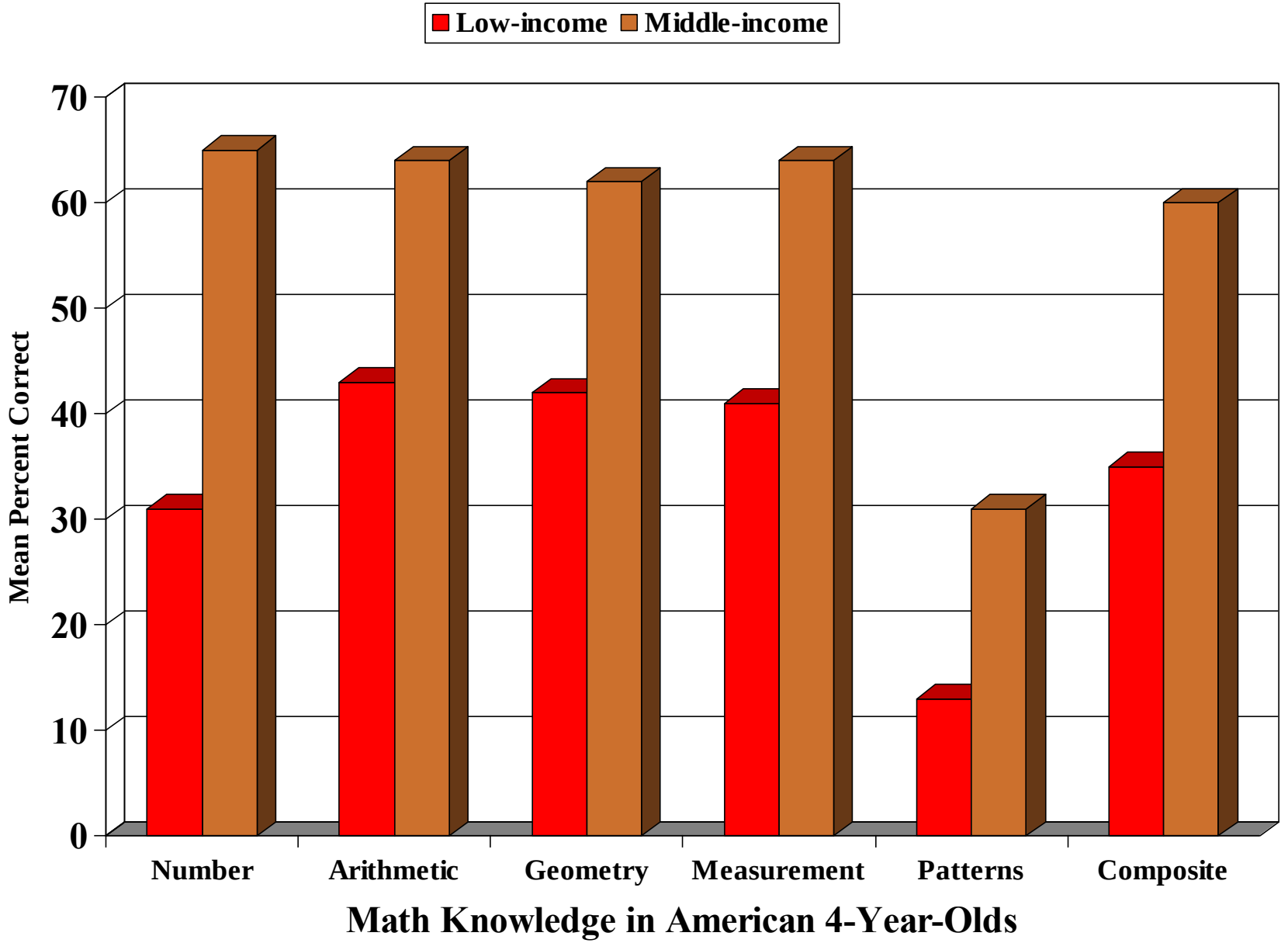
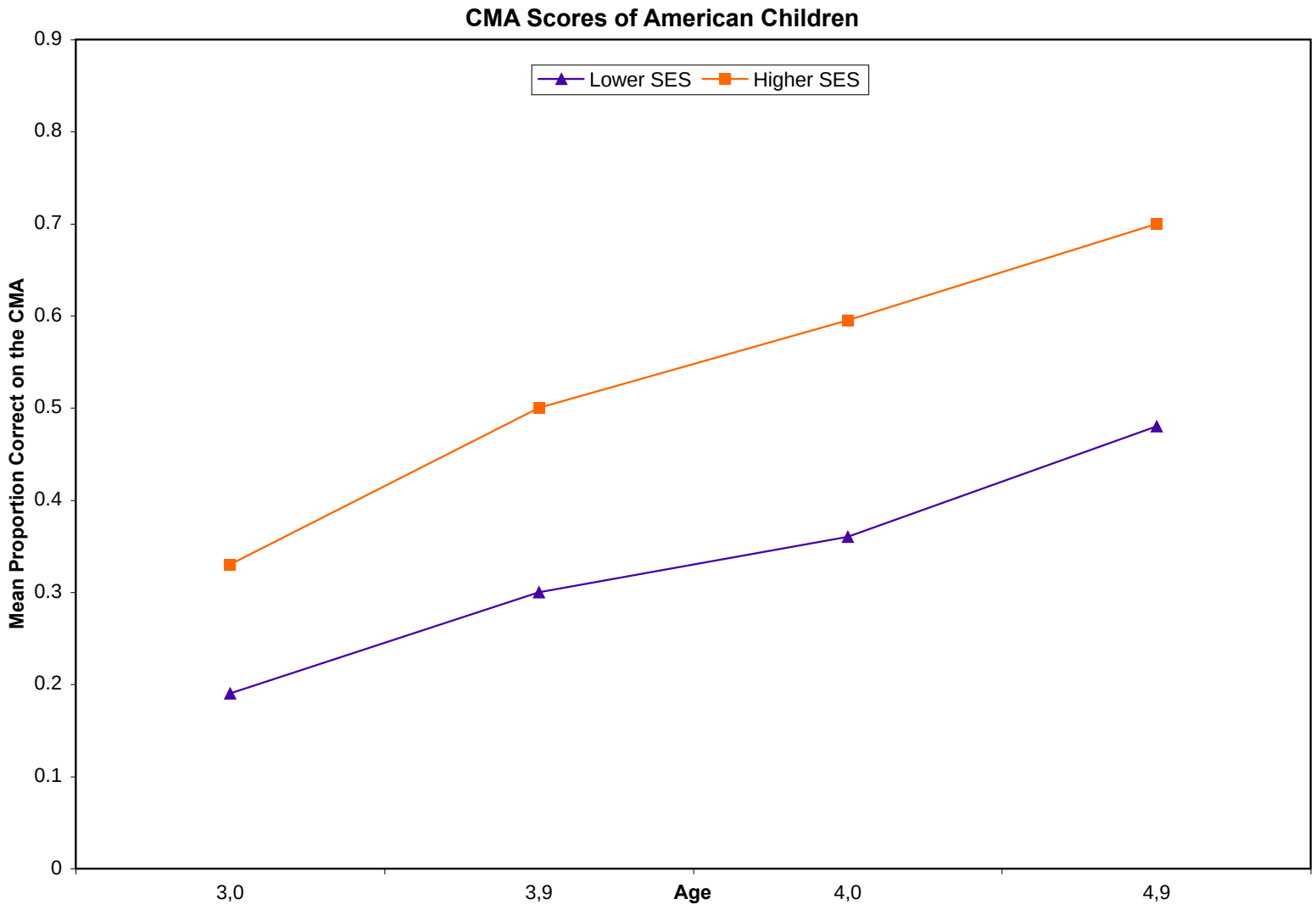
The Research

Socioeconomic Status and Math Achievement

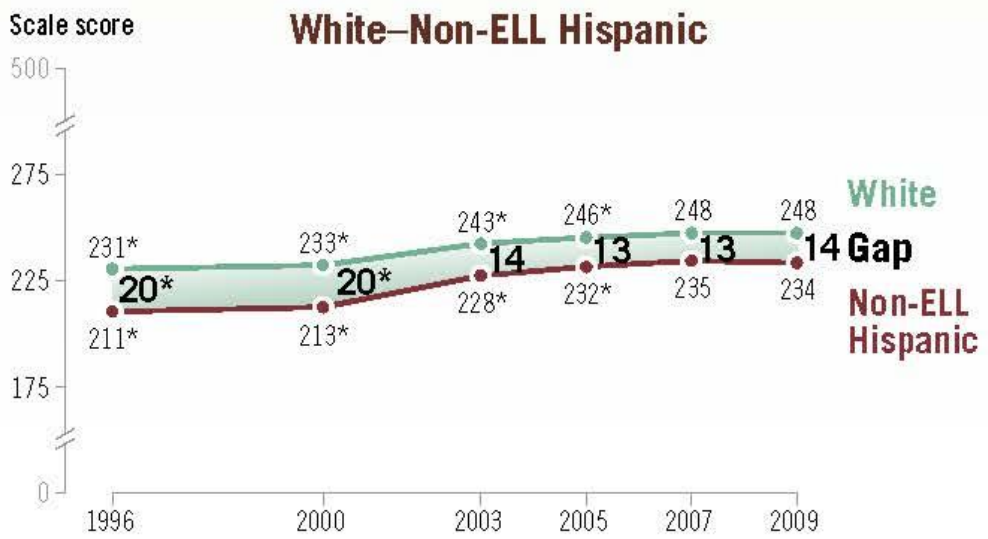
- Mathematical knowledge is less extensive among low-income pre-kindergarten (pre-k) children than in their middle-income peers.
- The socioeconomic gap is broad, and it emerges before 3 years of age.
- Thus, children from different socioeconomic backgrounds enter elementary school at different levels of readiness for school mathematics.
- These early differences lay the foundation for the SES-related achievement gaps in mathematics found later in K-12 and beyond

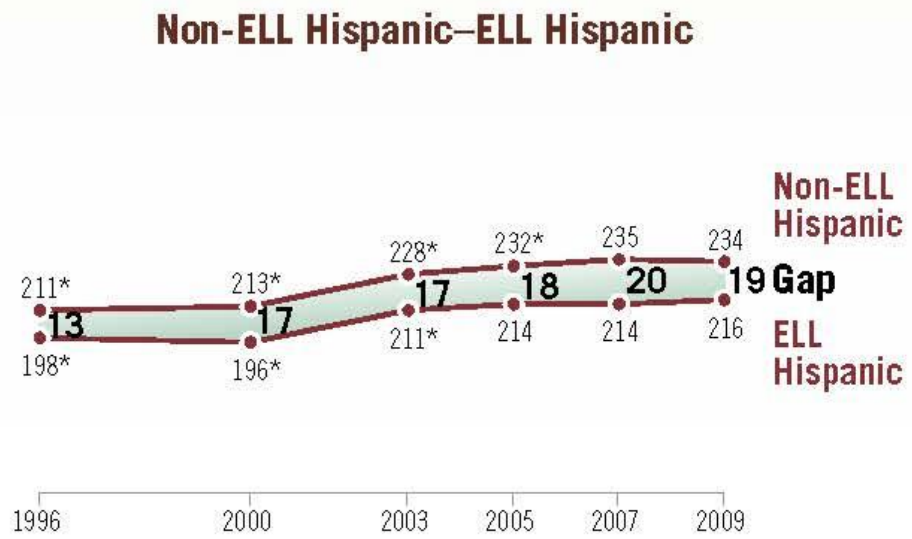

Low-income
Middle-income
Mean Percent Correct
70
60
50
40
30
20
10
0
Number
Arithmetic
Geometry
Measurement
Patterns
Composite
Math Knowledge in American 4-Year-Olds


CMA Scores of American Children
Lower SES
Higher SES
Mean Proportion Correct on the CMA
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
3,0
3,9
Age
4,0
4,9

Language-Related Gap in Math Achievement

Figure 11. Mathematics achievement score gaps between Hispanic and White public school students at grade 4, by English language learner status: Various years, 1996–2009





* Significantly different ($p<.05$) from 2009.

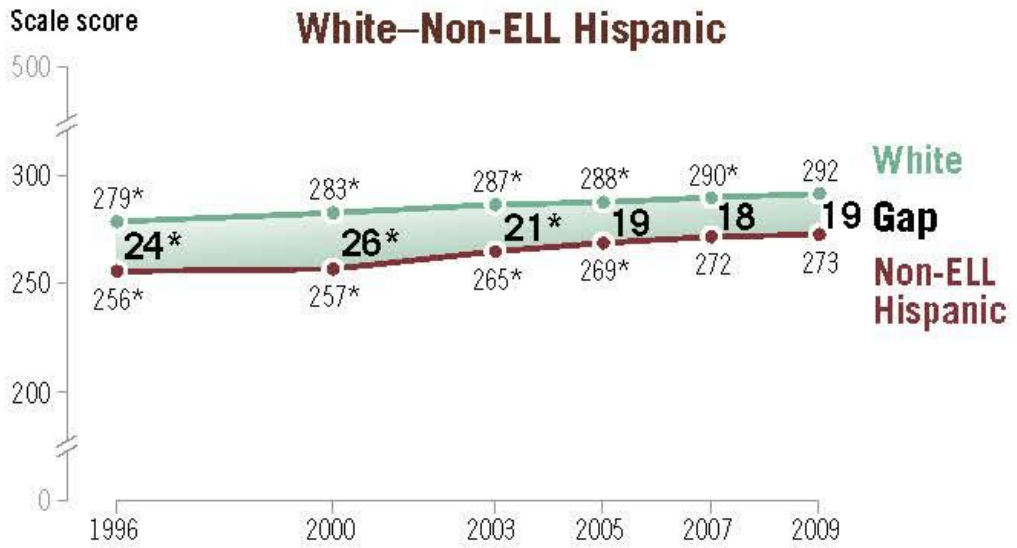
NOTE: Score gaps are calculated based on differences between unrounded average scores. White includes ELL and non-ELL White students.

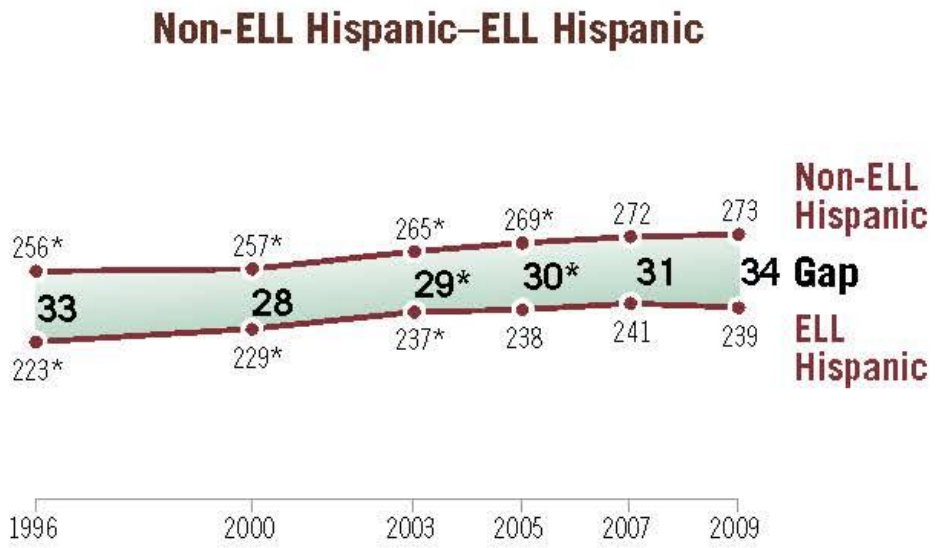
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), various years, 1996–2009 Mathematics Assessments.

Hemphill & Vanneman, 2011, p. 17

Language-Related Gap in Math Achievement

Figure 12. Mathematics achievement score gaps between Hispanic and White public school students at grade 8, by English language learner status: Various years, 1996–2009





* Significantly different ($p<.05$) from 2009.
NOTE: Score gaps are calculated based on differences between unrounded average scores. White includes ELL and non-ELL White students.
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), various years, 1996–2009 Mathematics Assessments.

Hemphill & Vanneman, 2011, p. 17

Language-Related Gap in Math Achievement

- The language-related achievement gap in math also seems to appear early, and has implications for later learning.
- Dual language learners with limited English proficiency (DLL-LEP) finish kindergarten with significantly lower math skills compared to both Spanish-speaking children who are also English proficient (DLL-EP), and/or monolingual English speakers (MLLs) (Halle, et al., 2012)
  - DLLs who are English proficient by kindergarten entry perform as well on measures of math knowledge throughout elementary and middle school as their monolingual English speaking peers (Halle, et al., 2012)
  - For DLLS not English proficient by first grade, the gap widens over time (Halle, et al., 2012).

Our Research

- We will present findings from two studies, each designed to target the SES-related gap in early math knowledge
- High percentage of dual language learners (DLLs) in each sample allows for secondary analyses focused on relations between developing English proficiency and developing math knowledge

Study 1: The effects of a one-year, pre-k math intervention on developing math knowledge

- Data drawn from two IES-funded efficacy studies
- In each, Head Start and State Pre-K classrooms were randomly assigned to conditions
  - Treatment: One-year pre-k math intervention
  - Control: Business-as-usual (BAU)
- Teachers in treatment classrooms received professional development via workshops and biweekly coaching to implement tier 1 math curriculum
- Children's math knowledge was assessed in the fall and spring of pre-k

Study 1: Participants

TOT Sample (N)	Age @ Pretest	Gender (% female)	Latino	MLL	DLL-EP	DLL-LEP
Treatment : One-Year PK Intervention						
286	4.41 years	49%	70%	32%	52%	16%
BAU Control						
289	4.43 years	52%	76%	25%	40%	35%
Total						
575	4.42 years	51%	73%	29%	46%	26%

MLL = Monolingual (English-Only) Language Learner; DLL-EP = Dual Language Learner-English Proficient by End of Pre-K; DLL-LEP = Dual Language Learner-Limited English Proficiency at End of Pre-K

Study 1: Measures and Procedures

Math Measure

- Test of Early Mathematical Ability, 3rd edition (TEMA-3)

Implementation Procedures

- Math intervention: *Pre-K Mathematics* (tier 1 math curriculum)
- All components of the math intervention were available and implemented with children in Spanish and/or English

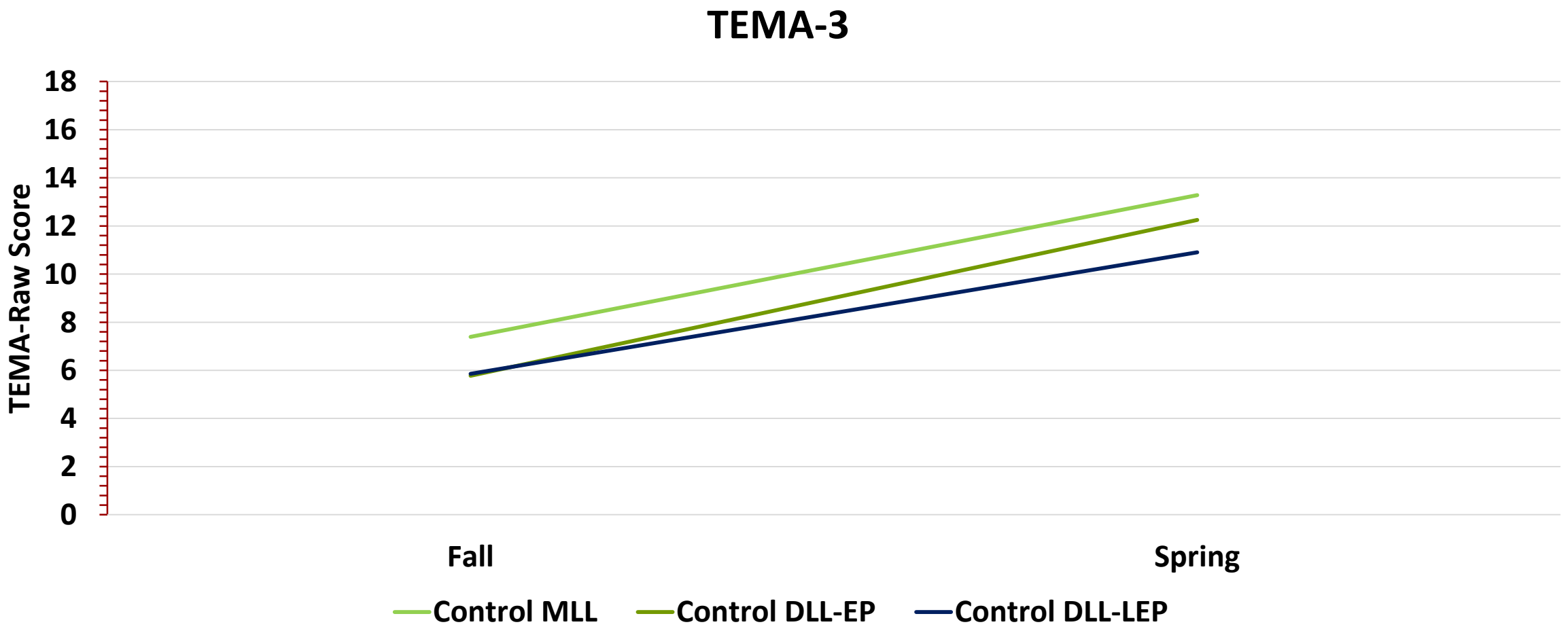
Data Collection Procedures

- Children were individually assessed in English and/or Spanish by a research project staff at the beginning and end of the school year

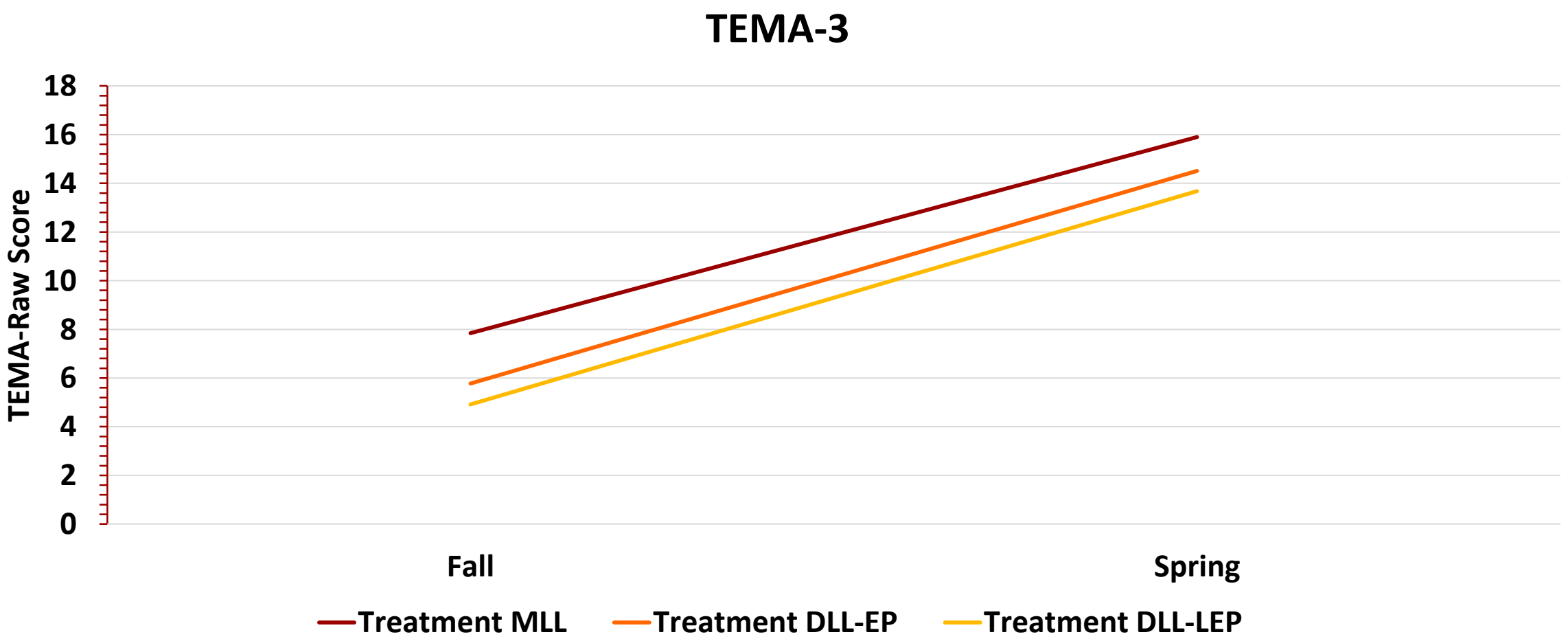
Study 1: Research Questions

1. Under BAU conditions, to what extent does informal math knowledge differ between MLLs and DLLs who are English proficient (DLL-EP) and not English proficient (DLL-LEP) at the beginning and end of the pre-k year?
2. To what extent does participation in an early math intervention influence any potential differences in math knowledge by language status?

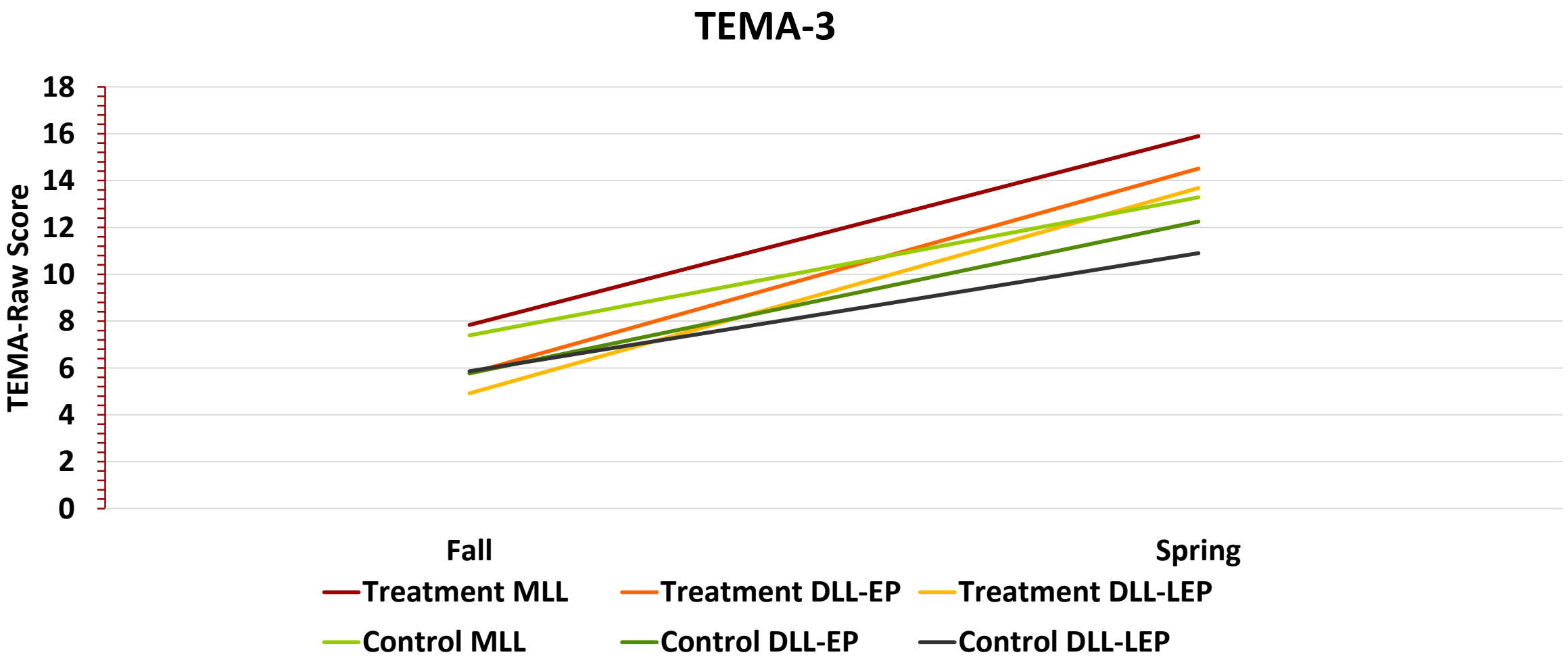
BAU Control Condition, TEMA-3



Treatment Condition, TEMA-3



Treatment vs. Control by Level of English Proficiency, TEMA-3



Study 1: Condition X Language (TEMA-3)

	MLL M (SD)	DLL-EP M (SD)	DLL-LEP M (SD)
Fall PK			
Treatment	7.84 (6.11)	5.77 (4.78)	4.92 (3.68)
Control	7.39 (5.23)	5.77 (4.72)	5.86 (5.16)
Spring PK			
Treatment	15.90 (6.78)	14.51 (13.68)	13.68 (5.89)
Control	13.28 (7.39)	12.25 (6.81)	10.90 (6.60)

Study 1: Conclusions

- A language-related gap in math knowledge is already present at the beginning of pre-k
- Both DLL-EP and DLL-LEP children benefitted from the math intervention
- DLLs who were English proficient by the end of pre-k performed similarly on math to MLLs at the end of pre-k
- DLL-LEP treatment children performed similarly to MLL control children at the end of pre-k

Study 2: The effects of a two-year, preschool math intervention on developing math knowledge

Since the language gap already exists at the start of pre-k, examination of even younger children is warranted

- Many children attend preschool for two years
- Math intervention in Study 1 was implemented during the pre-k year only
- Purpose of Study 2 was to examine relations between language and math over two years of preschool—the pre-pre-k year (3-year-olds) and the pre-kindergarten year (4-year-olds)

Study 2: Design

- 42 classrooms were randomly assigned to one of two conditions
  - Treatment: Two-year pre-k math intervention
  - Control: Business-as-usual
- Children remained in the same classroom over both years of preschool
- Teachers in treatment classrooms received professional development via workshops and biweekly coaching to implement tier 1 math curriculum over both years
  - Year 1: *Pre-Pre-K Mathematics*
  - Year 2: *Pre-K Mathematics*
- Children's math knowledge was assessed in the fall and spring of each preschool year (measures and procedures the same as Study 1)

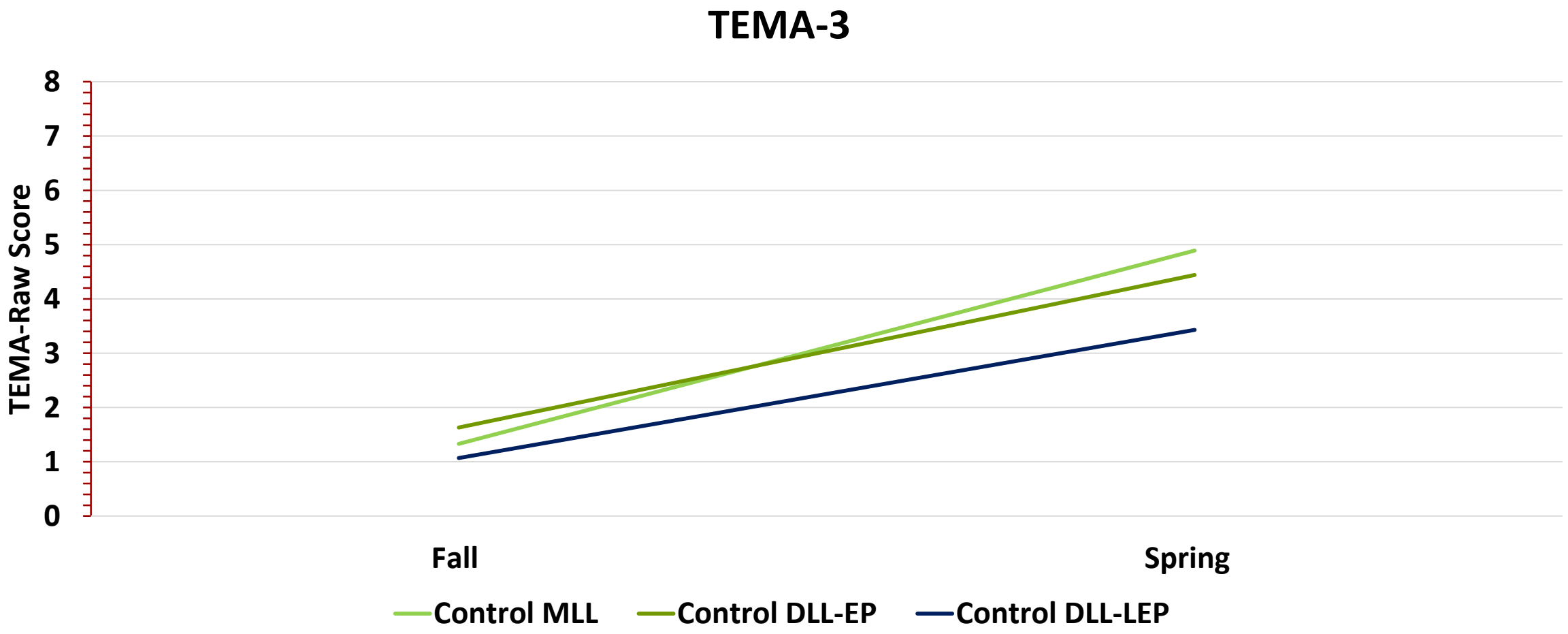
Study 2: Participants

TOT Sample (N)	Age @ Pretest	Gender (% female)	Latino	DLL	DLL-EP	DLL-LEP
Two-Year Intervention						
144	3.35	56%	60%	65%	35%	30%
Control						
117	3.41	51%	73%	72%	26%	46%
Total						
261	3.38	54%	66%	68%	31%	37%

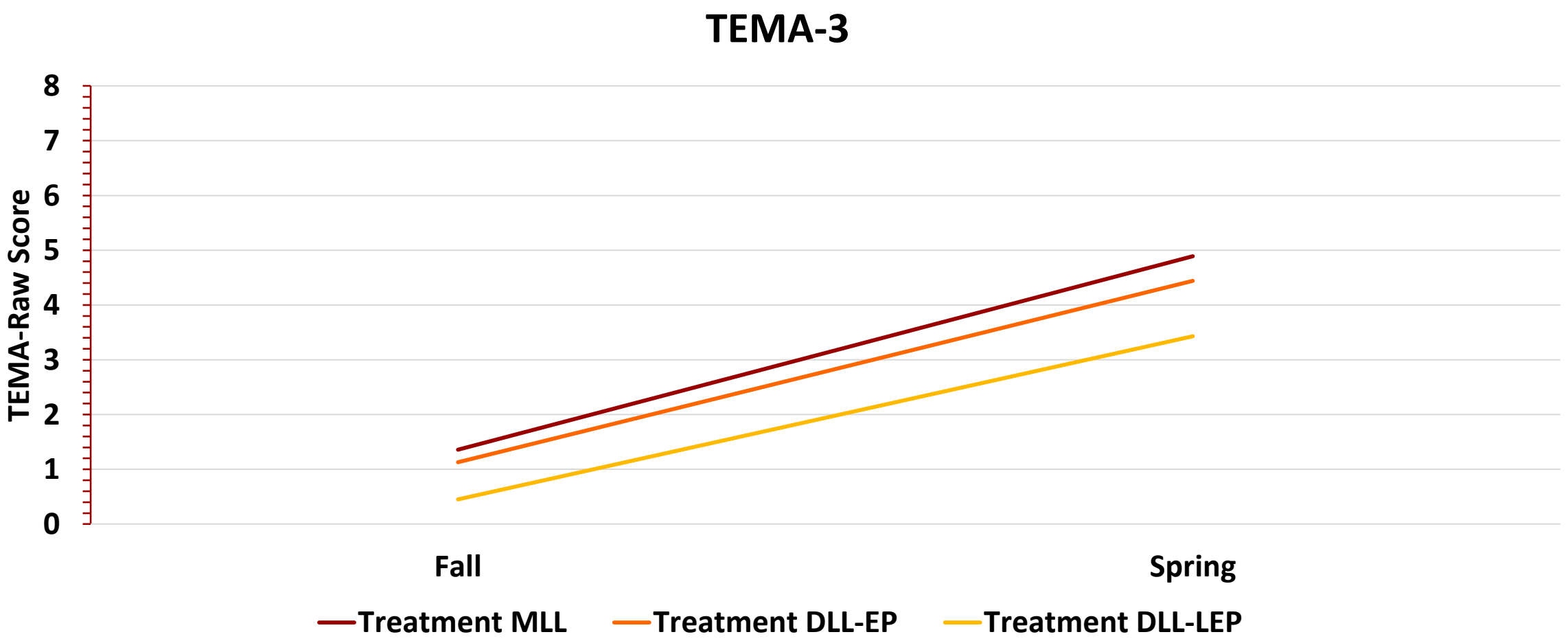
Study 2: Research Questions

1. Under current (BAU) conditions, does informal math knowledge differ among (1) MLLs, (2) DLL-EPs, and (3) DLL-LEPs in the pre-pre-k year?
2. If so, to what extent does participation in an early math intervention impact these differences?

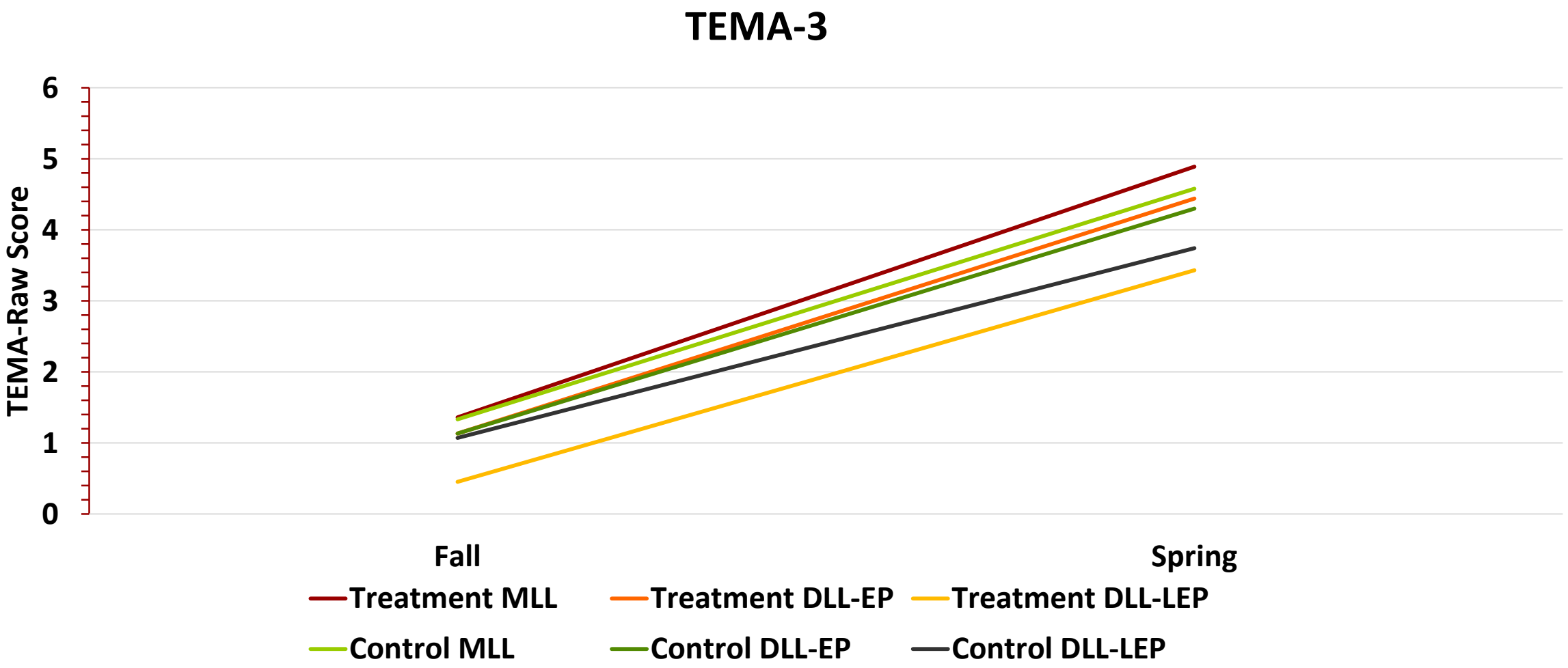
BAU Control Condition, TEMA-3



Treatment Condition, TEMA-3



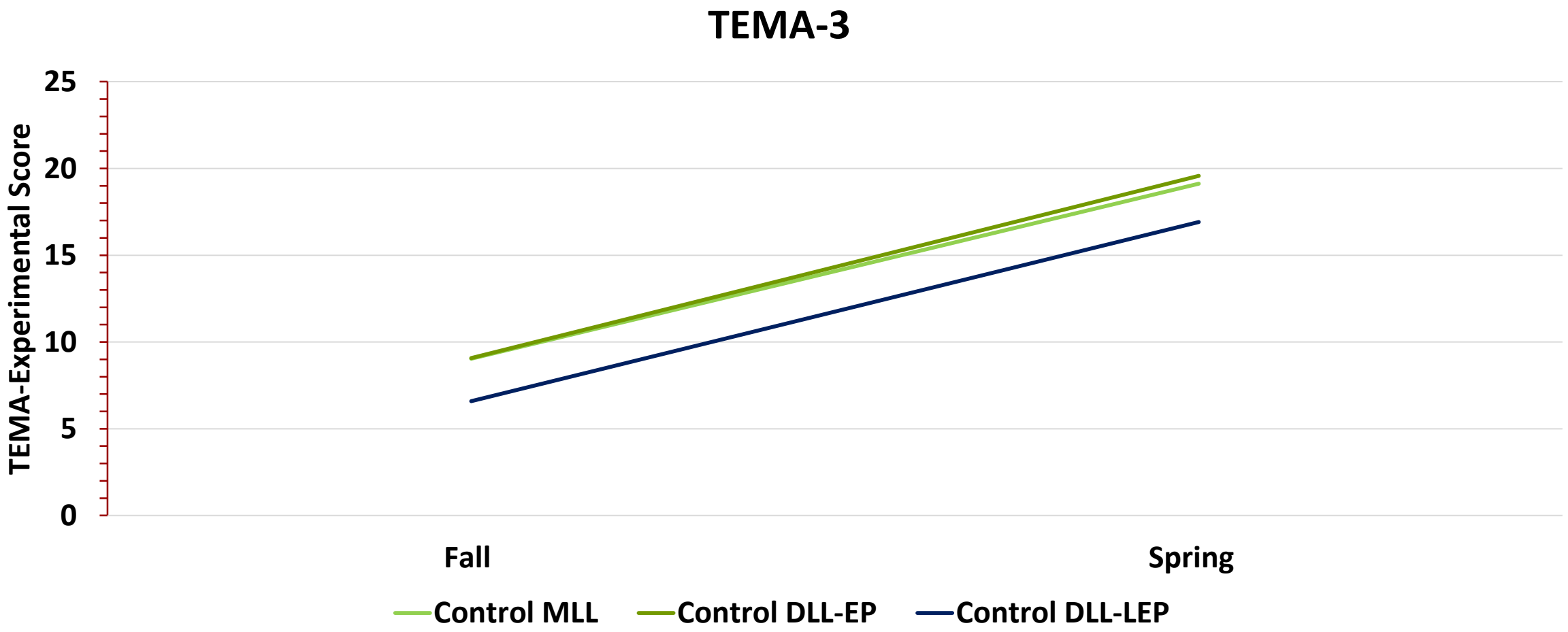
Treatment vs. Control by Level of English Proficiency, TEMA-3



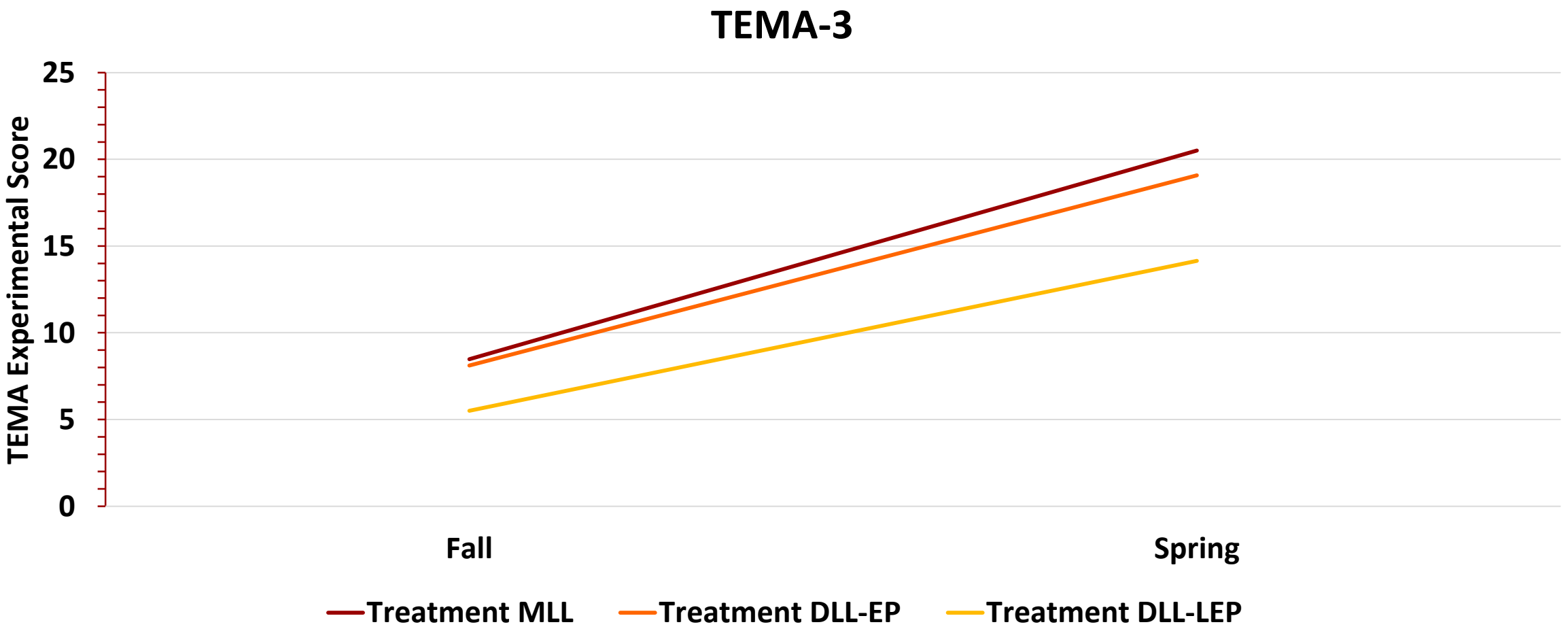
TEMA Scores from Preschool Entry through End of Pre-K

	MLL M (SD)	DLL-EP M (SD)	DLL-LEP M (SD)
Fall PPK (Year 1)			
Treatment	1.36 (2.24)	1.13 (1.69)	.45 (.96)
Control	1.33 (1.61)	1.63 (2.41)	1.07 (1.64)
Spring PK (Year 2)			
Treatment	15.90 (6.78)	14.51 (6.45)	13.68 (5.89)
Control	13.28 (7.39)	12.25 (6.81)	10.90 (6.60)

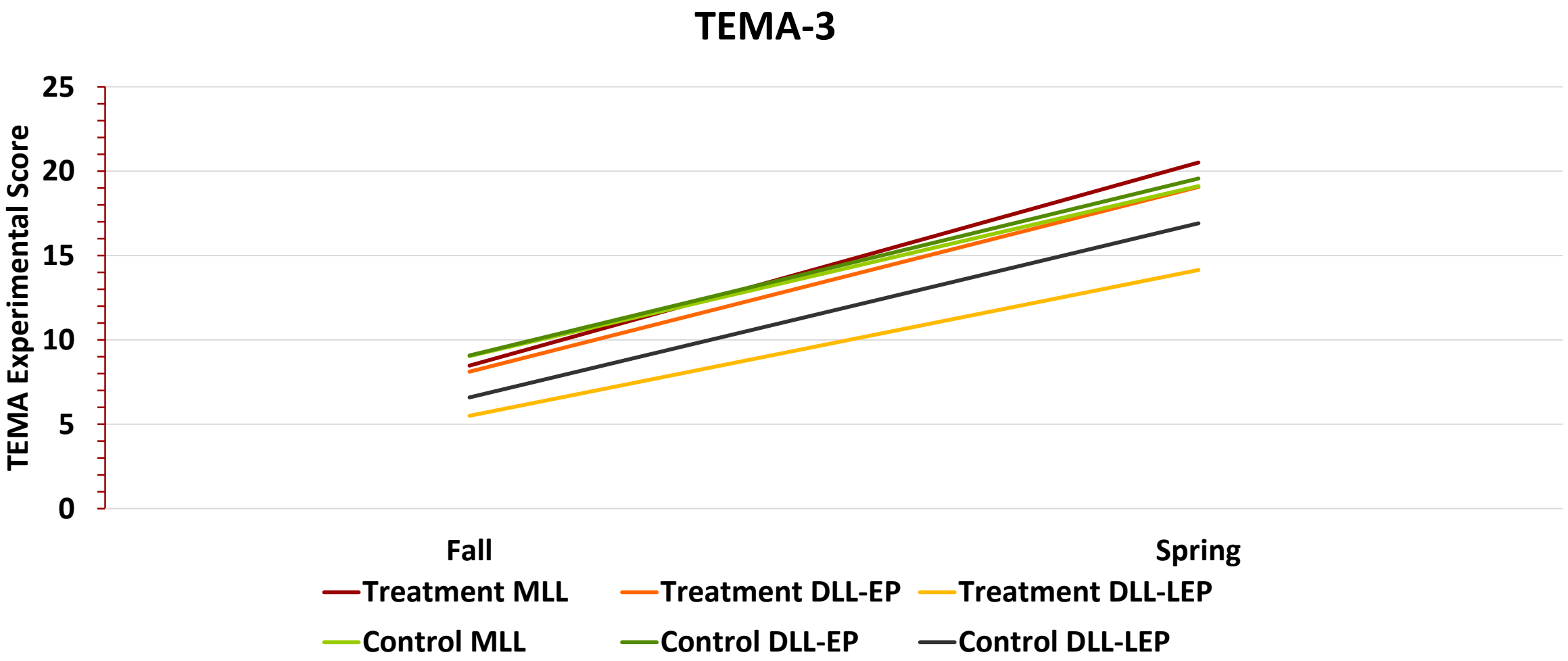
BAU Control Condition, TEMA-3 Experimental Scoring



Treatment Condition, TEMA-3 Experimental Scoring

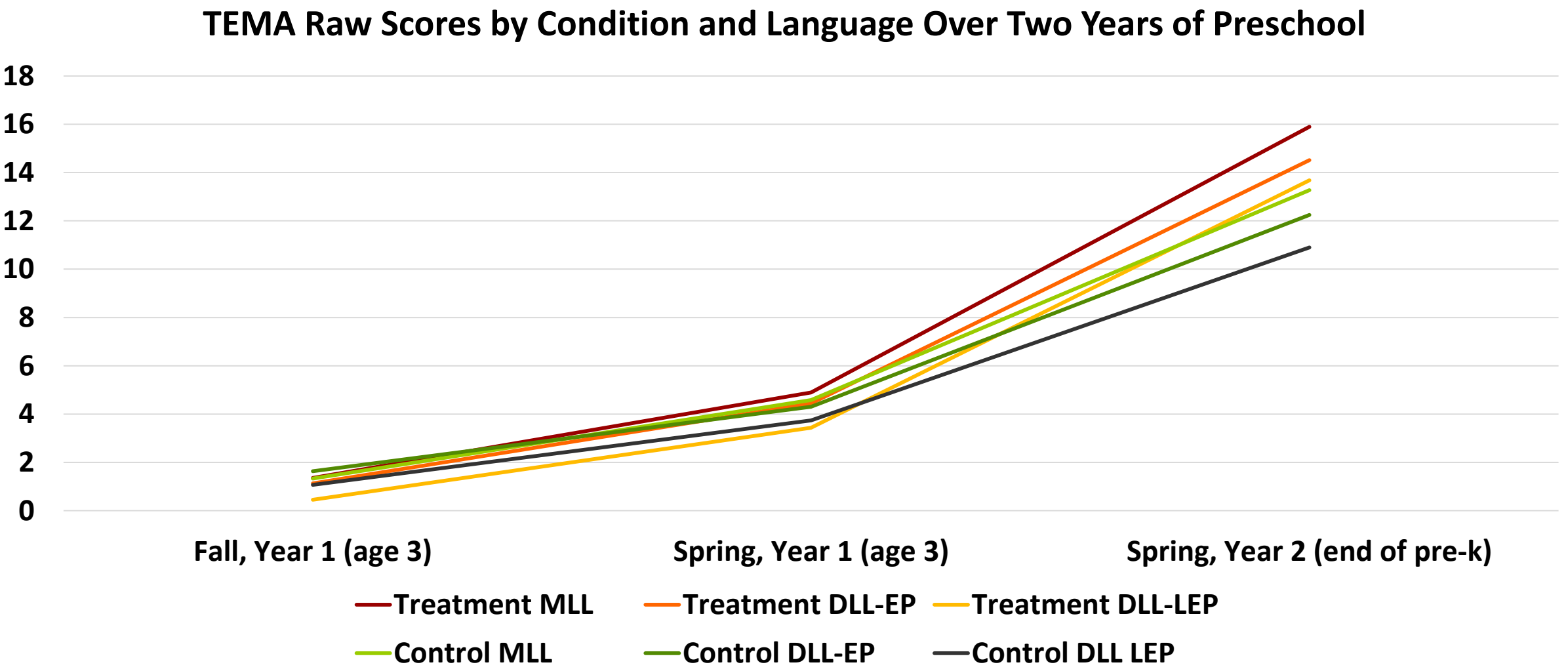


Treatment vs. Control by Level of English Proficiency, TEMA-3 Experimental Scoring



Study 2: Research Question #3

3. To what extent does informal mathematical knowledge differ by condition and language status over two years of preschool?


TEMA Raw Scores by Condition and Language Over Two Years of Preschool
18
16
14
12
10
8
6
4
2
0
Fall, Year 1 (age 3)
Spring, Year 1 (age 3)
Spring, Year 2 (end of pre-k)
Treatment MLL
Treatment DLL-EP
Treatment DLL-LEP
Control MLL
Control DLL-EP
Control DLL LEP

Study 1 & 2 Conclusions

- The SES gap in early math knowledge is more nuanced than previously thought: Children who differ in their dual language proficiency also differ in early math knowledge
- Even in preschool, MLLs and DLLs who will be English proficient by kindergarten appear to develop math knowledge at similar rates;
- DLLs benefit from effective math curriculum; however, children who are slower to develop English proficiency (DLL-LEP) may be in need of more intensive intervention (e.g. dual math and language intervention)
- Research is needed to better understand the relationship between English proficiency and the development of mathematical knowledge

The Pre-K Mathematics Intervention

Pre-K Mathematics: Overview

- The *Pre-K Mathematics* curriculum provides support for children's mathematical development in their preschool classrooms and at home
- It is designed to foster a broad foundation of informal mathematical knowledge
- We have developed and evaluated this math curriculum in different types of preschools serving children from diverse socioeconomic backgrounds

Components of the *Pre-K Mathematics* Intervention

- Classroom component
  - *Pre-K Mathematics* curriculum
  - Math learning center
- Home component
  - *Pre-K Mathematics* home activities
- Professional development component
  - Workshops and on-site coaching for teachers

The *Pre-K Mathematics* Curriculum

Units of the curriculum:

- Unit 1 - Number Sense and Enumeration
- Unit 2 - Arithmetic Reasoning (Fall)
- Unit 3 – Spatial Sense and Geometric Reasoning
- Unit 4 – Pattern Sense and Pattern Construction
- Unit 5 – Arithmetic Reasoning (Spring)
- Unit 6 – Measurement and Data Representation

The *Pre-K Mathematics* Curriculum

- Each unit contains multiple small-group activities with concrete materials for teachers to use in their classrooms
- Activities are introduced at a rate of approximately one per week, in accordance with a prescribed curriculum plan
- Each unit includes home activities for parents to use with their children. Home activities are explicitly linked to small-group activities in the classroom. Instructions for home activities are provided as illustrations with minimal text (in English and Spanish) to reduce literacy demands on parents
- Teachers are encouraged to keep records of individual children's progress in mastering the small-group activities; review weeks are built in to the curriculum plan for teachers to revisit activities not mastered by individual children

Developmental Approach of the Curriculum

- Activities are designed to be sensitive to the developmental needs of individual children
- Classroom activities include downward extensions for children who have difficulty with the main activity, and upward extension for those who complete the main activity easily.
- Scaffolding, or extra support, is suggested for children who experience difficulty with a part of the activity

Pre-Pre-K Mathematics

- Similar to Pre-K Mathematics, but developed for three-year-olds (e.g., focus on simpler foundational concepts, fewer activities with increased dosage)
- Includes classroom, home, and professional development components
  - Classroom component
    - *Pre-Pre-K Mathematics* curriculum
    - Math learning center
  - Home component
    - *Pre-Pre-K Mathematics* home activities
  - Professional development component
    - Workshops and on-site coaching for teachers

Q & A

Our Questions to You

- Which features of the curricular interventions promoted math gains among DLLs?
- What are the implications for classrooms/teachers not participating in a targeted math intervention?
- Why might DLL-LEP children have less math knowledge than DLL-EP children?
- Should DLL children be dichotomized into two categories (EP vs. LEP), or is there an argument for placing them on a continuum?