Early Math Skills: Their importance and individual differences

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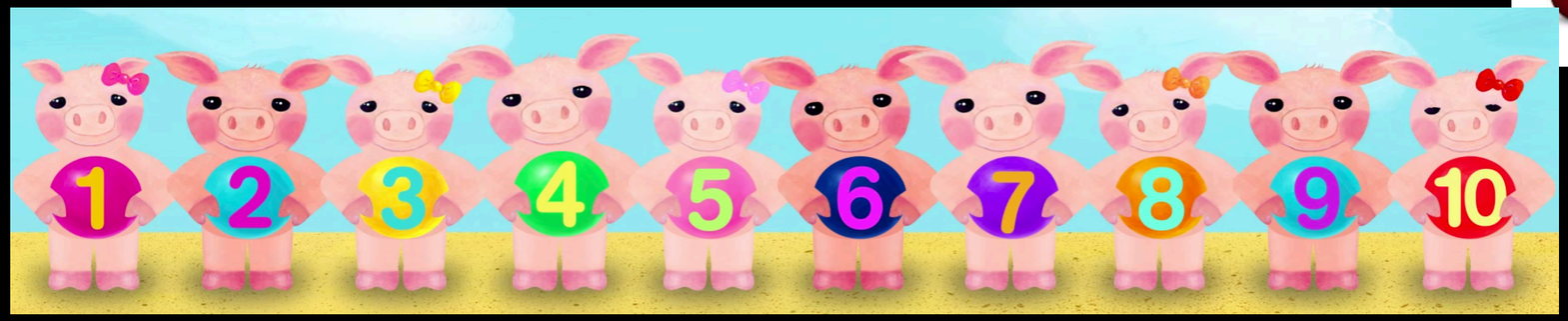
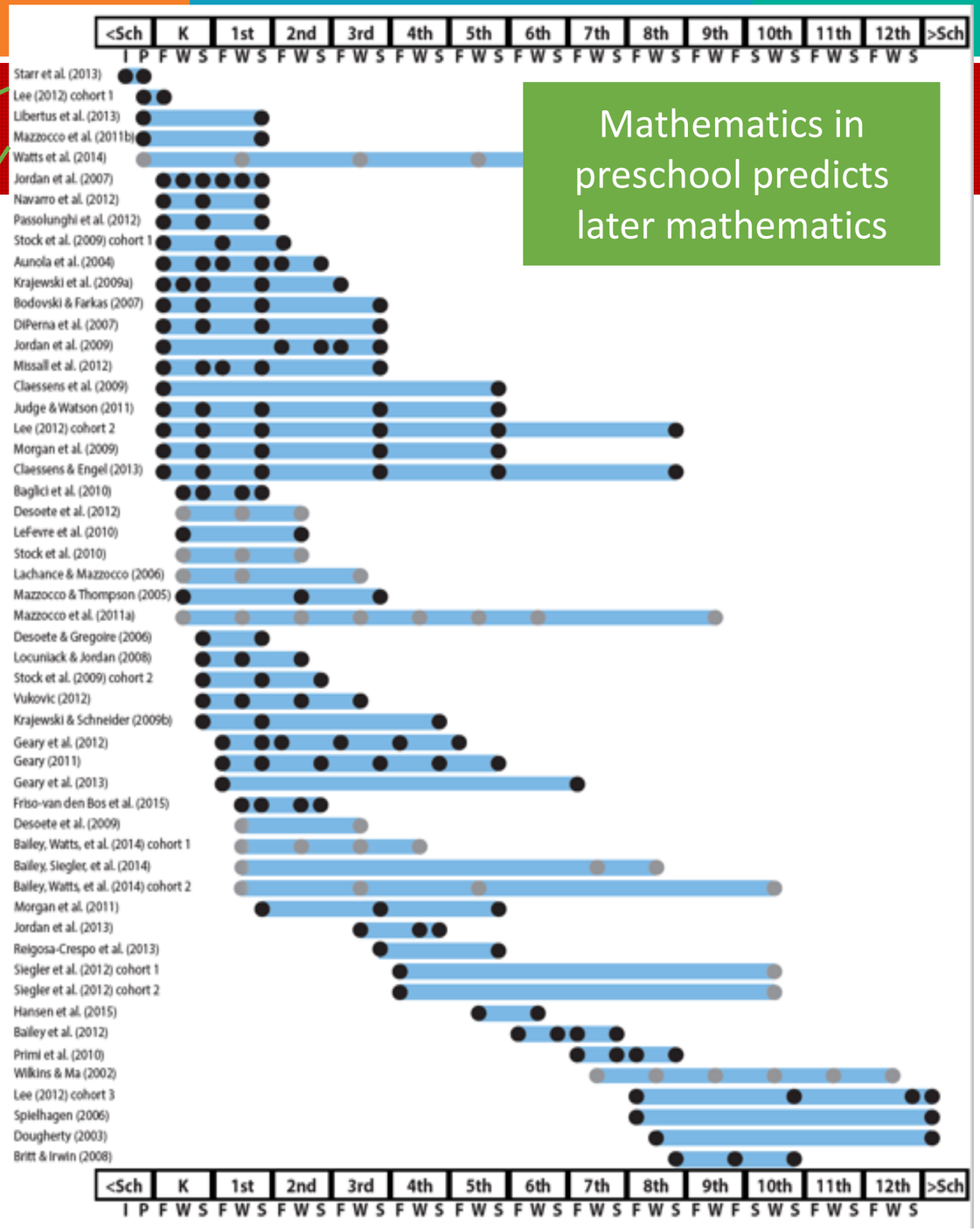


Broad math in preK predicted K broad math

Broad math in preK predicted grade 10 broad math



Mathematics in preschool predicts later mathematics

http://www.greatertexasfoundation.org/trajectories-of-mathematics-performance/

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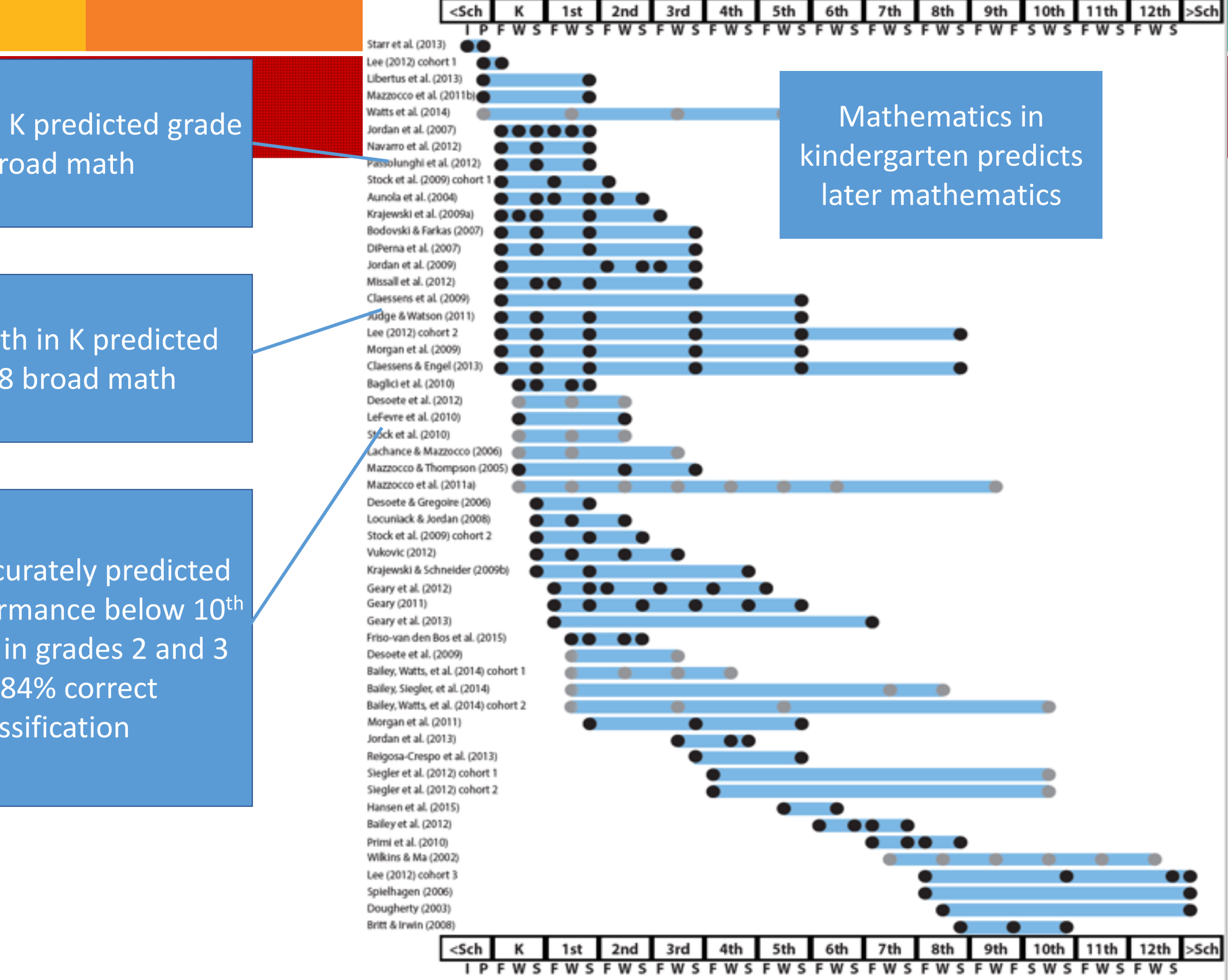
Counting in K predicted grade 1 broad math

Broad math in K predicted grade 8 broad math

K math accurately predicted math performance below 10th percentile in grades 2 and 3 with 84% correct classification



Mathematics in kindergarten predicts later mathematics

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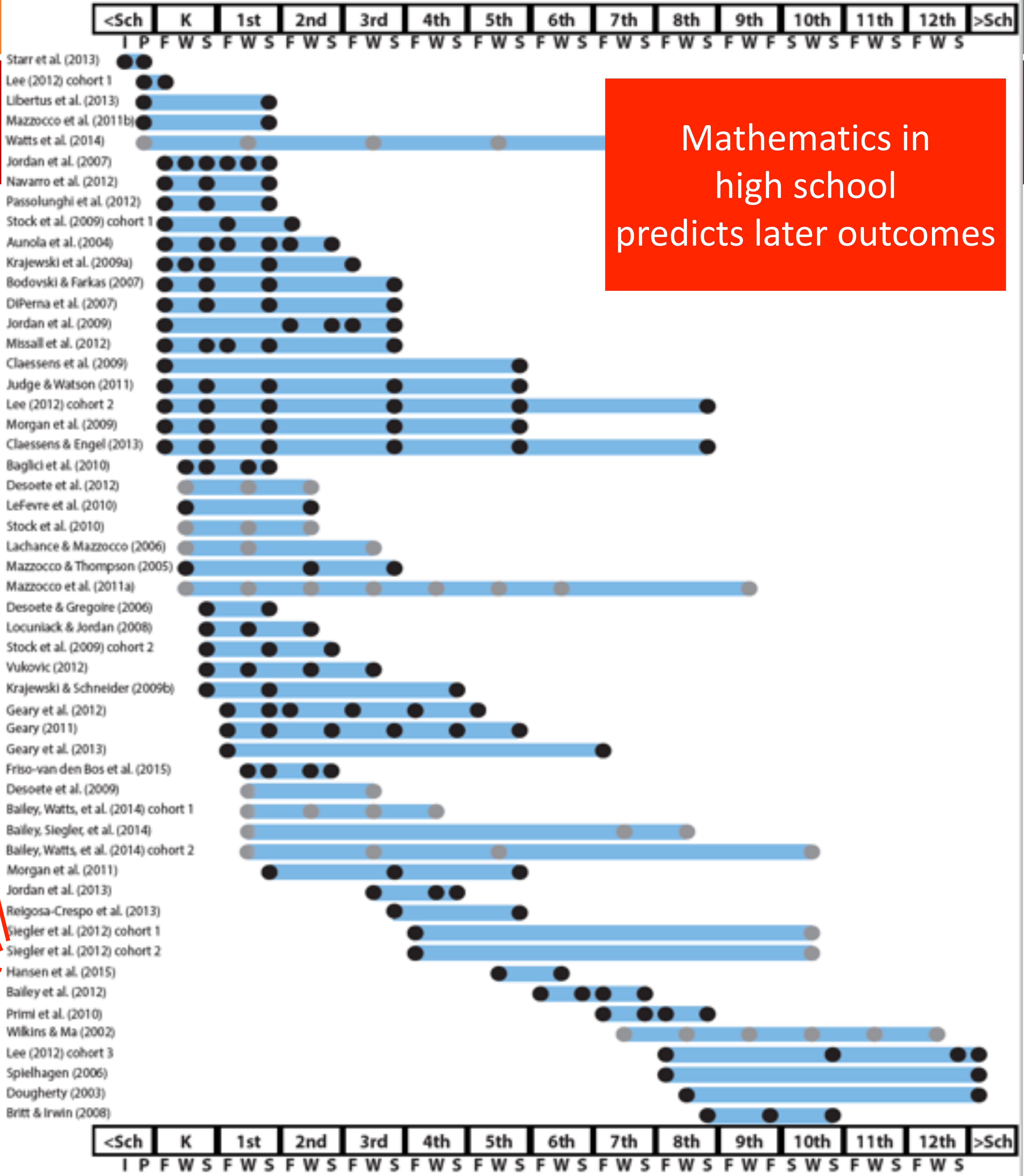
Broad math in grade 8 predicted completion of 4-year college degree

Students who took algebra in grades 8 took more advanced math courses and enrolled in 4-year colleges more often than students who took algebra in grade 9

Numeracy measured in adolescence impacted hourly earnings 7 to 15 years later



Mathematics in high school predicts later outcomes

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Mathematics in preschool predicts later mathematics

Mathematics in kindergarten predicts later mathematics

Mathematics in elementary school predicts later mathematics

Mathematics in middle school predicts later mathematics

Mathematics in high school predicts later outcomes

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Early Math Matters!

- Two related studies:
  - Study one – Cross-cultural study examining informal and formal math skills in U.S. and Shanghai
  - Study two – Exploring longitudinal growth in informal and formal math skills among at-risk children compared to their peers
- Discussions and Q&A

High Expectations for Kindergarten Readiness in Math

Visually identify randomly presented numbers from 1 to 20

Rote count from 1 to 20

Counts out the number of objects (1 to 5)

Write numbers in order from 1 to 20

Copies and extends repeating pattern

Identifies at least 4 basic shapes

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Avenues for Learning: Informal and Formal Math

Ginzburg and Baroody (2003) description

Informal learning: "Children seem to acquire …(math) concepts and skills" through "spontaneous interactions with their environment …observations and reflections on…everyday activities,...imitation of adults...watching programs such as Sesame Street, informal play or conversations."

Formal learning: "...entails explicit understanding; student should be able to explain/justify the answer"

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Informal and Formal Math Concepts

Informal Math Concepts –

Numbering --*"How many cats do you see?"*

Number Comparison --*"Which side has more?"*

Calculations --*"How many does he have altogether?"*

Concepts --*"How many stars did you count?"*

Formal Math Concepts –

Numeral Literacy --*"What number is this?"*

Number Facts --*"How much is two take away one?"*

Calculation --*"How many points does he have altogether?"*

Concepts --*"Which number sentences here are correct for this word problem?"*

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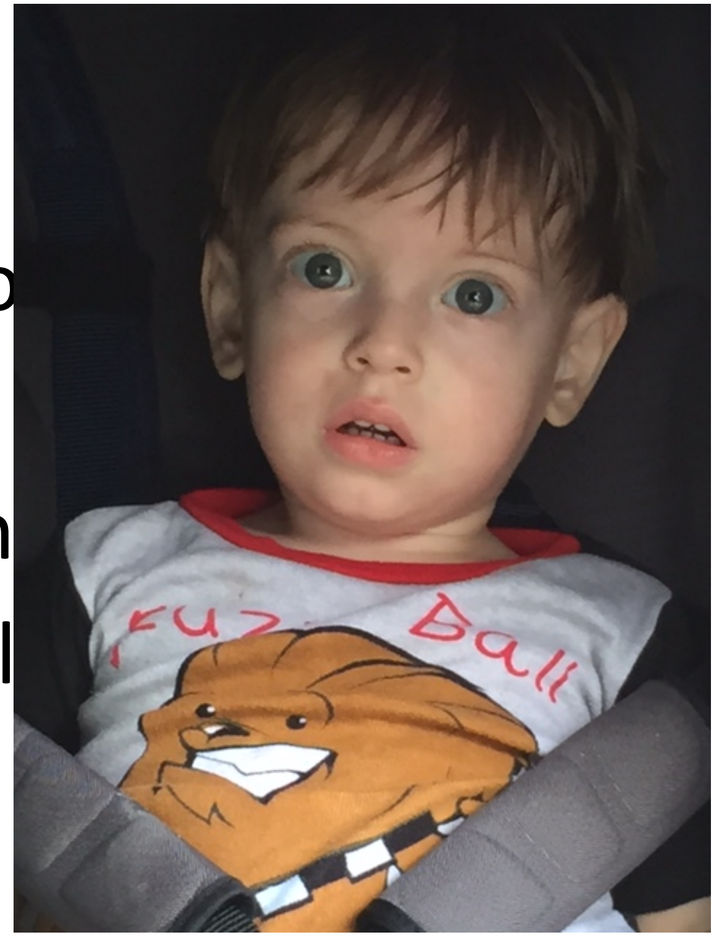
Push Back About Kindergarten Entry Math Skills

- Are the expectations realistic?
- Do typical math activities at home – like rote co

help children understand quantity?

- Do home and school activities include writing n
- Is it developmentally appropriate for young chil

be able to create patterns?



What color comes next?

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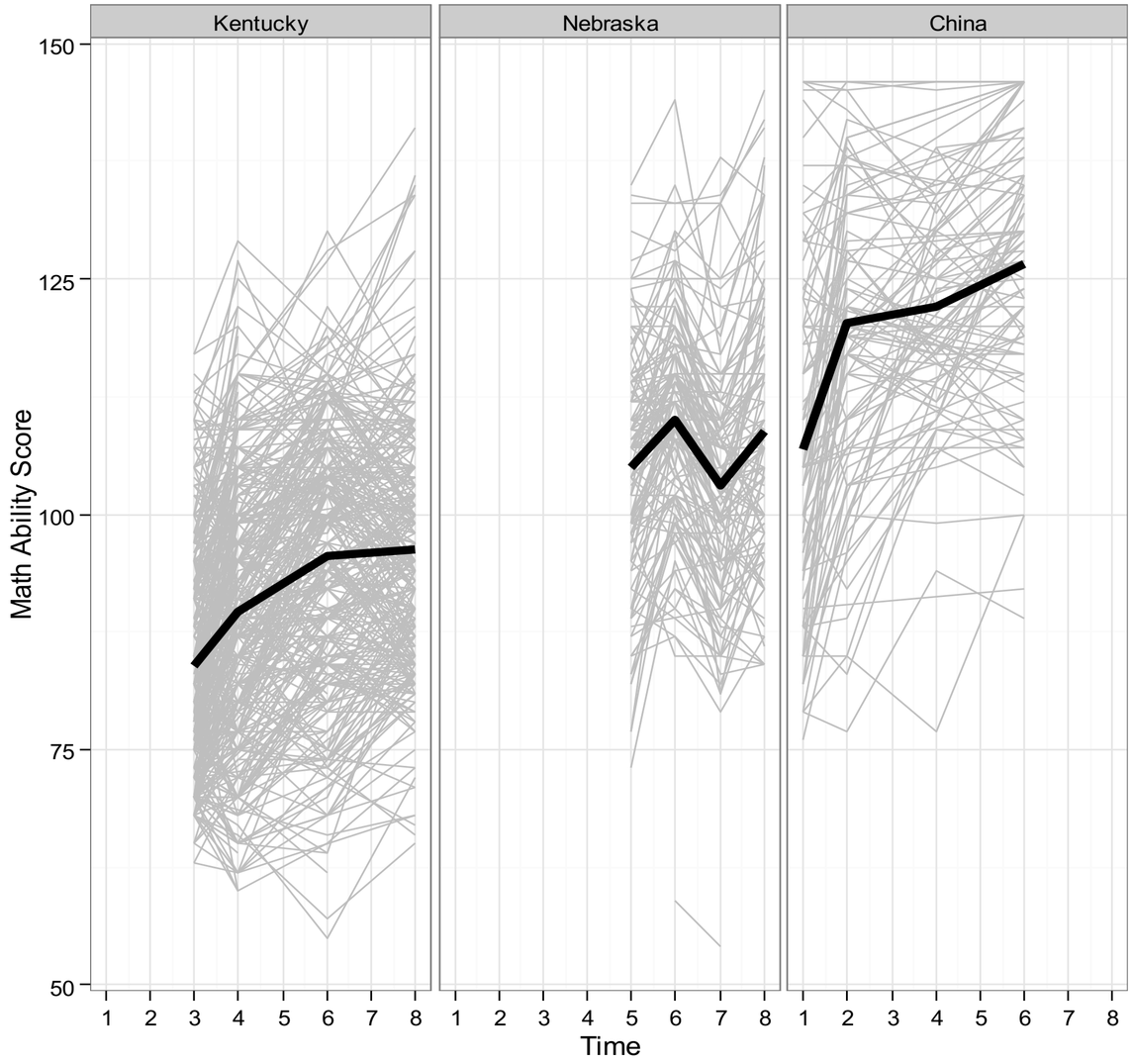
Kentucky, Nebraska and Shanghai (China) -TEMA Scores of Pre-K, K and 1st grade Children



Pre-K3 Fall	Pre-K3 Spring	Pre-K4 Fall	Pre-K4 Spring	K Fall	K Spring	1st Fall	1st Spring
Time1	Time2	Time3	Time4	Time5	Time6	Time7	Time8

Kentucky Range: fall PreK 4 – spring 1st grade
Nebraska Range: fall K – spring 1st grade
Shanghai Range: fall PreK3 – Spring K

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Take Away

- *Are the expectations realistic?*
  - Probably if the math activities at home and at school are age and skill-level appropriate for children
- *Do typical math activities at home help children understand math*?
  - Yes when a variety of math concepts are included beyond rote counting
- *Do home and school activities include writing numbers*?
  - Experiences in writing numbers help with identification and differentiation
- *Is it developmentally appropriate for young children to be able to create patterns?*
  - Playing games involving creating and describing patterns is helpful

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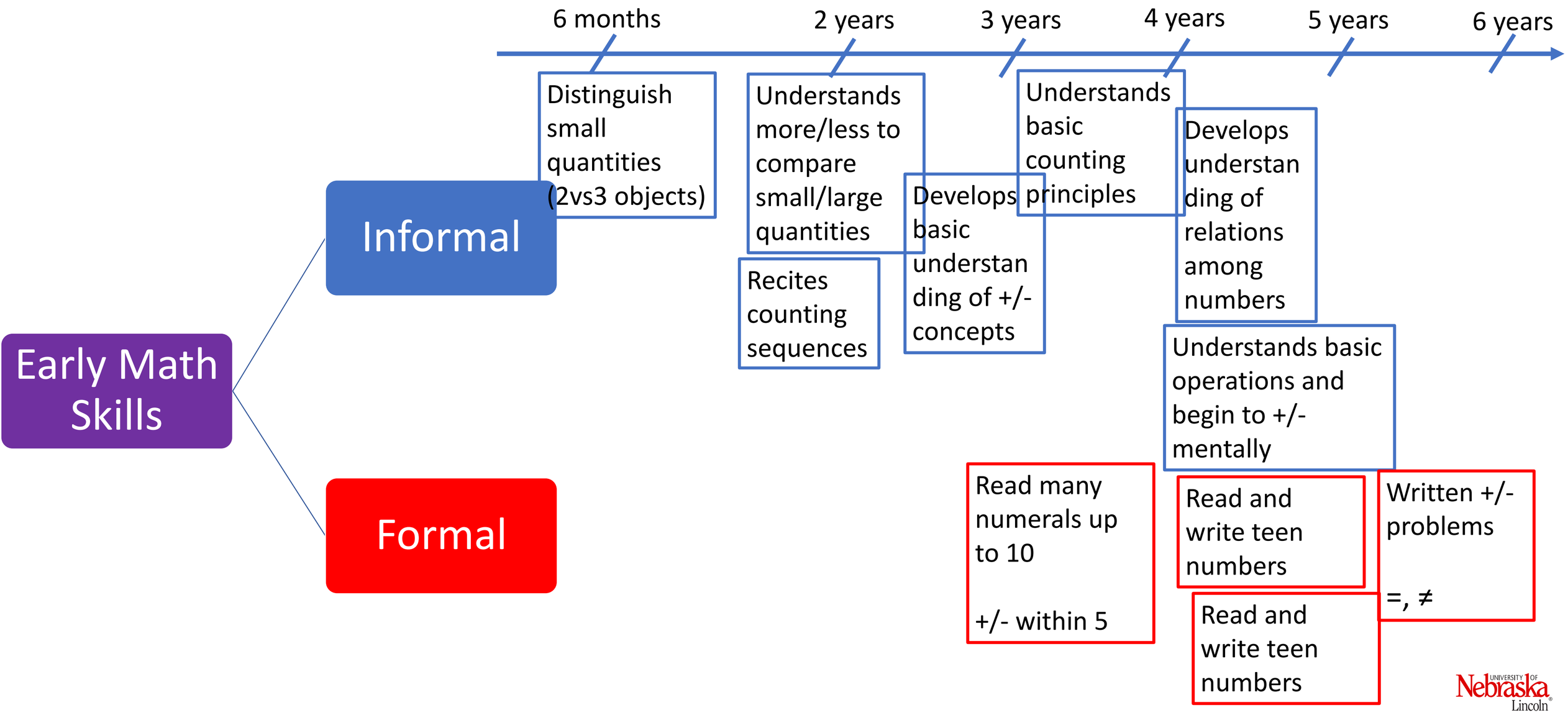
Exploring Growth Trajectories



Exploring Growth Trajectories

- Early math skills predict later reading and math achievement
- Achievement gap in math develops early and continues to widen
- Children with math learning difficulties (LD) show early difficulties in various math skills: comparing quantities, understanding counting principles, subitizing, understanding numerical magnitudes, etc.

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Young Children Struggling with Math

Cognitive Difficulties

- Memory
- Attention
- Processing Speed
- Coordination

Cognitive Difficulties

Low SES

Genetic / Neurological Factors

Lack of Exposure

- Home
- Daycare
- Secondary Caregivers

Difficulties in Processing and Representing Numbers

Quantitative Processing

- Representing and processing symbolic & non-symbolic quantities

Math Learning Difficulties

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Exploring Growth Trajectories

- Mixed findings:
  - Only few studies have looked at informal and formal math skills separately
  - Primary focus has been on school-age children

- Focus: How informal and formal math skills develop in children with math learning difficulties (MD)

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Participants

- 281 Children attending state funded and Head Start preschool programs

- Assessed on TEMA-3 at the end of pre-k, kindergarten, and 1st grade
  - 40 items that assess informal math skills (e.g., counting on fingers, comparing sets of dots)
  - 31 items that assess formal math skills (e.g., reading & writing numbers, single-digit addition, subtraction)

- MD status:
  - Below 10th percentile on TEMA-3 at the end of pre-k
  - MD: 76 children
  - TD Peers: 205 children

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Participants

Table 1. Student Demographics and Raw Scores by MD Status

	TYP (n = 205)		MD (n = 76)	
Variable	*n*	*Percent*	*n*	*Percent*
Females	121	59.0	28	36.8
Race				
Caucasian	171	85.9	53	72.6
African American	12	6.0	12	16.4
Hispanic	9	4.5	3	4.1
Other	7	3.5	5	6.8
	M	*SD*	*M*	*SD*
Age (months)				
Time 1	60.26	3.78	60.93	3.42
Time 2	69.99	3.70	70.73	3.28
Time 3	84.29	3.75	85.13	3.35
Informal Knowledge				
Time 1	14.55	4.86	6.22	2.92
Time 2	24.08	5.91	15.19	6.05
Time 3	33.29	3.02	27.55	5.72
Formal Knowledge				
Time 1	2.16	1.41	.21	.50
Time 2	5.04	2.08	2.63	1.64
Time 3	11.40	5.24	6.21	2.31

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Data Analysis

- Initial Analysis:
  - Children with MD had significantly lower informal and formal math scores at all assessment points
  - Male children were more likely to be identified as having MD
- Growth Modeling:
  - No significant intraclass correlations (very little classroom level variance)
  - Children's age at each time as a proxy for time to accurately present intervals between assessments

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Data Analysis

- Growth Modeling:
  - Average level of informal and formal math skills (intercept)
  - Average growth rate over time (slope)
  - Average rate of acceleration of growth over time (quadratic slope)
  - Covariates: MD status and gender

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Results

- Children with MD had significantly lower informal and formal math skills compared to their TD peers

- Informal math skills:
  - Children with MD grew and accelerated at a significantly faster rate their TD peers
  - No gender differences

- Formal math skills:
  - TD children grew and accelerated at a significantly faster rate than children with MD
  - Male children grew and accelerated at a significantly faster rate than female children

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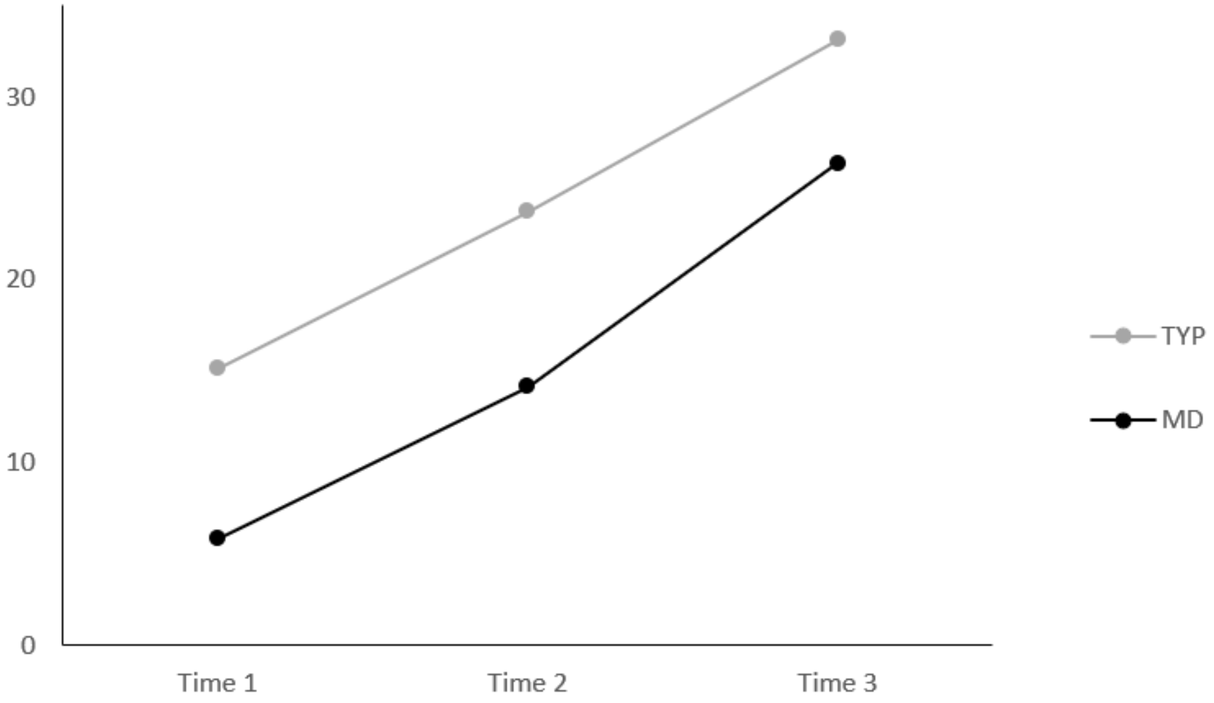
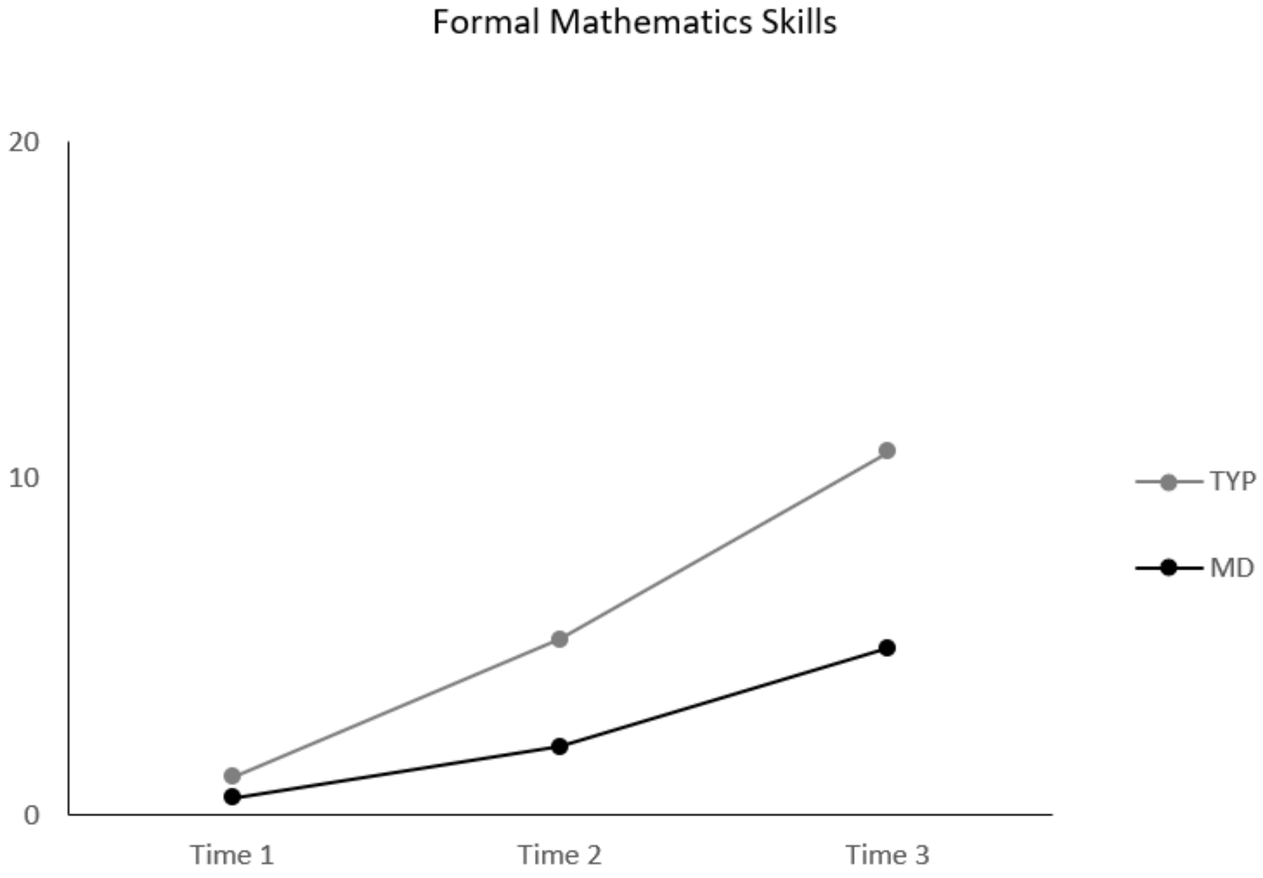
Growth Trajectories





Take Away

- Do children as early as preschool show difficulties with both informal and formal math skills?
  - Yes, but they will catch up to their TD peers in informal skills whereas the achievement gap widens for formal skills
  - Informal math skills may not accurately discriminate children with MD at older ages whereas formal math skills continues to build a stronger link
- Are both informal and formal math skills important precursors of MD in early childhood?
  - Yes
  - Home and other care environments play a critical role in fostering informal math skills
    - Parents/teachers focus more on supporting literacy activities and socio-emotional skills
    - Parents/teachers do not feel confident in teaching math
- How can we provide a mathematically stimulating environment?

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Discussions and Q&As

Provided Discussion Questions:

- What information resulted from this investigation? What are the key take-away points?
- How can information from this study inform or advance early childhood practice?
- How can information from this study inform or advance early childhood public policy?
- What additional research is needed to inform or advance early childhood practice and/or policy?
- How can lessons from practice or policy inform this line of research?

Our Question to Focus:

- How can we better support young children’s math development?

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