Arlington Public Schools

EVERY STUDENT COUNTS
EXCELLENCE FOR ALL

APS Strategic Plan
2024-30



Mathematics & The Science of Learning

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Tuesday, March 24, 2026

Presentation Outline



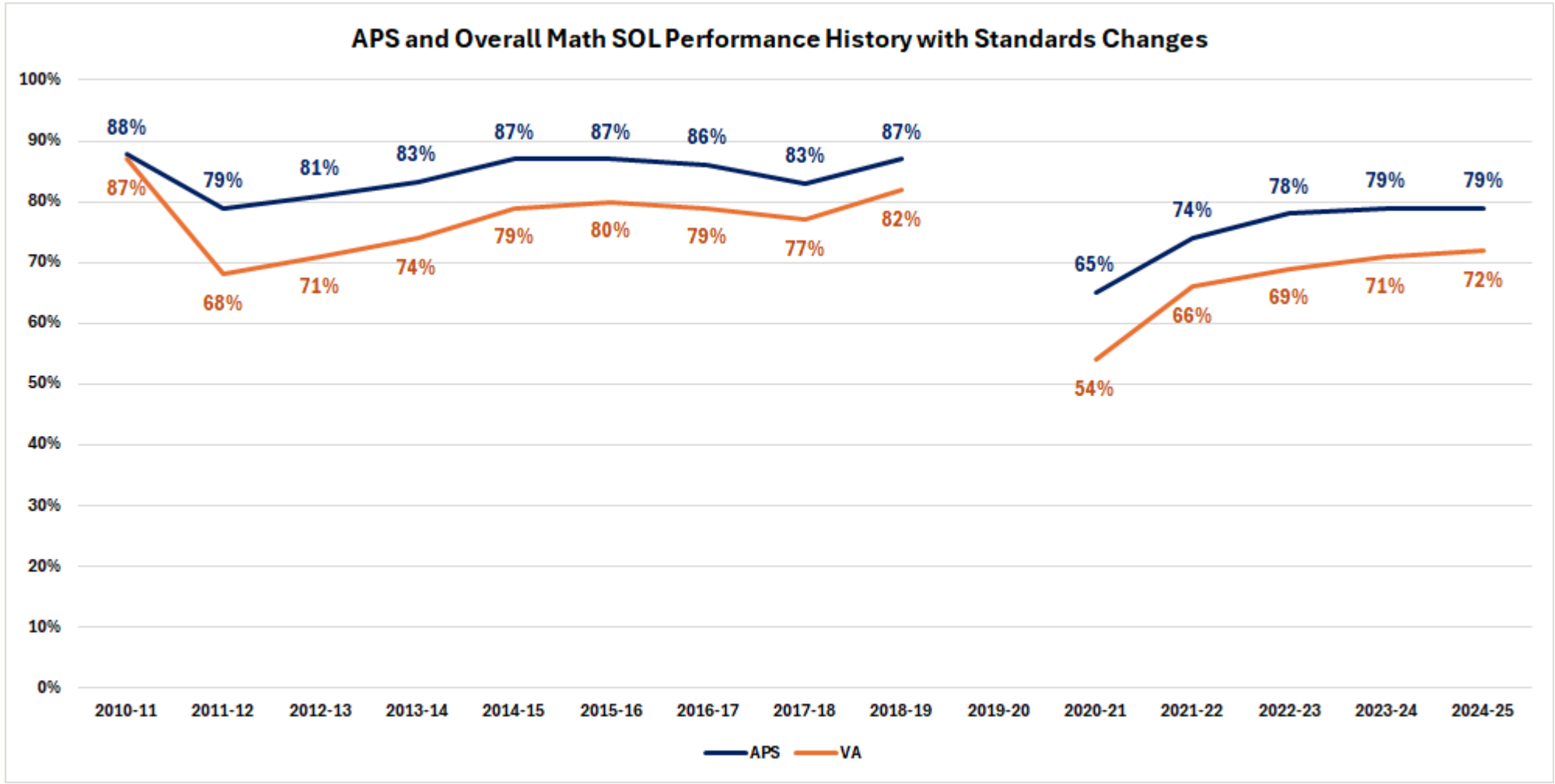
Student Academic Growth and Success

- Data Insight
- Where We Are… At the Moment…
- What is the Science of Learning?
- Partner EAB
- Next Steps

Math SOL Performance When New State Standards were Tested

Student Academic Growth and Success

APS students maintained their performance with the introduction of new VDOE standards, breaking past trends when the new standards were tested.



Where We Are...At The Moment...



Student Academic Growth and Success

Static Math Outcomes

- Math outcomes have been static for three consecutive years, showing current approaches may *be maintaining* achievement but ***not accelerating*** achievement.

Revised Math Standards

- VDOE Standards of Learning for Mathematics demand even higher cognitive rigor and conceptual understanding from students.

Need for Increased Coherence Around Instructional Best-Practices

- Establishing a new vision of mathematics instruction that is grounded in research-based instructional tactics, designed to boost student understanding and learning of concrete and conceptual mathematical ideas.

New Textbook Adoption

- Adopting new math resources gives us an opportunity to enhance instructional quality...under a proper instructional framework.

The Importance of This Moment



Student Academic Growth and Success

Clarity **Coherence** **Rigor**

We have an opportunity to build instructional clarity and division wide coherence to mirror the rigor of mathematics instruction for all our students... and all our adults!

What Is the Science of Learning?



Student Academic Growth and Success

Research-based study on how students acquire, retain, and transfer knowledge.

Integrates finding from cognitive science, psychology, and neuroscience to guide teaching practices that make learning more effective and engaging.

For mathematics, it emphasizes understanding concepts deeply, practicing strategically, and building the thinking skills that enable students to solve problems across contexts.

The Science of Learning and Foundational Mathematics

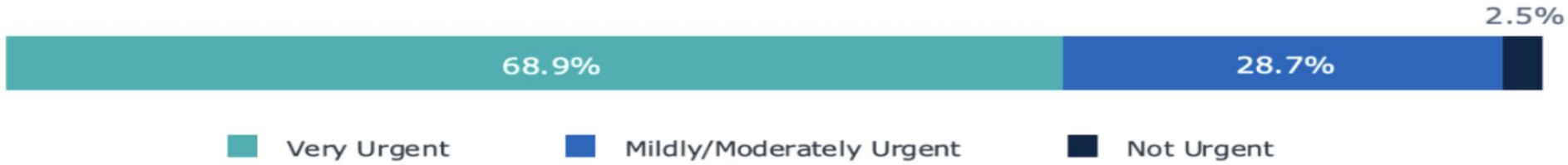


Student Academic Growth and Success

Superintendents Agree: We Need Help with Math

Findings from the 2025 Voice of the Superintendent Survey

How Superintendents rate the urgency of accelerating growth in Math (April 2025)



Percentage of Superintendents who rate accelerating growth in Math as "very urgent," by subgroup

Student Enrollment	
20,000+	**81.8%**
5,000 – 19,999	**69.4%**
1,000 – 4,999	**66.2%**
0 - 999	**75.0%**

Locale (Urban, Suburban, or Rural)	
Urban	**100%**
Suburban	**60.8%**
Rural	**74.3%**

Percentage of students qualifying for Free or Reduced-Price Lunch	
75%+	**100%**
50 – 74%	**82.4%**
25 – 49%	**65.0%**
0 – 24%	**37.9%**

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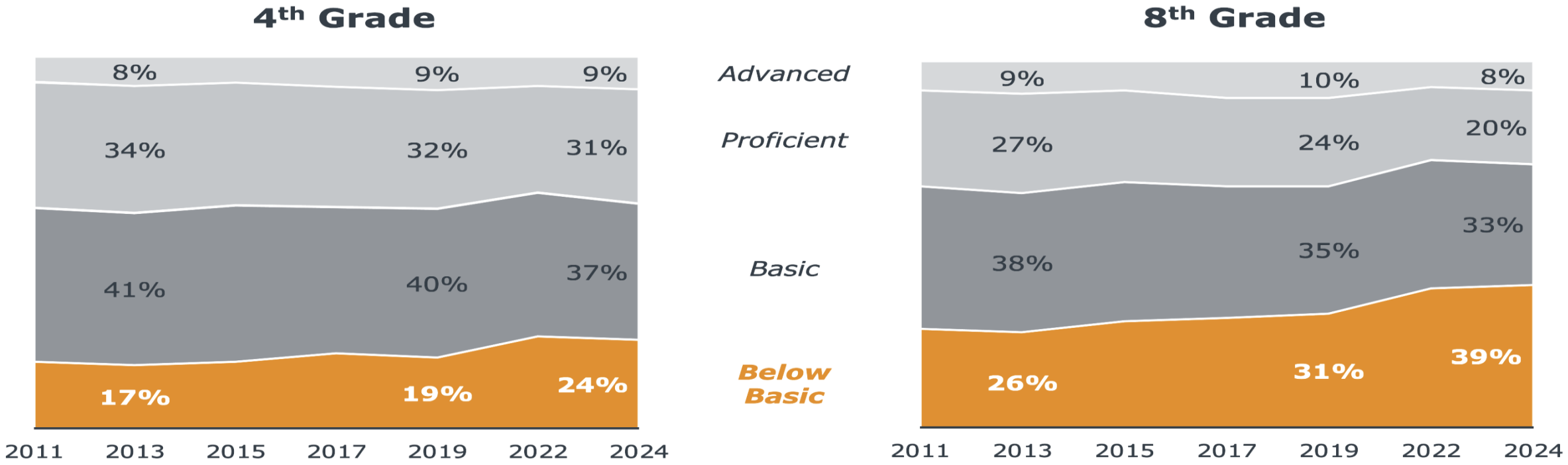
Source: EAB, Voice of the Superintendent Survey, 2025.

Too Many Students Get Stuck "Below Basic"

Trend in NAEP Math Achievement-level Results



Key Insights:

- **Performance peaked in 2013** and has since stagnated or declined for all students.
- **The lowest performers are falling faster each year**. The 10th and 25th percentile of students declined faster than students at the 50th percentile or above.

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Sources: National Center for Education Statistics, NAEP Report Card: Mathematics, 2024; EAB interviews and analysis.

Why Are More Students Struggling in Math?



Pandemic Disruptions?

- Avg. NAEP math score declined 8 points 2019-2024…
- …yet avg. score declined 13 points 2013-2019



Socioeconomic Challenges?

- Low-income NAEP scores fell 12 points 2013-2024…
- …yet higher income scores fell 9 points 2013-2024



Increasing Screen Time?

- Adolescent screen time rose 54% worldwide…
- …yet US still ranks #1 for achievement gap growth



Poor Literacy Skills?

- Reading and math achievement are related…
- …yet early math skills uniquely predict future math success



…Math *Instruction*?

- ~93% of students are capable of learning math without intensive support[1]
- …yet only 61% of students are proficient by 8th grade.

1) Dyscalculia affects 3–7% of individuals across all ages, causing persistent difficulty with arithmetic that significantly impairs calculations.

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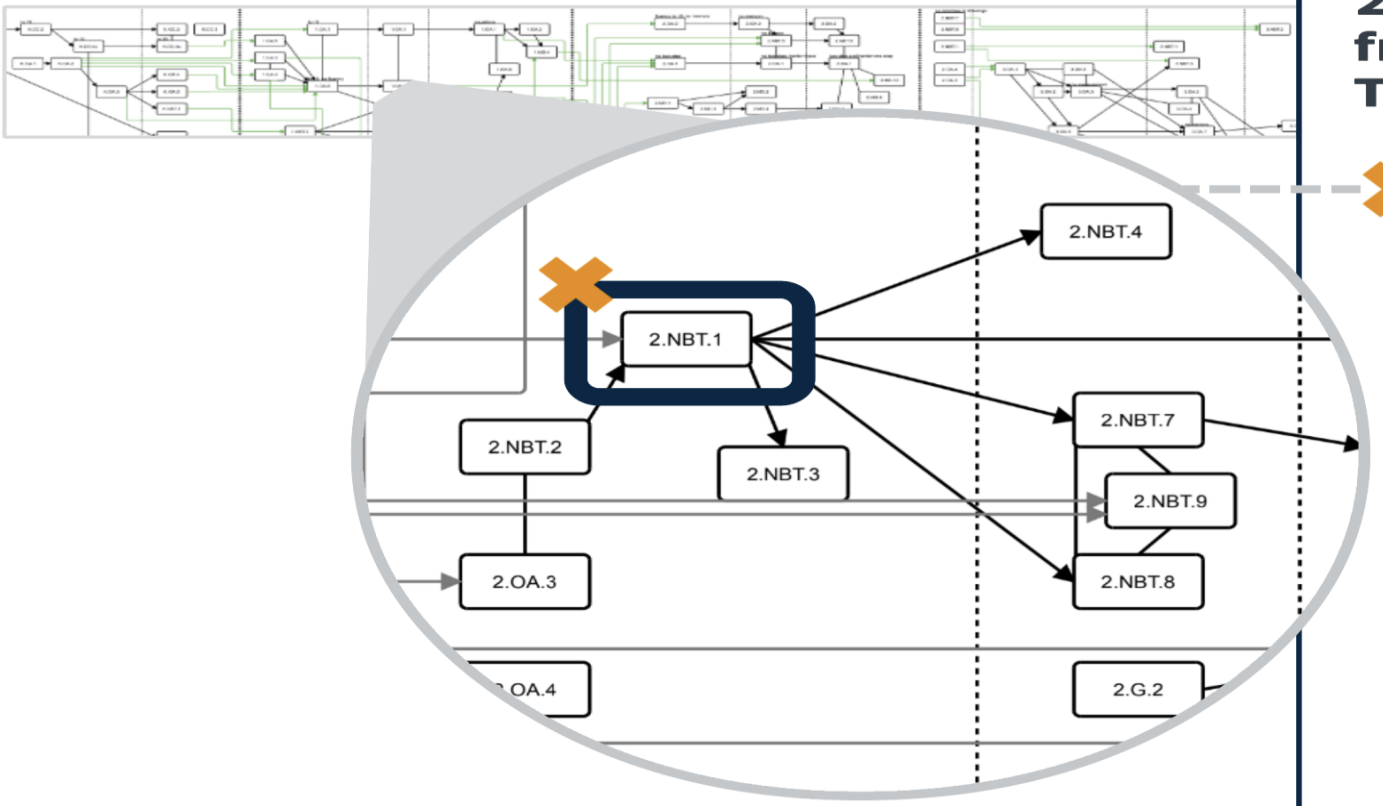
Sources: National Center for Education Statistics, NAEP Report Card: Mathematics – Performance by Student Group, 2024; Madigan, et al., Assessment of Changes in Child and Adolescent Screen Time During the COVID-19 Pandemic, 2022; Malkus, Testing Theories of Why, 2025; EAB interviews and analysis

Skill Gaps Can Multiply Into A Bigger Problem

Math Is Relentlessly Cumulative, So A Weak Foundation Stalls Learning

53+ longitudinal studies show early math skills predict later math skills



Excerpt from Common Core State Standards for Math Coherence Map

Failing to Master One Standard in 2nd Grade Directly Bars a Student from Mastering Eight Others Across Three Grade Levels

2.NBT.1[1] – Understand that the three digits of a three-digit number represent amounts of hundreds, tens, and ones; *e.g., 706 equals 7 hundreds, 0 tens, and 6 ones.*

- Write numbers to 1000 in expanded form
- Add and subtract using concrete models
- Round multi-digit whole numbers
- Multiply multi-digit numbers
- Compare 3-digit numbers
- Mentally add 3-digit numbers
- Mentally subtract 3-digit numbers
- Apply concepts of place value in division

1) **2.NBT.1** refers to Grade 2, Number and Operations in Base Ten, Standard 1 from the Common Core State Standards for Mathematics

Sources: Nelson & Powell, Trajectories of Mathematics Performance: From Preschool to Postsecondary, 2016; Zimba, A Graph of the Content Standards, 2012; EAB interviews and analysis

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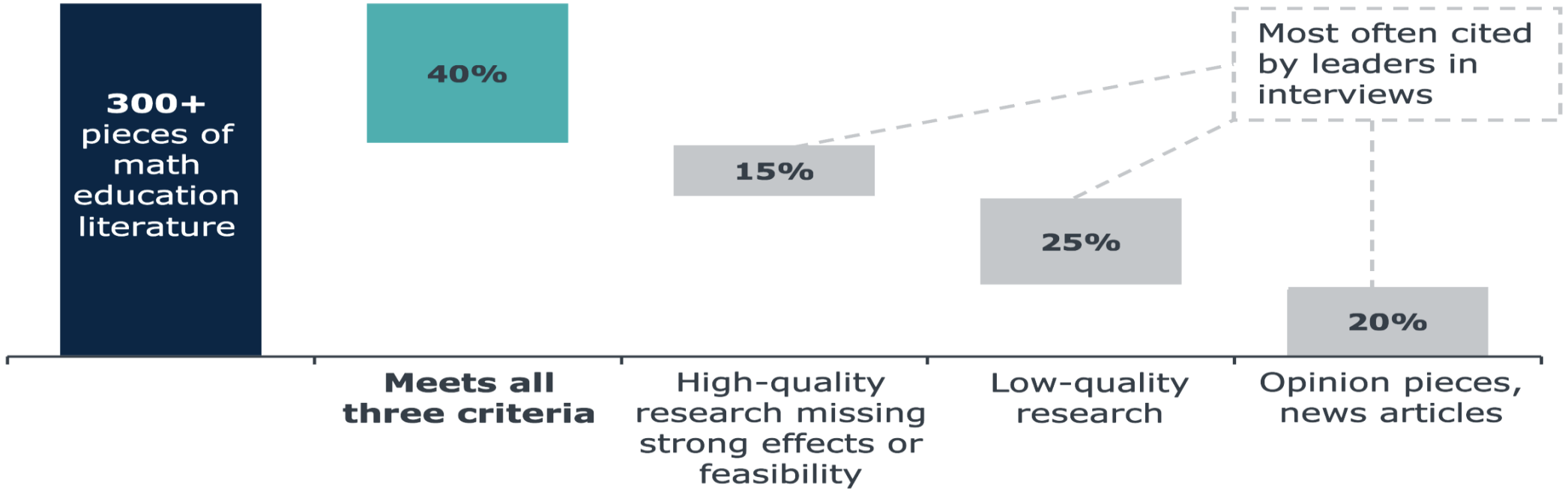
High-Quality Evidence for "What Works" Is Rare

EAB's Criteria for Evaluating Effective Math Instructional Approaches

- ✓ High-quality research design
- ✓ Strong effect on validated math learning metrics
- ✓ Feasible for teachers to deliver to in real classrooms

Popular Instructional Approaches Often Fall Short of Standards for Evidence

Estimated Distribution of Literature on Math Instructional Approaches, by Characteristic



Sources: National Center for Intensive Intervention, Academic Intervention Rating Rubric, 2022; Kilpatrick, et al., *Adding It Up*, 2001; Hansford & Schechter, Evidence Framework, 2022; Sparks, Picking 'Evidence-Based' Programs: 5 Mistakes for Educators to Avoid, 2024; EAB interviews and analysis.

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Instruction Is Never One-Tactic-Fits-All

"There is no such thing as a tactic that works all of the time for all learning. That's the whole key of the ***Instructional Hierarchy****."*

Dr. Amanda VanDerHeyden,
Education Psychology Researcher

Source: Korbey, Why so many students can't master math, 2025

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The Fastest Route to Skill Mastery

The Instructional Hierarchy: An Empirically Validated Learning Path

	ACQUISITION	FLUENCY	GENERALIZATION
Student Goals	**Accuracy**: Perform skill accurately and understand concept(s) behind procedure	**Efficiency**: Increase speed and accuracy	**Novel application:** Apply the skill flexibly in unstructured situations
Instructional Tactics	**Explicit instruction** (modeling, guided practice, immediate feedback)	**Maximum practice opportunities**, favoring independent and/or timed practice	**Novel problems and student-led tasks**; spiraling to ensure skill maintenance

Sources: Maki, et al., Intervening with Multiplication Fact Difficulties, 2020; Codding, et al., Using Data to Intensify Math Instruction, 2023; VanDerHeyden, et al., Randomized Evaluation of a Supplemental Grade-Wide Mathematics Intervention, 2012; Codding, et al., Comparing mathematics interventions, 2007; Burns, et al., Meta-analysis of acquisition and fluency math interventions with instructional and frustration level skills, 2010; Codding, et al., Meta-analysis of mathematic basic-fact fluency interventions, 2011

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Where Have You Seen This Before?



Playing Piano

ACQUISITION	FLUENCY	GENERALIZATION
Learning which notes go with which keys; understanding sheet music notation	Practicing scales every day; practicing new pieces of music to achieve proper tempo	Sight-reading new music; improvisation; "rule breaking"



Excelling in a Sport

ACQUISITION	FLUENCY	GENERALIZATION
Learning the rules of a new game; running plays in low-stakes environments	Drilling "the fundamentals"; building key muscle groups; practicing error-prone moves	Playmaking during a game; performing under pressure; having "instinct"



Learning to Read

ACQUISITION	FLUENCY	GENERALIZATION
Recognizing phoneme patterns; learning to decode words accurately through explicit phonics instruction	Practicing reading passages; reading "fluently"; building comprehension through repeated exposure to high-quality texts	"Reading to learn"; immediately deciphering unknown words in context

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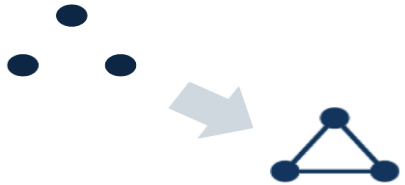
Source: EAB interviews and analysis.

Aligned with How the Brain Loves to Learn

Three Learning Science Principles Embedded in the Instructional Hierarchy



Cognitive Load Theory

When learning something new, students can only hold 3-7 new pieces of information at a time in their working memory



Intentional Sequencing

Systematic ordering of new concepts or skills that incrementally builds toward mastery and connects new to existing learning



Spaced Practice

Skills are embedded into long term memory through short, repeated practice sessions over time

Sources: Cowan, The magical number 4 in short-term memory: A reconsideration of mental storage capacity, 2001; Gupta & Zheng, Cognitive Load in Solving Mathematics Problems: Validating the Role of Motivation and the Interaction Among Prior Knowledge, Worked Examples, and Task Difficulty, 2020; Maki, et al, Math anxiety in elementary students: Examining the role of timing and task complexity, 2024 Watkins, Project Follow-Through, 1997; Doabler & Fien, Explicit Mathematics Instruction: What Teachers Can Do for Teaching Students With Mathematics Difficulties, 2013; Kirschner, et al., Why Minimal Guidance During Instruction Does Not Work, 2006; Fuchs, et al., Assisting Students Struggling with Mathematics: Intervention in the Elementary Grades, 2021; Yeager, et al., Breaking the Cycle of Mistrust: Wise Interventions to Provide Critical Feedback Across the Racial Divide, 2013; EAB interviews and analysis.

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Missteps Often Bar Students from Full Mastery

Common Missteps in Acquisition Phase

Results

Using fluency tactics in acquisition (i.e., timed activities)



Rote memorization and unfinished learning

Using generalization tactics in acquisition (i.e., unstructured tasks)



Student participation, but unfinished learning

Common Missteps in Fluency Stage

Stopping at acquisition, never reaching fluency



Inefficient problem solving and unfinished learning

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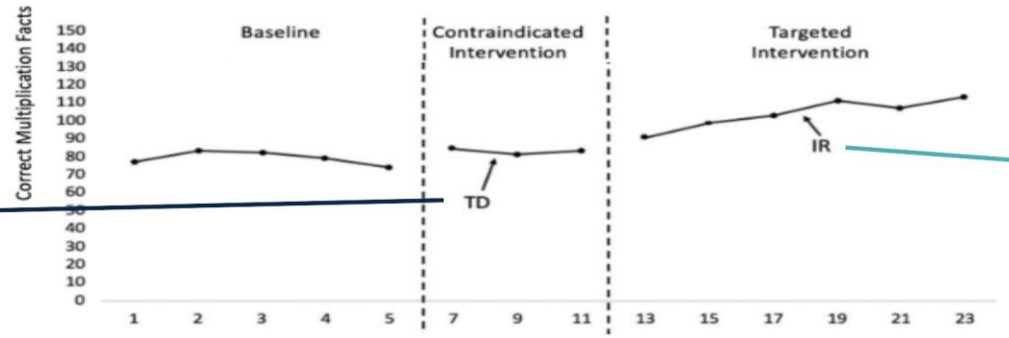
Source: EAB interviews and analysis

Research Confirms: Tactic Must Match Stage

When Students Are in Acquisition Stage, Fluency Tactics Do Not Work

Maki et al., 2020[1]:

Flat progress while doing timed drills (TD), a fluency-building intervention

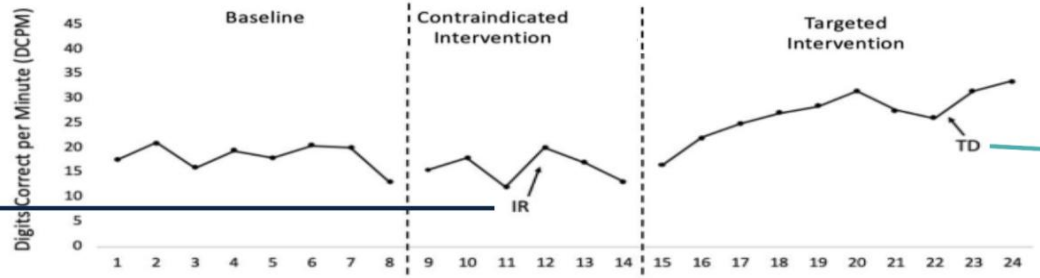


Immediate, sustained improvement when doing incremental rehearsal (IR), an acquisition intervention

When Students Are in Fluency Stage, Acquisition Tactics Do Not Work

Maki et al., 2020[2]:

Fluency progress is stagnant amid six weeks of acquisition intervention



Progress immediately increases following beginning of fluency intervention

1) Accuracy Progress of Student in Acquisition Stage, by Type of Intervention Received, and Number of Weeks
2) Fluency Progress of Student in Fluency Stage, by Type of Intervention Received, and Number of Weeks

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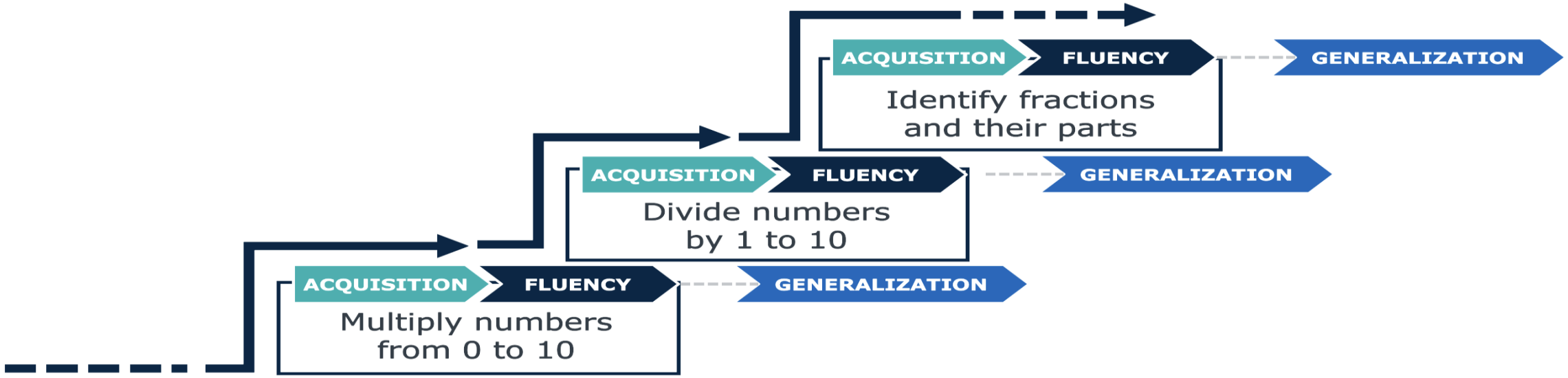
Sources: Maki, et al., Intervening with Multiplication Fact Difficulties, 2020

Skill by Skill, Students Can Build a Stronger Foundation

Ensure Students Progress through Acquisition *and* Fluency in Priority Skills

Example priority skill sequence, overlayed with instructional hierarchy phases



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Source: Delta Math RTI, 2026.

Many Curricula Unaligned to Instructional Hierarchy

Most Core Curricula Do Not Support Teaching with the Instructional Hierarchy

Findings from Doabler et al., 2012:



Explicit, Systematic Instruction

17% of 2nd grade lessons

8% of 4th grade lessons



Adequate Practice to Master Skills

25% of 2nd grade lessons

0% of 4th grade lessons

> *Textbooks were missing consistent opportunities for explicit and systematic instruction. A potential result of missing this principle in a core math textbook is providing* ***math instruction that is confusing for students."***
>
> Doabler et al., 2012

Shifting Instruction Without Curriculum Puts Undue Burden on Teachers

Requiring instructional shifts without aligned resources means teachers must:



Filter through competing advice in core resource



Use materials in counter to how they're designed



Find and use other materials to fill gaps in core program

Sources: Bryant, et al., Preventing Difficulties in the Primary Grades: The Critical Features of Instruction in Textbooks as Part of the Equation, 2008; Doabler, et al., Evaluating Three Elementary Mathematics Programs for Presence of Eight Research-Based Instructional Design Principles, 2012; EAB interviews and analysis

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Research Points to "Priority" Skills for Recovery

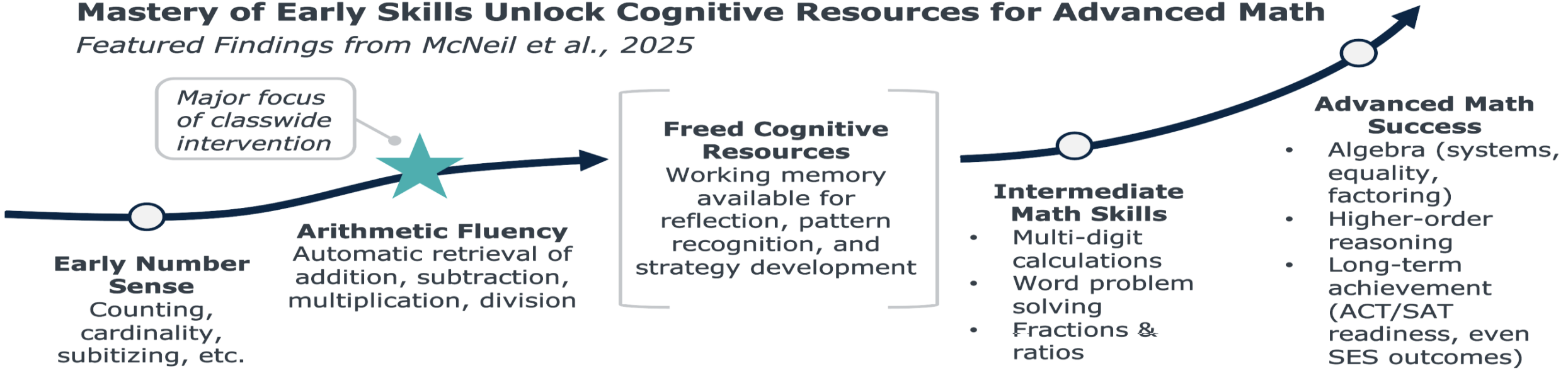
Skills That Lead to Arithmetic Fluency *Strongly Predict* Future Success

High-quality studies show that arithmetic fluency **strongly predicts** later math performance in fractions, algebra, and problem solving.

*"The evidence from longitudinal studies has been robust, showing that **arithmetic fluency prospectively predicts math achievement even when accounting for other variables** (Carr & Alexeev, 2011; Cheng et al., 2022; Fuchs et al., 2016; Geary, 2011; Jordan et al., 2003; Lin & Powell, 2021; Powell et al., 2019)"*

Mastery of Early Skills Unlock Cognitive Resources for Advanced Math

Featured Findings from McNeil et al., 2025



Source: McNeil, et al., What the Science of Learning Teaches Us About Arithmetic Fluency, 2025

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The Science of Learning in APS Moving Forward



Student Academic Growth and Success

Leadership Lab with EAB

- Provides guidance for school divisions/districts to design a scalable plan to close foundational math skill gaps.

Pilots at Specific Schools and Grades

- Elementary Schools: Abingdon, Carlin Springs, Drew, and Jamestown
- Middle Schools: Gunston and Thomas Jefferson

APS Learning Together About the Science of Learning

- Organizing time to share research connected to the instructional hierarchy as defined in the Science of Learning.

Textbook Adoption Process aligned with the Science of Learning

- Products reviewed embody many science of learning principles
- It’s the "How" that matters: Retrieval Practice, Spaced Practice, Scaffolding

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