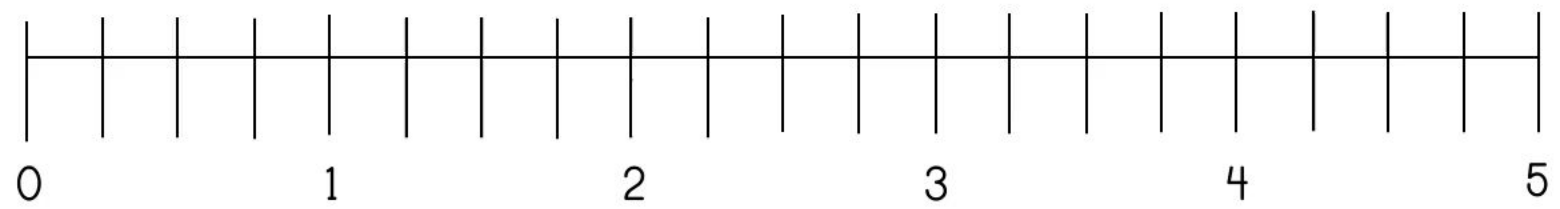


These are overlapping constructs

- **conceptual understanding.** Conceptual understanding, developed and measured in tandem with procedural skill, occurs by helping children learn definitions that are permanent, to reason mathematically by proofing solutions, adapting solutions based on situational or contextual variables, describing solutions using skills already known or mastered, and using math procedures with purpose. Conceptual understanding is not unique and specifically distinct from procedural skill. Rather, these are **overlapping constructs for which improvements in one leads to improvements in the other and unique measurement of either in isolation is very difficult.**
- **procedural skill.** Using procedures (laws, operations, algorithms) to accurately solve math problems. Procedural skill is necessary for mathematical proofing of solutions (i.e., math reasoning). Math skills are logically connected with each skill depending upon prior procedural skill mastery and, in turn, enabling future skill mastery in a hierarchical way. Procedural skill development means understanding whether, how, and when a given algorithm or procedure will be useful and what the associated limitations of that procedure in the context of the problem you are trying to solve are as well as being able to successfully complete the problem-solving procedures. Also read: Star (2005) <https://eric.ed.gov/?id=EJ764986>.

See also https://evidenceadvocacycenter.org/wp-content/uploads/Math_Glossary.pdf



- Curricula are poorly designed and yield weak effect sizes on student achievement.
- Skill development
 - Specified skill sequences (progressions)
 - Assessed for mastery on each skill
 - first build accuracy, then build fluency, then give generalization opportunities

How does learning happen?

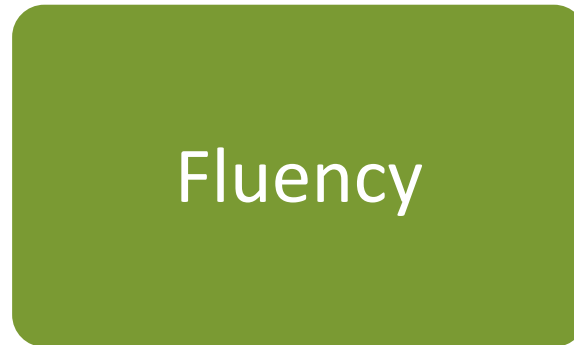
New understanding.
Child cannot accurately
respond without help.



Goal of instruction is
Discrimination.



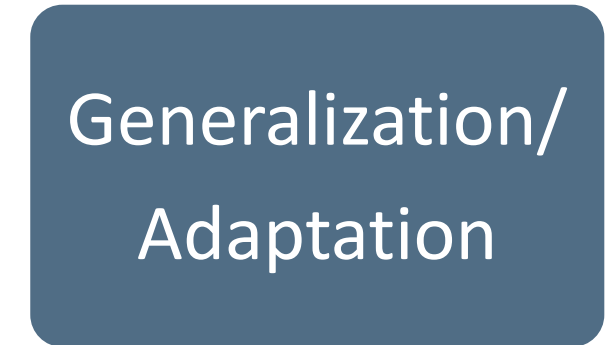
Child performance is
accurate, but
response is labored.



Goal of instruction is Fluency
(rapid and accurate responding).

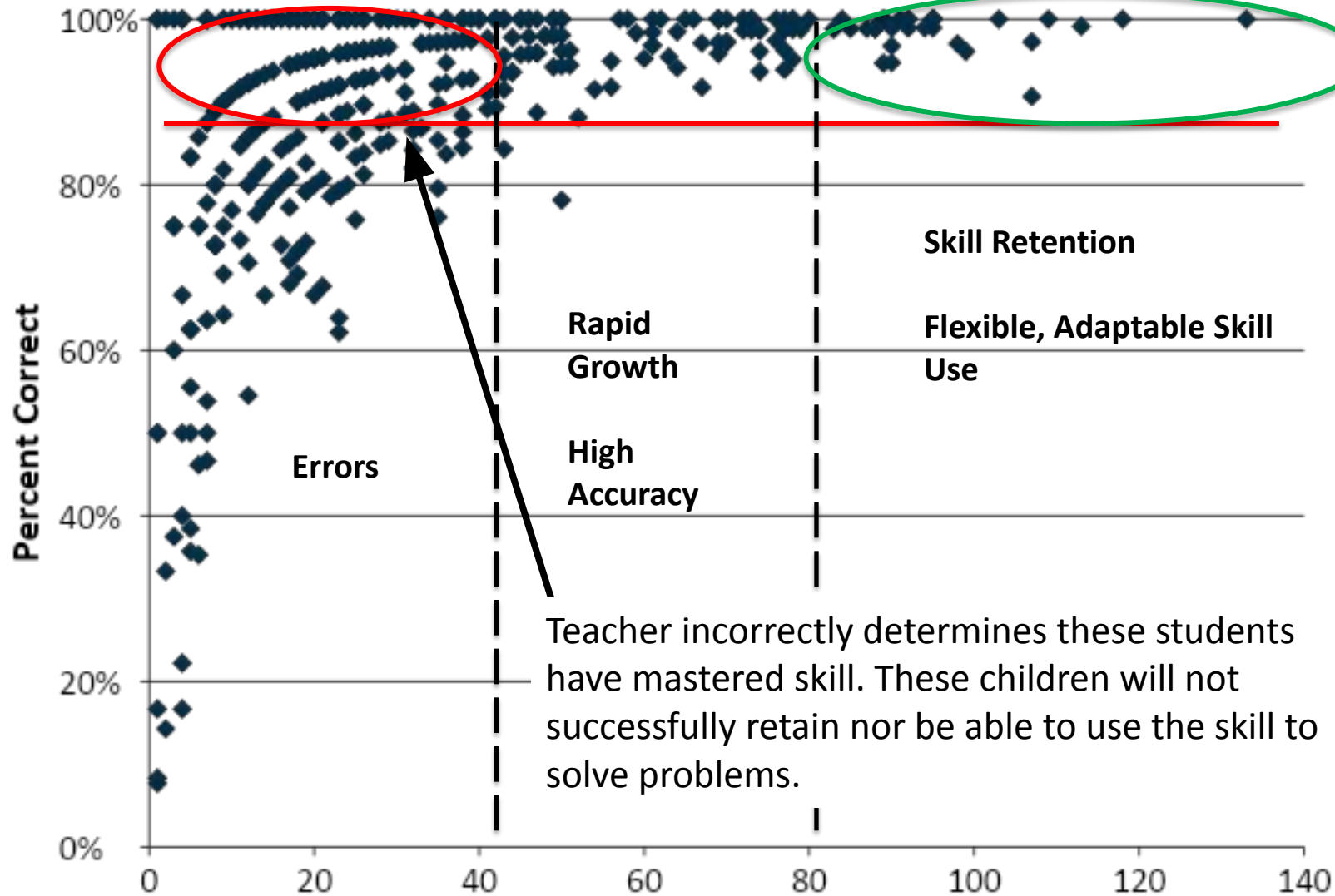


Skill is fluent.



Goal of instruction is to increase
the conditions under which the
child can respond correctly
(stimulus generalization) &
alteration of the skill to solve new
problems (response adaptation)

Fluency by Accuracy



Teachers determine mastery



Errors

Rapid Growth
High Accuracy

Skill Retention
Flexible, Adaptable Skill Use

Teacher incorrectly determines these students have mastered skill. These children will not successfully retain nor be able to use the skill to solve problems.

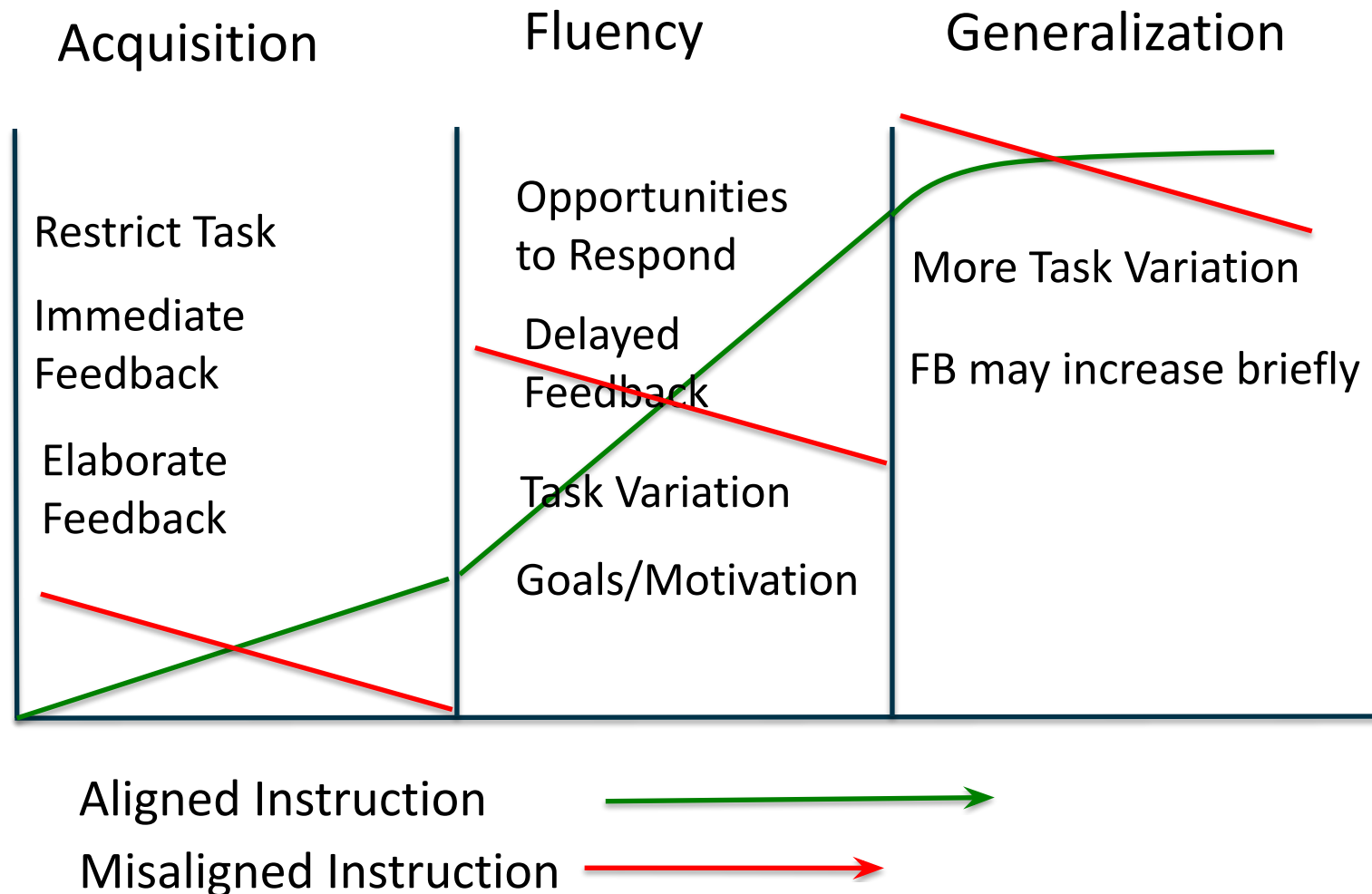
These children are ready for more challenging work & will have high probability of learning success, generalization.

Acquisition

Fluency-Building

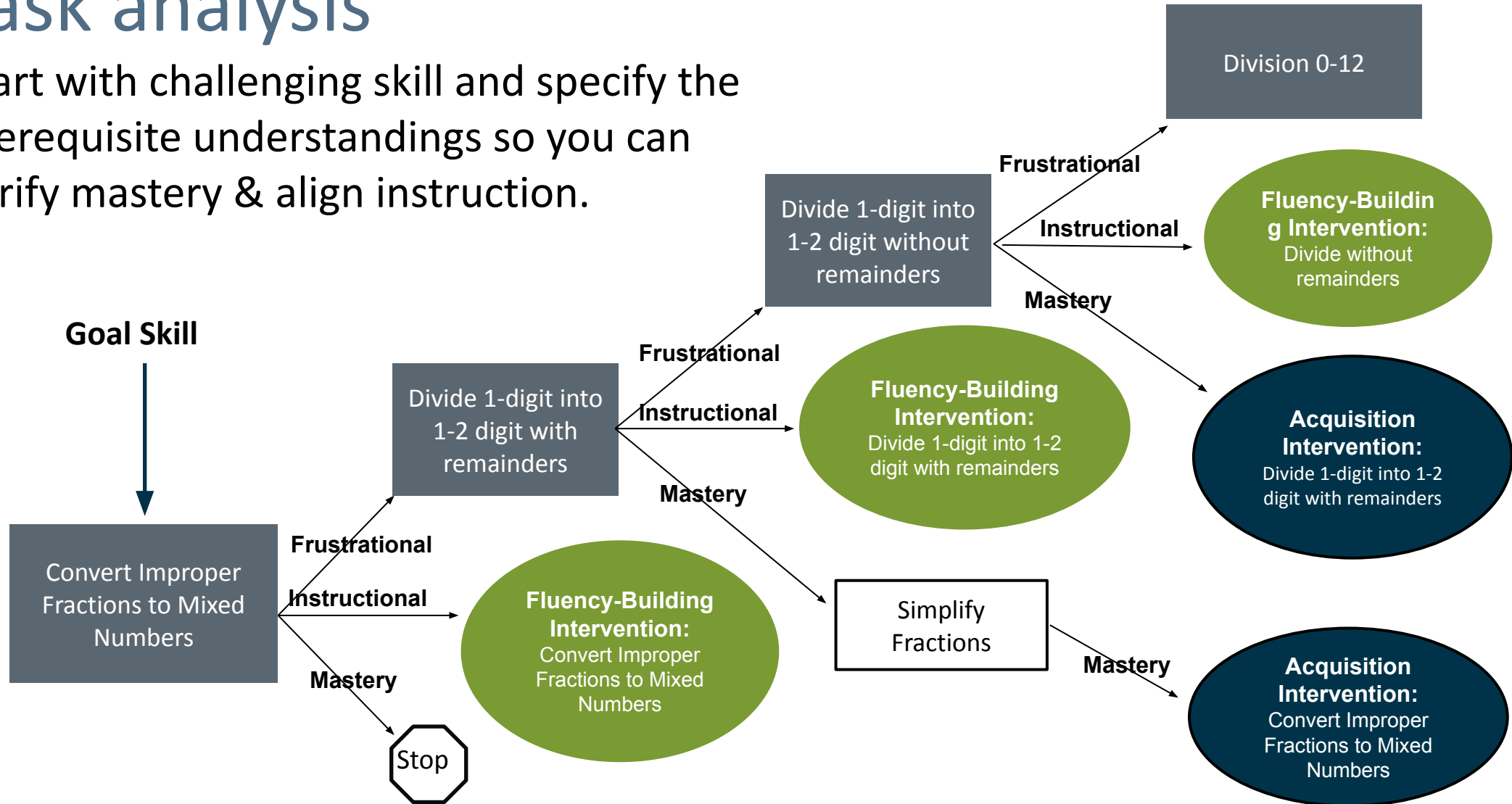
Generalization

The Instructional Hierarchy: How it Works



Task analysis

Start with challenging skill and specify the prerequisite understandings so you can verify mastery & align instruction.



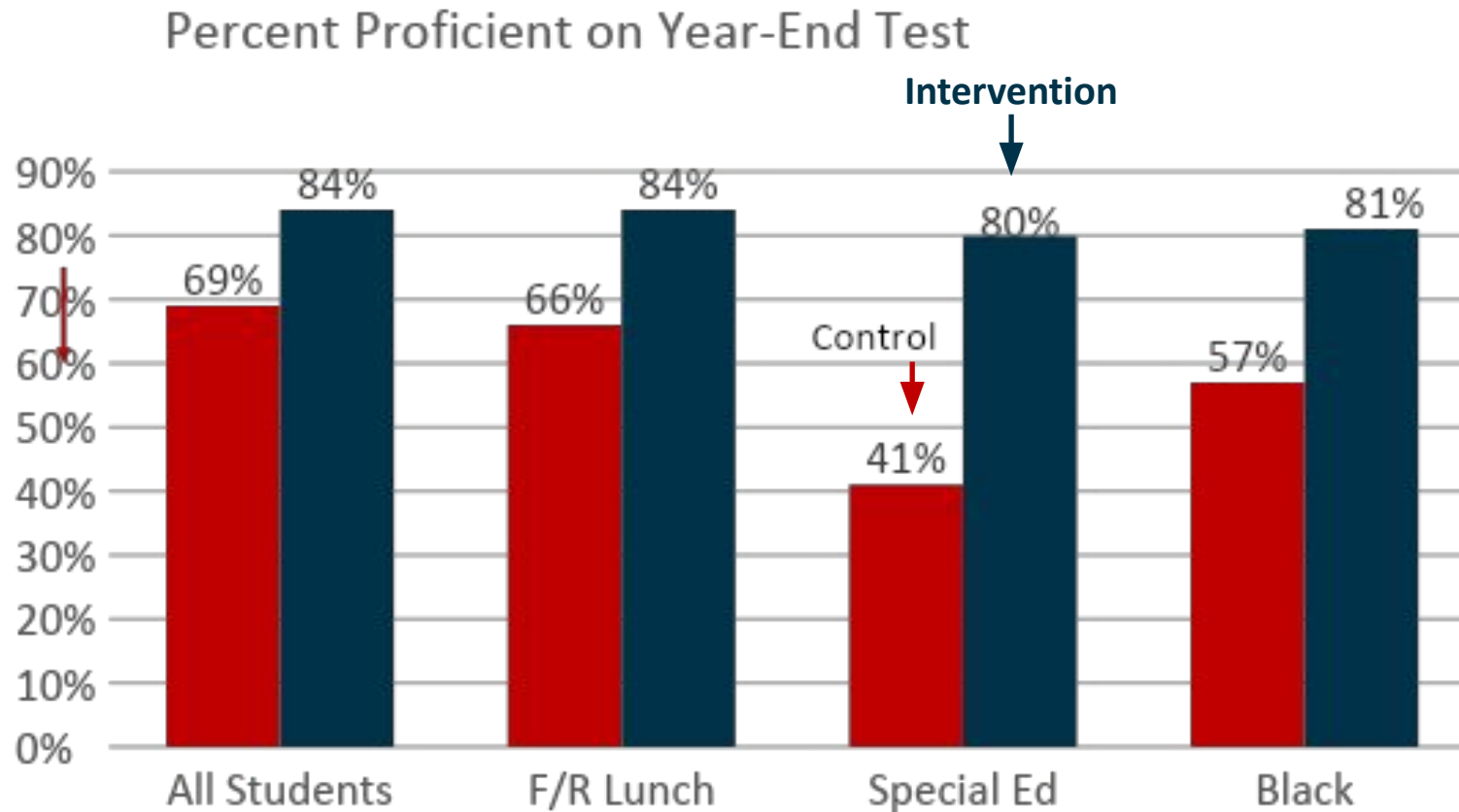
Decision tree graphic



On Fluency

Roediger & McDaniel: “Pitting the learning of basic knowledge against the development of creative thinking is a false choice. Both need to be cultivated. The stronger one’s knowledge about the subject at hand, the more nuanced one’s creativity can be in addressing a new problem. Just as knowledge amounts to little without the exercise of ingenuity and imagination, creativity absent a sturdy foundation of knowledge builds a shaky house.”

Classwide Intervention is Extremely Protective



ES = .68 CBMs

ES = .18 Gr 4

ES = .79 for at-risk

VanDerHeyden, A. M., McLaughlin, T., Algina, J., & Snyder, P. (2012). Randomized evaluation of a supplemental grade-wide mathematics intervention. *American Education Research Journal*, 49, 1251-1284
<https://doi.org/10.3102/0002831212462736>

VanDerHeyden, A. M. & Coddling, R. (2015). Practical effects of classwide mathematics intervention. *School Psychology Review*, 44, 169-190.
<https://doi.org/10.17105/spr-13-0087.1>

<https://charts.intensiveintervention.org/aintervention>

<https://www.thescienceofmath.com/classwide-mathematics-intervention>



The Science of Learning: Conceptual v. Procedural Skill Development

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