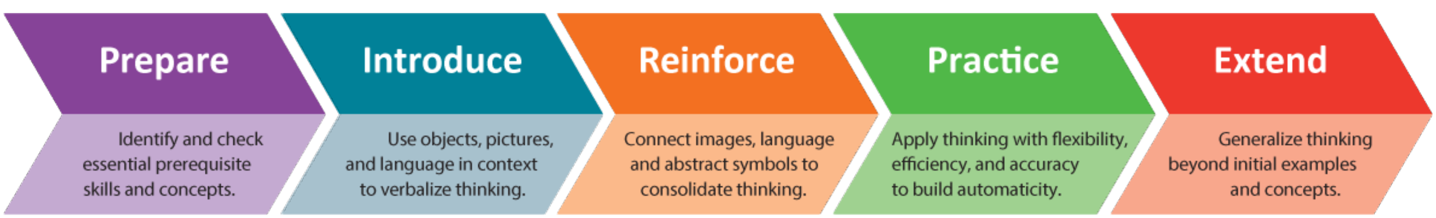
Research Background for
The Book and Box of Fact Strategies

Current standards typically call for students to develop computational skills based on physical and visual models, place-value-linked strategies, and mathematical reasoning. In other words, students are expected to know how to figure out the answer (and why that method works) rather than simply memorizing facts on flash cards. This emphasis on reasoning and connecting mathematics procedures with concepts builds a strong foundation for understanding operations with greater whole numbers, common fractions, and decimal fractions later in elementary school, as well as a strong foundation for algebraic reasoning in secondary school. As such, it is critical to get this right.

These standards are driven by research findings which support the connection of concepts with procedures and the building of strategy-based understanding of basic facts and algorithms. NCTM's Effective Teaching Practices (NCTM, 2014) include *building procedural fluency from conceptual understanding*. The findings of a number of researchers also support the idea that students build fact fluency through understanding number relationships and principles, not by rote memorization (Baroody, Fell, & Johnson, 2007). *Adding It Up*, the National Research Council's 2001 seminal publication on how children learn mathematics, supports this same idea that fact fluency is important, but recall of facts should be based on understanding of the operations and thinking strategies. Procedural fluency includes four components: accuracy, efficiency, appropriate strategy selection, and flexibility (Kilpatrick, et al., 2001; NGO & CCSSO, 2010).

In addition to this specific research base on building fluency, there is a broader research base on using a Piagetian developmental approach to teaching mathematics by working across concrete, visual, and symbolic representations. Elementary mathematics teachers often have and use physical manipulatives as concrete representations of mathematics. They may not have access to a wide range of visual representations, which often serve as a powerful connector to symbolic representations. It is important for deep learning that students not only use the various representations, but also connect them (Hattie, et al, 2017). Using and connecting multiple representations is another NCTM effective teaching practice (NCTM, 2014). This Piagetian approach has a very high effect size (1.28) in the Visible Learning database (Hattie, et al, 2017).

ORIGO Education's *Book and Box of Fact Strategies* resources teach all four operations (addition, subtraction, multiplication, and division) from this perspective of connecting procedural fluency to conceptual understanding, number sense, and an efficient set of generalizable strategies. First, students are prepared for the strategy by ensuring each has mastered the required prerequisite skills. Each strategy is then introduced and reinforced before being used to practice the associated facts. This happens through direct instruction as well as through games and a set of specially-designed visual representations, all of which support the Piagetian developmental approach noted above. Further information about the resources included can be found here: https://www.origoeducation.com/book-and-box-of-fact-strategies/.



Once students have mastered the basic facts, they are able to extend that knowledge. The figure below shows the extension of the three commonly-used addition strategies from basic facts through greater whole numbers, fractions, and decimals.

Extensions Across Grades

Begin with a fact strategy.

Strategies	First Extension	Further Extensions	Fraction Extension	Decimal Extensions
Count on	**Count on**	**Count on**	**Count on**	**Count on**
6 + 1	16 + 1	26 + 21	$\frac{5}{8} + \frac{1}{8}$	3.6 + 2.1
9 + 2	19 + 2	29 + 12	$2\frac{3}{6} + 1\frac{1}{6}$	2.9 + 1.2
Use doubles	**Use doubles**	**Use doubles**	**Use doubles**	**Use doubles**
7 + 7	25 + 25	27 + 27	$2\frac{1}{4} + 2\frac{2}{4}$	2.5 + 2.5
6 + 5	26 + 25	126 + 125	$3\frac{1}{8} + 3\frac{3}{8}$	1.26 + 1.25
Bridge to ten	**Bridge to ten**	**Bridge to ten**	**Bridge to ten**	**Bridge to ten**
9 + 4	39 + 4	198 + 25	$5\frac{4}{5} + 2\frac{3}{5}$	1.98 + 0.06

References

Baroody, A., Feil, Y., & Johnson, A. (2007). "An Alternative Reconceptualization of Procedural and Conceptual Knowledge." Journal for Research in Mathematics Education, 38(2), 115-131.

Hattie, J., Fisher, D., Frey, N., Gojak, L. M., Moore, S. D., & Mellman, W. (2017). Visible Learning for Mathematics: What Works Best to Optimize Student Learning K-12. Thousand Oaks, CA: Corwin.

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