The Past, Present, & Future of CBM: A Tribute to Stanley L. Deno

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Stan Deno had a brilliant and revolutionary idea.

The CBM Idea

Simple indicators of a student's level of academic performance can be used to model the trajectory of the student's development across time.

Among the few with brilliant ideas, fewer still have developed a systematic program of research. Stan did this.

- He created a framework for rigorously studying CBM and saw it become a major influence on the research of countless scholars and on the practice of education across the nation and around the world.
- His CBM framework provided the basis not only for hundreds of studies conducted throughout the U.S. and beyond, but also for changes in how the progress of children—especially children with disabilities—is monitored in schools.
- The University of Minnesota gave Stan its very highest honor its Outstanding Achievement Award for his creativity, his corpus of work, his influence on fellow researchers, and his profound impact on education practice.

Stan's Central Hypothesis

• When a teacher considers CBM level (performance at a single point in time) and trajectory (performance over time) to estimate response to instruction, and uses that information on an ongoing basis to evaluate and iteratively adjust an educational intervention program, teacher planning becomes more child specific and meaningful and student learning improves.



The Central Hypothesis

• Many scores of experimental and quasi-experimental studies across decades, across research teams, and across the U.S. and beyond have demonstrated the efficacy of this process, referred to as *data-based individualization* (CBM-DBI), and have confirmed Stan's central hypothesis.

• CBM-DBI is considered a signature special education practice: to use a currently popular phrase, a "high-leverage" education practice.

In This Inaugural Stan Deno Distinguished Lecture, we address the following.

• What CBM is and its potential impact

• What we know about CBM-DBI

• What we still need to know about CBM-DBI

What CBM Is and Its Potential Impact: The Apgar – CBM Analogy

- The Apgar score was another simple indicator of performance. It changed the practice of obstetrics and the health of newborns (as Atul Gawande described in *Better*).
- In the 1930s, the mortality rate in obstetrics was 1 in 30 newborns. This statistic had not substantially improved over the previous century.

The Apgar Score

- In 1953 Virginia Apgar set the stage for altering the practice of obstetrics with the publication of a "ridiculously simple" and "revolutionary" idea: rating the general health of newborns on a 10-point scale.
- This quick indicator of health
 - Turned "an intangible and clinical impression, the condition of newborn babies, into numbers that could be collected and compared."
 - Permitted obstetricians to experiment with their own practices, using Apgar scores as the dependent variable.
 - Permitted hospitals to aggregate data over obstetricians to identify which practices produce better outcomes. permitting administrators to standardize practice in ways that further decreased death rates.

The Apgar Score

- According to Gawande, the Apgar score "changed everything," producing dramatic improvements in the practice of obstetrics: The 1930s death rate dropped from 1 in 30 to 1 in 500.
- Gawande concluded, "All patients deserve a simple measure that indicates how well or badly they have [responded to intervention] ... and that pushes the rest of us to innovate."

The Apgar – CBM Analogy

- The analogy isn't perfect.
- But like the Apgar score, a simple indicator of overall academic competence has the potential to transform an impressionistic clinical judgment about academic competence into a meaningful score educators can routinely collect and compare.
- Just as the Apgar score transformed obstetrics, CBM permits educators to experiment with their practices. It allows them to repeatedly evaluate and formatively develop their students' programs. It permits schools, districts, and states to aggregate data over teachers to identify instructional practices that accelerate academic achievement.

Toward Realizing CBM-DBI's Potential

• Over the past 40 years, generations of researchers have conducted impressive programs of research on CBM and CBM-DBI.

• Realizing CBM-DBI's potential involves understanding

- Strand 1: Technical features of the single score
- Strand 2:
- Strand 3:

Technical features of the single score
Technical features of slope or other metrics of improvement/response
Issues of CBM's instructional utility: how teachers use CBM affects the quality of their instructional decisions and their students' learning

Strand 1

- To date, CBM research has focused largely on Strand 1: CBM as a single-point performance indicator.
- Interest in the technical features of the performance level score may be the result of CBM's popularity as a universal screening tool.
- Yet, screening tools are widely available.

Strands 2 and 3

- The unique benefits of CBM are for modeling student trajectories of learning and improving instructional decision making.
- To capitalize on CBM's uniqueness, systematic attention to the other strands of CBM research is needed.
- Publication of slope studies, focused on longitudinal modeling of progress, has increased over the past 20 years.
- By contrast, in the same timeframe, instructional utility research, centered on the effects of teachers' use of CBM progress-monitoring data on instructional planning and student learning, has decreased.

This Inaugural Stan Deno Distinguished Lecture

• What CBM is and its potential impact

• What we know about CBM-DBI's instructional utility (Strand 3)

• What we still need to know about CBM-DBI

Our Analysis of What We Know about CBM-DBI's Instructional Utility

- We begin by summarizing Jung, McMaster, Kunkel, Shin, & Stecker's (2018) meta-analysis of CBM-DBI studies focused on student outcomes in reading, math, and spelling-writing.
- Studies outside the focus of this talk
 - Were conducted in general education, outside the context of intensive intervention
 - Relied on teacher-created assessments without demonstrated reliability and validity
 - Relied on mastery measurement
 - Assessed effects of professional development on teacher outcomes (see Gesel & Lemons's 2021 meta-analysis, which found positive effects on teacher skills and confidence to conduct DBI)
- We center on Jung et al. instead of Filderman et al.'s 2018 meta-analysis, because Filderman's focus was limited to reading and its studies largely fell outside our scope
 - A high proportion (67%) relied on teacher-created tests or mastery measurement
 - Most (87%) included struggling or at-risk students.
- In the Jung et al. meta-analysis, all but one study relied on CBM, and all but one focused entirely on students with disabilities.

Jung et al.'s 2018 Meta-Analysis 14 Studies: Two ES Categories

DBI-Only ES Category (DBI vs. control)

- This category included 2 types of ESs.
 - 2-condition studies (DBI vs. control). Each contributed one ES.
 - 3-condition studies (control and two DBI condition: one with a less innovative DBI support; the other with a more innovative DBI support): Each contributed one ES, contrasting the study's <u>less innovative DBI condition vs. control</u>.

DBI-Plus ES Category (less vs. more innovative DBI supports)

• This category included the other ESs from 3-condition studies. ESs indexing the added value of more innovative over less innovative DBI supports.

Jung et al.'s 2018 Results

- *DBI Only* category: The mean ES for DBI vs. control (including the less innovative DBI condition vs. control contrasts from 3-condition studies) was significant at 0.37. This mean estimate was comparable for reading, math, and spelling-writing.
- Results suggest that when teachers implement DBI, their students' learning improves.
- This finding is consistent with DBI's status as a "high-leverage" special education practice (HLP6 CEC, 2017).
- DBI Plus category: The mean ES for the added value of more vs. less innovative types of DBI supports was significant at 0.38. This suggests that when CBM-DBI is conducted with more innovative supports, the ES is 0.75 (0.37 + 0.38 = 0.75).

Jung et al.'s 2018 Results

- In the *DBI-Only* category of studies, moderator analysis indicated ESs were larger when
 - Teachers receive individual visits plus small-group collaboration (vs. individual visits only): ES = 0.86 vs. 0.46.
 - Teacher support visits occur weekly (vs. less frequently): ES = 0.66 vs. 0.49.
- But as Jung et al. discussed, this is difficult to interpret because the same study (Jung, McMaster, & delMas, 2017) was the only study to
 - Combine small-group collaboration with individual visits
 - Provide visits lasting 90 min per week
 - Rely on a validated writing program as the platform for starting DBI.
- Also, there was insufficient power in the *DBI-Plus* category to pursue moderator analysis concerning types of supports.

Our Narrative Synthesis

- For these reasons, we conducted a narrative synthesis (*Journal of Learning Disabilities*, 2021) of the studies included in the meta-analysis.
- For our synthesis, we also searched the post-2017 literature and found no additional CBM-DBI studies meeting our inclusion criteria:
 - RCTs with ongoing CBM progress-monitoring data, conducted in the context of intensive intervention, and disaggregating effects on the academic outcomes of students with intensive needs.

Our Narrative Synthesis

• Because each 2-condition study relied on a different amount of time for teacher visits, we looked at the pattern across studies to see if *amount of teacher support* is associated with the quality of teacher planning or student outcomes.

 Because each 3-condition study (2 DBI conditions and control) tested the effects of an enhancement in DBI supports, we used those studies to deepen insight about which *types of supports* are associated with quality of teacher planning and student outcomes.

Is Increased teacher time spent in support visits associated with stronger ESs?

Overview of 2-condition (DBI v. control) studies:

from weakest to strongest ESs

• King et al. (1983) provided teachers initial CBM-DBI training but without ongoing support visits: 0 min per week. Teachers collected data but didn't engage in data-driven instructional decision making, and there was no evidence of improved teaching planning or student achievement (ES = -0.09).

 Fuchs et al.'s (1989b) provided teachers brief ongoing visits: 10 min per week. Teachers engaged in data-driven instructional decision making, and *CBM-DBI's* effect was significant: ES = 0.51.

- Allinder (1996) provided teachers brief visits: 12 min per week. The analysis separated high from lower implementers.
 - 30% of teachers (6 of 20) were high implementers: They used CBM data to drive DBI, and their students' achievement significantly exceeded the control group: ES = 1.26.
 - But the other 70% of teachers were lower implementers: 12min visits were insufficient to help them individualize programs, and the effect on student achievement was not significant: ES = 0.40.

• Fuchs et al. (1984) and Jung et al. (2017) provided teachers with substantially longer visits: 45 min and 90 min weekly visits, respectively. Teachers used data productively to improve instructional quality, and effects on student learning were clear and strong. Respective ESs were 0.75 and 1.40.

Conclusions:

Increasing teacher time spent in support visits is associated with stronger ESs.

- When substantial time is allocated to ongoing support visits, CBM-DBI's effects on student learning dramatically exceed the meta-analytic mean of 0.37.
- But the amount of support time required to achieve strong effects on student learning in Fuchs et al. (1984) and Jung et al. (2017) is not feasible.
- This prompts the question, *Can innovative CBM-DBI teacher* supports produce similar student outcomes, while keeping visits reasonably short?

Can innovative CBM-DBI teacher supports produce similar student outcomes, while keeping visits reasonably short?

We addressed this question using 3-condition studies.

- Random assignment to conditions: a control group and two CBM-DBI conditions
- One CBM-DBI condition involved a less innovative type of support; the other was identical but with a more innovative type of support.
- Teacher time in support visits was held constant across the two CBM-DBI conditions.

We illustrate the types of innovative teacher supports we tested and their effects with two studies.

Does Increasing Teacher Engagement in Graph-Based Analysis Improve Decisions or Student Outcomes? (Fuchs et al., 1989b)

- Random assignment: control group and CBM-DBI with and without computer-enhanced teacher engagement in graphed analysis
- Support visits: 10 min per week (20 minutes every other week)
- Other types of supports in place across conditions: computer-generated decision rules for analyzing graphed data
- Innovation: Teachers first inspected the student's graph independently and responded to "What should you do?" If correct, the computer beeped, and a message appeared, "Correct according to the decision rules." Regardless of whether the teacher was correct, a message explained the basis for the correct decision.
- Implementation accuracy was comparable across conditions, except a significantly higher percentage of enhanced engagement teachers timed instructional adjustments correctly.
- Learning outcomes in the enhanced condition were significantly stronger than control: ES = 0.45. By contrast, the effect between the <u>un</u>enhanced condition vs. control group was not significant (ES = 0.23).

Increasing Teacher Engagement in Graph-Based Analysis Improves Decision and Student Outcomes

- Teachers' adherence to DBI decision rules improves with embedded software that (a) structures teachers' independent inspection of CBM graphs to formulate decisions when to make teaching changes while (b) supporting teacher understanding.
- The significant ES of 0.45 on student outcomes is notable in that support visits took only 10 min per week.
- But the effect on student outcomes (v. control) is low compared to later innovations designed to help teachers link CBM data to instructional decisions. We illustrate this next.
- Note first that, as part of an IES Development grant, Jess Toste created an app that provides personalized coaching to train teachers in CBM graphed analysis. This may reduce or eliminate the need for support visits focused on graphed analysis. Jess is examining effects on teachers' graphed analysis.

Later Innovations Focused on Instructional Changes

- In reading, math, spelling, we conducted a pair of studies: one testing effects of providing teachers with diagnostic analysis; the other testing effects of an expert advice system. The nature of the questions, diagnostic analysis, and expert advice systems varied depending what was possible given the nature of the automatically collected CBM data.
- Across reading, spelling and math, the pattern of results suggests diagnostic analysis derived from CBM-generated data, as well as expert advice systems, can be designed to
 - Help teachers engage more productively in DBI decisions
 - With less time in support visits (7 12 min per week)
 - Yet with similar ESs to Fuchs et al.'s (1984) 45-min visits and Jung et al.'s (2017) 90-min visits.
- In this talk, we illustrate this potential with one spelling study.

Later Innovations Focused on Instructional Decisions: What Does Diagnostic Analysis Mean? A Spelling Example

- CBM-DBI diagnostic analysis was available to teachers each time they looked at their students' CBM graphs.
- The diagnostic feedback was derived from 50 words the student had spelled on most recent CBM tests. Software searched each misspelling for 27 phonetic error types and, using a decision tree, identified up to 3 error types on which the teacher might focus their instructional change.

• Diagnostic feedback comprised two pages.

- Main page reported numbers of correct, near miss, and far miss words. To inform instructional changes, it also showed 3 errors types that (a) the student committed frequently and (b) were most teachable among the student's larger set of frequent error types.
- Another page showed a list of all 50 words, with the student's actual spelling next to each correctly spelled word. The list was ordered from most to least correct in terms of letter sequences and grouped into corrects, near misses, and far misses.

CBM Spelling Analysis:

Types of Errors

Corrects (100% LS) 14 word(s) Near Misses (60-99% LS) 19 word(s) Moderate Misses (20-59% LS) 16 word(s) Far Misses (0-19% LS) 1 word(2)	

Туре	Correct	Possible	Pct	Туре	Correct	Possible	Pct	
Sing cons	48	50	96	Final vow	3	7	42	
Blend	7	10	70	Double	3	4	75	
FSLZ	0	0		c/s	0	1	0	
Sinale vow	21	31	67	c/ck	0	2	0	
Digraph	6	8	75	-le	4	7	57	
Vowel + N	6	8	75	ch/tch	2	2	100	
Dual cons	13	25	52	-dge	0	1	0	
Final e	1	5	20	Vowel team	4	12	33	
iah/ian	0	0		Suffix	5	6	83	
ild/old	0	0		tion/sion	0	1	0	
a+l+cons	0	0		ance/ence	0	0		
Vowel+R	9	14	64	sure/ture	0	0		

KEV	FRRORS
	ERRURO

Dual cons	Final e	Final vow
learner-leaner sample-samble	alone-alon knife-knif	taste-tast hero-hearow
chart-chard	rare-rar	lazy-lazz
mumble-mobble tractor-trater apart-apeot	cube-cub	unlucky-unluke

CBM Spelling Analysis: Ordered word lists

Name	: John S	mith	Spelling 4	ł	Date: 3/12
Corrects (100% LS)					
100	March		March		
100	death		death		
100	sometimes	S	sometimes		
100	thankful		thankful		
100	baker		baker		
100	uncover		uncover		
100	shy		shv		
100	weakness		weakness		
100	forgot		forgot		
100	eves		eves		
100	army		army		
100	powerless		nowerless		
100	wife		wife		
100	mix		mix		
100	Nee				
77	shinment	i wisses (shapmont	Single vow	
75	instand		ineted	Vound toom	
15	natchee		notooo	Digraph	
75	paicnes		parces	Digraph	
75	moisten		mosten	vowel team	
75	quieter		quiter	Vowel team	
75	learner		leaner	Dual cons	
75	trouble		trubble	Vowel team	
71	sample		samble	Dual cons	
71	listen		lesten	Single vow	
66	badge		bage	-dge	
66	taste		tast	Final vow	
66	chart		chard	Dual cons	
66	alone		alon	Final e	
66	restless		reasless	Blend	
66	knife		knif	Final e	
60	hero		hearow	Final vow	Vowel + R
60	rare		rar	Final e	
60	cube		cub	Final e	
60	lazy		lazz	Final vow	
	Mod	lerate Miss	ses (20-59% LS)		
57	tickle		teakle	c/ck	Single vow
57	French		fanch	Vowel + N	Blend
57	mumble		mobble	Dual cons	Sinale vow
50	unlucky		unluke	Final vow	c/ck
50	tractor		trater	Vowel + R	Dual cons
50	apart		apeot	Vowel + R	Dual cons
44	calendar		cander	Vowel + R	Vowel + N
42	mumble		mommbe	-le	Single vow
40	rail		real	Vowel team	C
37	station		stanch	tion/sion	
28	sample		scembe	-le	Dual cons
25	certain		chanten	Vowel team	
25	squeeze		scease	Vowel team	Diaranh
20	treatment		tempemt	Suffix	Vovelteer
	— Farl	Misses (0-	19% I S) ———	Sum	vowerteant
14	giggle		aelly	-le	Double
	3 33		30		DOUDIE

Later Innovations Focused on Instructional Decisions: Added Value of Spelling Diagnostic Feedback (Fuchs et al., 1991)

- Teachers were randomly assigned to DBI with automatic graphed analysis with vs. without diagnostic feedback or a control group.
- Weekly teacher support visits averaged 7 minutes.
- Each teacher included 4 students who were randomized (within teacher) to determine whether teachers saw ordered word lists
 - For 2 students, diagnostic analysis teachers saw the graph and summary page with ordered word list but, for the other 2 students, they saw the graph and summary page without ordered word list.
 - For 2 students, graphed analysis teachers saw the graph with ordered word list for 2 students but, for the other 2 students, they saw the graph without the ordered word list.

Technological supports for enriching and connecting CBM feedback to instructional decisions: Added Value of Spelling Diagnostic Feedback (Fuchs et al., 1991)

- Diagnostic feedback teachers addressed significantly more spelling error types than graphed analysis teachers and their students outperformed the control group: ES = 1.56. Ordered word lists were of no added value.
- By contrast, in the graphed analysis condition, ordered word lists provided added value. But the ES between control group vs. graphed analysis with ordered word lists was lower (0.79) than for diagnostic teachers (1.56).
- Findings illustrate clear advantages for CBM-DBI with diagnostic analysis and illustrate how profiles of student performance, which organize information in instructionally relevant ways, strengthen teachers' decision making and student learning.

Expert Advice Systems Also Provided Added Value. What Does Expert Advice System Mean? An Example

- The spelling expert advice system relied on structured interviews. They
 - Manually entered CBM graphed and diagnostic analysis info into the computer.
 - Entered information about their previous instructional program and curricular priorities.
 - Answered questions about the quality of the student's daily work completion and their own availability for additional instruction.
- Based on this input, the advice system recommended a teaching change along with instructional packets for implementing that change.
 Recommendations included 2 of the following:
 - Structured instruction on error types
 - Practice on error types or "near misses"
 - Strategies for improving student motivation and work completion.

Conclusions: What We Know

- Results from the Jung et al. (2018) meta-analysis support DBI's status as a high-leverage practice for improving student outcomes, with an ES of 0.37.
- Moderator analysis suggests that CBM-DBI's potential for improving student outcomes exceeds the mean estimate of 0.37 when teachers are supported with individual visits plus small-group collaboration (vs. individual visit only) and with weekly (vs. less frequent) visits.
- The mean added value for more innovative types of DBI supports over less innovative DBI supports is 0.38. So, CBM-DBI's effects with the types of innovations tested in *DBI-Plus* studies may be 0.37 + 0.38 = 0.75.

Conclusions: What We Know

- Our narrative synthesis corroborates the need for ongoing supports to actualize what appears to be CBM-DBI's key ingredient: instrumental use of CBM data to drive instructional decisions in the DBI process.
- The synthesis extends the meta-analysis in these ways.
 - Clarifying the relation between increased visit time and student outcomes: ESs on student outcomes in the 2 studies with the longest teacher visits exceeded 1 SD. But such lengthy visits is costly.
 - Showing that with substantially shorter visits (7-12 min)
 - Increasing teacher engagement in the CBM-DBI process improves teacher decision making and student outcomes.
 - Diagnostic analysis and teacher advice systems provide added value, with ESs exceeding 1 SD with these innovations.
 - ESs for supports focused graphed analysis are smaller than for supports focused on improving the quality of instructional changes.

Maybe It's This Simple

- CBM-DBI with supports for accurate graphed analysis gets us to moderate ESs: 0.40 0.50.
- To achieve ESs of 0.75 and higher, supports focused on using CBM data to improve teachers' instructional changes are needed.
- This may be accomplished
 - Extensive teacher visits or
 - Brief teacher visits with diagnostic profiles derived from CBM data (including instructional packets) with some potential added value for teacher advice systems.

This Inaugural Stan Deno Distinguished Lecture

• What CBM is and its potential impact

• What we know about CBM-DBI

• What we still need to know about CBM-DBI

What We Still Need to Know about CBM-DBI

• What we know about CBM-DBI largely relies on studies conducted years ago. The exception is the programmatic work conducted by Kristen McMaster and colleagues.

• In the 2018 meta-analysis, there was a 17-year pause between the most recent CBM-DBI RCT (Jung, McMaster, & delMas, 2017) and next most recent RCT (Allinder et al., 2000).

• What we know about teacher supports is largely dated, and the software developed decades ago no longer exists.

What We Still Need to Know about CBM-DBI: Updating and Enriching Technological Supports

• Technological advances expand opportunities for automatically

- Collecting CBM performance data
- Applying decision rules for timing instructional changes and, when changes are needed, for automatically advancing students into additional diagnostic data-collection activities that expand student performance data beyond CBM

Such features, when used in conjunction with AI and machine learning, may revolutionize the nature of diagnostic profiles and the quality of instructional change recommendations.

We need to understand effects of such innovations on teachers' DBI decision making and how such changes in DBI decision making mediate CBM-DBI's effects on student outcomes.

What We Still Need to Know about CBM-DBI: The Ongoing Need to Support Teacher Instruction

- As shown in the need for instructional packets and exacerbated by present-day teacher supply issues, systematic attention to *instructional* supports within CBM-DBI is essential. This prompts additional questions.
 - What are the effects of adequately supported CBM-DBI with and without use of a validated intervention as the platform for initiating CBM-DBI?
 - What's the added value of intensive intervention taxonomies, which incorporate validated instructional principles, in supporting teachers' instructional changes and do these tools improve teacher knowledge and impact more generally?
 - What are the effects of technology-enhanced CBM-DBI when combined with computer-guided instruction on student learning, and does this approach strengthen effects over teachers' DBI and over what can be achieved with CAI's dominant mastery measurement model?

A renewed line of CBM-DBI studies focused on instructional utility would further strengthen Stan's continuing influence.



Stan's influence didn't end with his groundbreaking program of research.

- He mentored nearly 100 doctoral students and junior researchers in 40 years at the University of Minnesota and nurtured his colleagues in ways that enriched our careers and helped us live better lives.
- We are among the beneficiaries of Stan's mentoring and friendship.
- He encouraged intellectual curiosity with urgency and persistence.
- He taught us the skills necessary for conducing quality research and developing our own programs of research.
- Maybe most importantly, he insisted that conducting research is a moral endeavor and that integrity is the bedrock of the scientific enterprise.
- The two of us have always been grateful to have had Stan as our mentor, colleague, and friend. We know many people in this room feel the same way.



Thanks, Everybody!