CPAA Technical Report

Christopher Camacho, PhD

Children's Progress

Contents

- **Who this guide is for**
  - Teachers
  - Educational specialists
  - Administrators

- **What it will help you do**
  - Learn about the function and benefits of scaffolding in the CPAA
  - Identify the skills assessed in the CPAA
  - Explore the reliability and validity data of the CPAA

Introduction to the CPAA

The Children's Progress Academic Assessment (CPAA) is an early literacy and mathematics computer-adaptive formative assessment for Pre-K – Grade 3. It functions as an integral component of a comprehensive assessment program at the school, district or state level and consists of three parts:

1. An independently completed formative assessment
2. Immediately generated interactive reports
3. Recommended activities for one-on-one or small group instruction

The CPAA connects assessment with instruction by providing actionable data that can be used by teachers immediately to address each student's needs. The tool also enables educators to track student progress in service of meeting end-of-year learning standards in preparation for summative assessments.

Assessment Design & Development

Assessment is an essential part of every student's academic journey. It allows educators to ensure that students are on the right track and that instruction is adequately matched to their cognitive development. Observational records and analysis of one-on-one interactions have long been the major components of early childhood assessment. While these techniques provide valuable information when administered systematically, they can be time-consuming and influenced by expectations. These tests often produce norm-referenced results (i.e., percentile scores) that offer teachers little actionable information to inform instruction and can be difficult for parents to interpret. Most significantly, these types of tests tell a teacher what a student *cannot* do, without examining *why* he or she may be having difficulty with a particular concept.

Whereas traditional testing methods compare the results of an individual test with a normative group, the criterion-referenced CPAA examines students' underlying skills compared to end-of-year expectations and parse these results to gain a deeper understanding of students' learning abilities and instructional next steps that can help them succeed.

Children's Progress was founded at Columbia University under the guidance of Eugene Galanter, PhD, who has been at the forefront of educational technology since his publication of *The Ideal Teacher* in 1959. In this book, he outlined the challenges that educational technology must overcome in order to benefit both educators and students. Over several decades, Galanter worked at Columbia University to resolve these issues and co-founded Children's Progress to continue this work through computer-based assessment development. With the help of leading researchers from several fields (including psychometrics, computer science, literacy, mathematics and special education), Children's Progress produced an assessment that responds to the problems outlined by Galanter. The following solutions are built into the CPAA to ensure a nuanced and developmentally appropriate assessment for every student.

Challenges Identified by E. Galanter in *The Ideal Teacher*	CPAA Solutions
The Programming Challenge: What is the correct order of presentation of material and how far apart (conceptually) should assessment items be placed?	The CPAA's items are based on a growth model of early literacy and mathematics skills. The assessment begins with the assumption that each child is performing at an average level for his or her grade. Based on each student's responses, question complexity adjusts. If the student experiences difficulty with grade-level material, more foundational concepts are examined. If he or she demonstrates advanced ability, more complex questions are presented. Information about what material a child is partially capable of understanding (or capable of understanding with assistance or scaffolding) provides the basis for targeted instruction within the zone of proximal development.
The Multiple Track Challenge: Can one program be satisfactory for all students?	The path a student takes through the CPAA adjusts based on his or her responses. As such, the assessment experience is different for every child, uniquely adapted to be challenging yet developmentally appropriate for his or her learning needs.
The Prompting Challenge: How should prompts be used?	Positive feedback is used throughout the assessment to increase motivation and engagement. Scaffolding (targeted "hinting") is provided to students after each incorrect response to allow them to try to answer the question one more time. This builds a learning opportunity into the assessment and allows the reporting software to pinpoint misunderstandings more precisely.
The Error Rate Challenge: Is there an optimum number of errors that a student should make?	In order to determine each child's zone of proximal development, the adaptive structure of the CPAA attempts to hone in on areas of partial understanding. Children demonstrating mastery in grade level content are challenged with harder material, while those having difficulty are presented with questions that are more likely to reveal their current level of performance. In short, the CPAA provides little opportunity to "top out" or "fail". Rather, each student is presented with questions that are likely to reveal shades of understanding and therefore be more informative to teachers.
The Learning Progress Challenge: How do you know what the student has learned?	After each assessment, narrative and graphical reports summarizing performance and progress in each domain and concept are immediately generated for educators. As the student takes multiple assessments throughout each school year and from one year to the next, a measure of progress is calculated to help educators make decisions about necessary instructional adjustments.

Assessment Structure

A student's incorrect responses offer as much (if not more) information than his or her correct choices (Piaget, 2002; Piaget and Inhelder, 2000; Vygotsky, 1962, 1978). Take as an example a student who answers "6 - 3 = 9" and another who responds "6 - 3 = 63." These students are making two fundamentally different errors; however, without analyzing their individual response patterns, it would be impossible to determine how best to intervene and instruct each of them. However, many early childhood assessments do not thoroughly describe a student's response pattern and do not provide insights about the nature of each student's misunderstandings.

Unlike traditional assessments, the CPAA uses an adaptive structure to ensure that every student views material that is appropriately challenging. Correct responses are followed by more difficult questions and incorrect responses are followed by verbal and/or visual scaffolding. If the student struggles with the scaffolded content, the assessment presents him or her with less challenging material. Furthermore, the errors that each student commits are analyzed and different types of scaffolding are provided in response to different types of errors. For example, if a student is asked to identify the letter "B" and chooses the letter "V," the assessment provides a specific hint designed to direct the student's attention to "*listen* carefully." On the other hand, if the student responds with the number "8" instead of the letter "B," the scaffolding directs him or her to "*look* at the letters closely."

Unlike traditional assessments, such as paper and pencil tests, which only reveal two polar states of understanding (unaided success and unaided failure), the CPAA uses scaffolding to dissociate what a child can do independently from what he or she can do with targeted assistance. With this information, teachers can pinpoint each student's unique *zone of proximal development (ZPD)* and identify areas where instruction would be most effective for him or her. This extra step drives effective differentiated instruction across a broad range of early literacy and mathematics concepts.

Let's take a look at an example to understand how scaffolding works in the CPAA. If the student incorrectly answers the initial question (Fig. 1a), he or she will see the scaffolded question (Fig. 1b). The follow-up question presents the numbers vertically, with an added visual cue (four balls, three of which disappear from the screen). Moreover, depending on how the student answered the original question, different audio cues accompany the follow-up. For example, a student who answered "4-3=7" is instructed that the "minus sign means you *take away*... What is four take away three?"

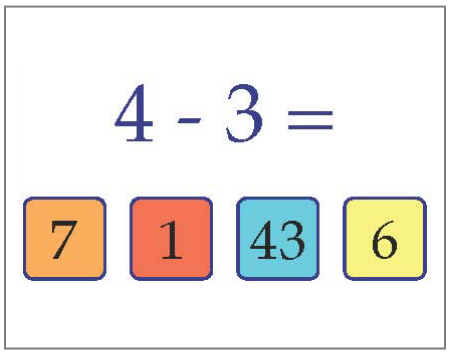

Fig. 1a. Initial Subtraction Question.

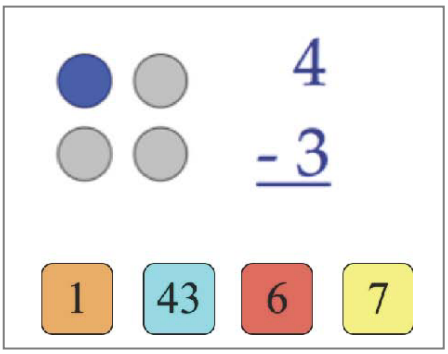

Fig. 1b. Follow-up Question with Scaffolding.

In another example, a sample of Kindergarteners was presented with the words “ball, bell, car, and yarn” and asked to identify the word that rhymes with “barn.” Almost 60% answered incorrectly. An analysis of their errors revealed that roughly 4/5 chose words that had the same initial sound as barn, such as “ball,” “bell” (Fig. 1a). For each of these incorrect responses, students received a targeted hint designed to clarify the concept. In this case, they were given an example of a rhyming pair and told to listen to the “ending sound” of the words. After seeing this hint, roughly half of those who initially answered incorrectly were able to answer the follow-up question (Fig. 1b). In sum, 72% of the students were able to answer this rhyming question correctly on their first try or with scaffolding (a hint).

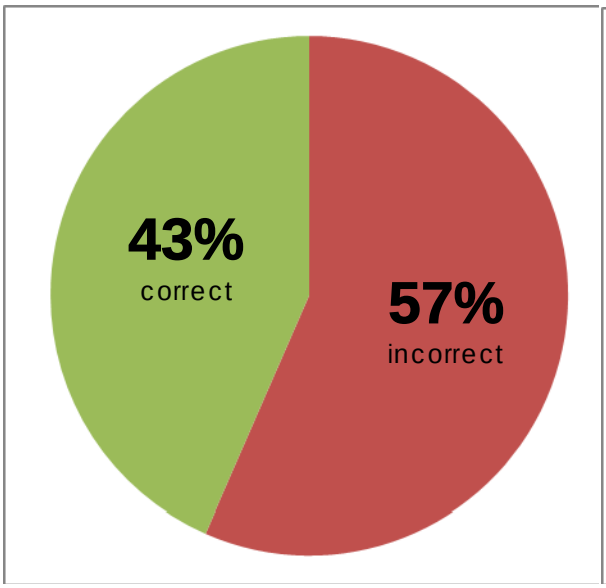

Fig. 1a. Responses after initial question

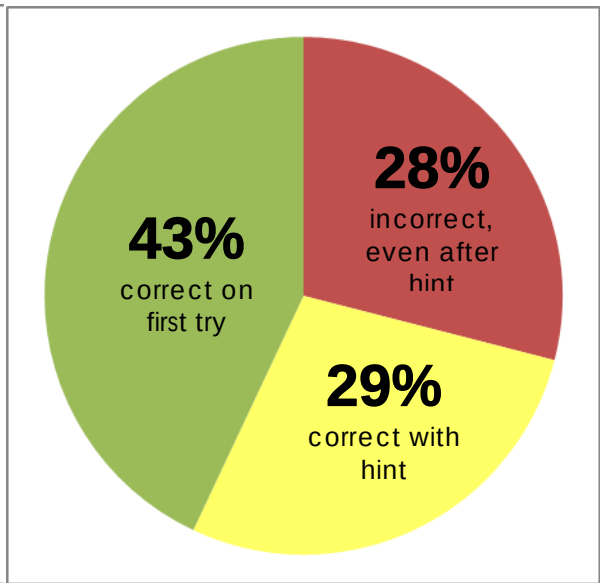

Fig. 1b. Responses after follow-up question

These examples demonstrate that targeted scaffolding can provide valuable instruction within an assessment, allowing students to perform successfully on skills they are on the brink of mastering.

Organization of Concepts Grounded in a Developmental Model

The CPAA contains three assessment banks (fall, winter, and spring). Each bank consists of unique questions that cover the same core literacy and mathematics concepts with increasing difficulty as the year progresses.

To ensure that the CPAA is broad yet sensitive enough to provide challenging content across a wide range of performance levels, it has the capacity to allow a student to view material approximately one grade level above and one below his or her grade, if necessary. For instance, a student demonstrating mastery in Grade 1 may move on to some content appropriate for Grade 2, while a student struggling with Grade 1 material will be directed to questions that are more appropriate at his or her level.

To illustrate both 1) how the CPAA adjusts to individual student responses on the fly and 2) how the content of the assessment is arranged in a developmentally appropriate way, on the next page is a

schematic map of the questions covering a single concept (phonemic awareness) in a single grade (Grade 1).

This map illustrates the many different combinations of questions that a student might experience. Each node represents a question and its respective scaffolded follow-up question (which is presented to a student if he or she incorrectly answers the initial question).

- **If the student correctly answers the initial question**, he or she moves on to more advanced content (indicated by green arrows).
- **If the student incorrectly answers the initial question but correctly answers the scaffolded follow-up**, he or she moves on to additional grade-appropriate content (indicated by orange arrows).
- **If the student incorrectly answers both the initial question and the scaffolded follow-up question**, the CPAA takes him or her to less challenging content (indicated by red arrows).

This dynamic structure ensures that there are more than 19,000 unique pathways that a student may take just through this one concept. This scope allows the assessment to adjust to the each student's skill level, providing him or her with the most appropriate content.

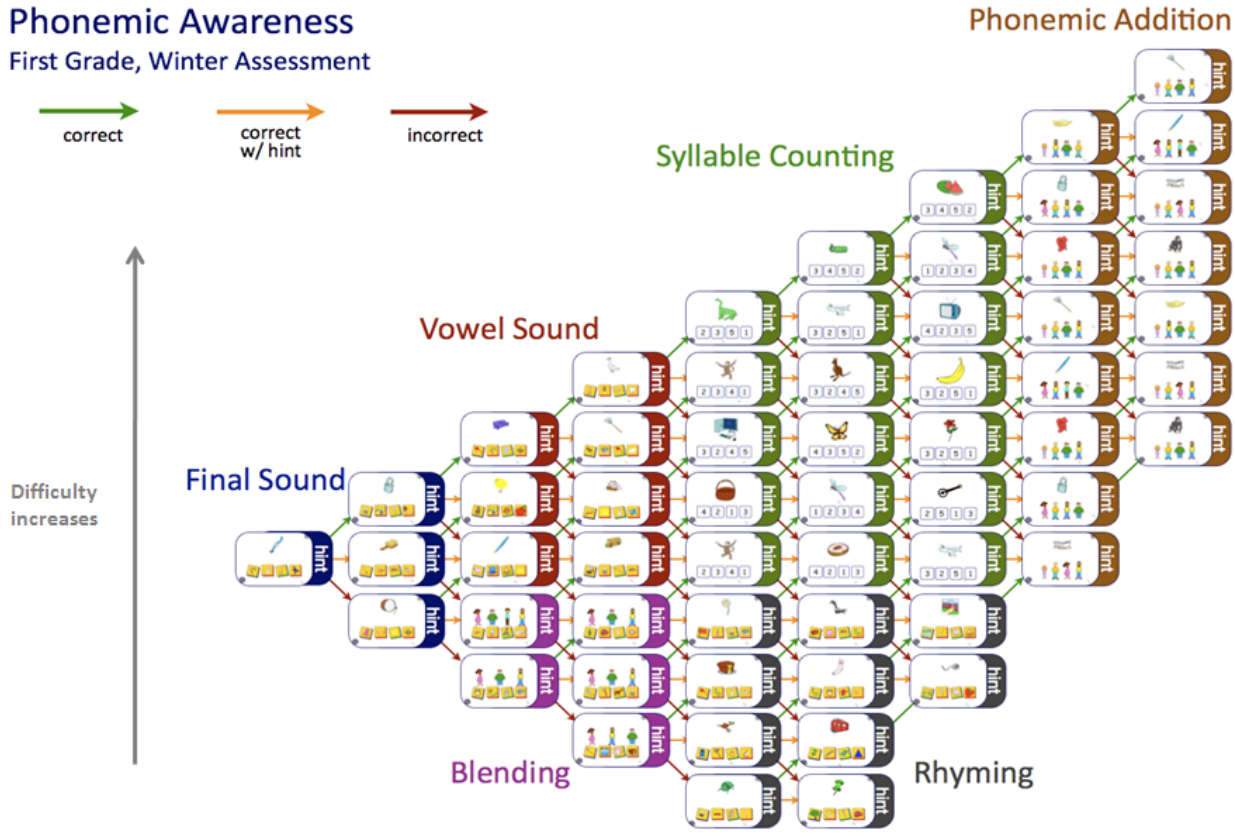

Fig. 2. Sample CPAA Schematic Map (phonemic awareness questions in the Winter 1st Grade Assessment**).**

Content Covered & Scoring Paradigm

The CPAA covers the following literacy and mathematics concepts essential to early childhood development:

Early Literacy

Listening	• Listening Skills	• Listening Comprehension
Phonemic Awareness	• Compound Words • Blending • Rhyming • Initial Sound • Final Sound	• Vowel Sound • Syllable Counting • Phonemic Addition • Decoding Nonsense Words
Phonics & Writing	• Letter Id. • Letter-Sound *(single letter, blends & digraphs)* • Spelling • Alphabet Order	• Editing *(punctuation, capitalization, contractions, syntax, verb tense, possessive noun, plurals, pronouns)* • Paragraph Completion
Reading & Reading Mechanics	• Name Fluency • Concepts of Print *(book & text)* • Sight Words • Decodable Words • Sentence Reading • Synonyms/Antonyms • Homographs/Homophones • Advanced Vocabulary	• Short Passage Comprehension • Long Passage Comprehension *(details, main idea, inference, concepts of print - genre, vocabulary, sequences and true statement/opinions)* • Prefixes • Parts of Speech *(prepositions, verbs, adverbs, adjectives, pronouns)*

Mathematics

Measurement	• Shape Id. • Length/Height/Size/Weight Comparison • Positions • Quantity Comparison • Currency Id. • Currency Addition & Subtraction • Measurement Units	• Length/Weight/Temperature Estimation • Time Id. • Elapsed Time • Calendar • Bar & Line Graphs • Rounding
Numeracy	• Number Id. • Quantity Id. • Subitizing • Ordinality • Number After • Correct Order • Unit Blocks	• Place Value • Expanded Notation • Number Comparison • Fraction Id. • Fraction Comparison • Fraction Addition & Subtraction • Decimal Comparison
Operations	• Addition • Subtraction • Multiplication	• Division • Word Problems
Patterns & Functions	• Categorization • Shape Patterns	• Numerical Patterns • Addition/Subtraction/Multiplication/ Division Functions

This conceptual scope and sequence was developed according to the standards outlined by the International Reading Association (IRA) and National Council of Teachers of English (NCTE) in *Standards for the English Language Arts* (1996) and the National Council of Teachers of Mathematics (NCTM) in *Principles and Standards for School Mathematics* (2000). As such, the content covers the most critical foundational skills for early literacy and mathematics and is aligned to state and national learning standards, including the Common Core State Standards.

Building on extensive analysis of one-on-one interactions with students and pilot testing, we have operationalized a developmental model of knowledge acquisition. All concepts were arranged within the assessment to align with this order of how student learning progresses from skill to skill. For instance, it is widely acknowledged that the ability to isolate the initial sound of a word develops prior to the ability to isolate the final sound. Moreover, the ability to isolate the vowel sound of a word often develops after the ability to isolate a final consonant. The scope and sequence of these skills in our assessments reflects this order.

As mentioned previously, the dynamic structure of the assessment ensures that the set of sub-concepts that each student sees is dependent on his or her pattern of responses.

In addition to detailed narrative summaries, the CPAA supplies expectation scores for each concept assessed. In order to help educators identify how students are performing with respect to end of year expectations, reports in each state are customized to reflect relevant state expectations. Both numerical scores and narrative summary explanations are provided to help educators grasp individual and group performance at a glance and delve deeper into the details of any particular misunderstanding. A numerical score on a four-point scale serves as a shorthand to help identify students and groups on the right track with respect to expectations:

[1] – Below Expectation
[2] – Approaching Expectation
[3] – At Expectation
[4] – Above Expectation

Reliability & Validity Testing

Children's Progress was awarded a research grant from the National Institutes of Health (NIH -no. R44 HD 048134) to examine the reliability and validity of the CPAA. Data from 2412 students who completed fall, winter, and spring assessments between September 2006 and May 2007 was analyzed. The sample consisted of 120 students in pre-kindergarten, 650 in kindergarten, 686 in Grade 1, 683 in Grade 2, and 273 in Grade 3. These students attended 32 schools throughout New York City, Yonkers, New Haven and Philadelphia. All assessments were administered by trained Children's Progress research staff. The fall assessments were administered between October 1 and November 10, the winter assessments were administered between January 15 and February 20, and the spring assessments were administered between April 1 and May 10. Only students who completed all three administrations were included in the reliability analysis.

The tables below display the distribution of students across all four CPAA score categories (below expectation [1], approaching expectation [2], at expectation [3], and exceeding expectation [4]) for all grades and administration periods (fall, winter, spring). All scores reference end of year expectations for grade-level learning standards.

The data presented here demonstrates that student performance on the CPAA is regular and sound. Approximately 31% of all students scored "above expectation," 35% scored "at expectation," 26% scored "approaching expectation" and the remaining 8% scored "below expectation."

Pre-K Score Distributions

FALL

Domain	Concept	Score			
		Below Expectation (1)	Approaching Expectation (2)	At Expectation (3)	Above Expectation (4)
Literacy	Listening	15%	36%	19%	30%
	Phonemic Awareness	31%	43%	18%	9%
	Reading	22%	43%	16%	19%
	Phonics	14%	26%	7%	52%
	Total:	**21%**	**37%**	**15%**	**27%**
Math	Measurement	4%	12%	27%	57%
	Numeracy	14%	31%	24%	32%
	Patterns	27%	30%	23%	21%
	Total:	**15%**	**24%**	**24%**	**37%**

WINTER

Domain	Concept	Score			
		Below Expectation (1)	Approaching Expectation (2)	At Expectation (3)	Above Expectation (4)
Literacy	Listening	24%	19%	27%	31%
	Phonemic Awareness	34%	20%	27%	19%
	Reading	14%	31%	25%	30%
	Phonics	11%	15%	9%	65%
	Total:	**20%**	**21%**	**22%**	**36%**
Math	Measurement	1%	21%	26%	51%
	Numeracy	15%	19%	25%	42%
	Patterns	9%	23%	32%	36%
	Total:	**8%**	**21%**	**28%**	**43%**

SPRING

Domain	Concept	Score			
		Below Expectation (1)	Approaching Expectation (2)	At Expectation (3)	Above Expectation (4)
Literacy	Listening	4%	33%	27%	36%
	Phonemic Awareness	14%	21%	39%	25%
	Reading	18%	12%	27%	43%
	Phonics	8%	12%	7%	73%
	Total:	**11%**	**19%**	**25%**	**45%**
Math	Measurement	1%	8%	15%	76%
	Numeracy	9%	13%	35%	43%
	Patterns	5%	34%	18%	43%
	Total:	**5%**	**19%**	**23%**	**54%**

Kindergarten Score Distributions

FALL

Domain	Concept	Score			
		Below Expectation (1)	Approaching Expectation (2)	At Expectation (3)	Above Expectation (4)
Literacy	Listening	17%	17%	47%	19%
	Phonemic Awareness	10%	25%	55%	10%
	Reading	21%	47%	21%	11%
	Phonics	3%	19%	25%	53%
	Total:	**13%**	**27%**	**37%**	**23%**
Math	Measurement	1%	8%	41%	49%
	Numeracy	4%	26%	51%	19%
	Patterns	10%	17%	51%	22%
	Total:	**5%**	**21%**	**49%**	**25%**

WINTER

Domain	Concept	Score			
		Below Expectation (1)	Approaching Expectation (2)	At Expectation (3)	Above Expectation (4)
Literacy	Listening	8%	18%	19%	54%
	Phonemic Awareness	18%	32%	31%	19%
	Reading	34%	20%	28%	19%
	Phonics	3%	20%	46%	31%
	Total:	**16%**	**23%**	**31%**	**31%**
Math	Measurement	1%	3%	48%	49%
	Numeracy	7%	41%	39%	14%
	Patterns	10%	9%	40%	41%
	Total:	**6%**	**17%**	**39%**	**38%**

SPRING

Domain	Concept	Score			
		Below Expectation (1)	Approaching Expectation (2)	At Expectation (3)	Above Expectation (4)
Literacy	Listening	6%	18%	18%	58%
	Phonemic Awareness	6%	30%	42%	22%
	Reading	12%	32%	30%	26%
	Phonics	5%	40%	50%	5%
	Total:	**7%**	**30%**	**35%**	**28%**
Math	Measurement	3%	12%	47%	38%
	Numeracy	3%	15%	42%	40%
	Patterns	6%	5%	38%	51%
	Total:	**4%**	**20%**	**39%**	**37%**

Grade 1 Score Distributions

FALL

Domain	Concept	Score			
		Below Expectation (1)	Approaching Expectation (2)	At Expectation (3)	Above Expectation (4)
Literacy	Phonemic Awareness	9%	20%	45%	25%
	Reading	4%	25%	32%	39%
	Writing Mechanics	0%	9%	58%	33%
	Total:	**4%**	**18%**	**45%**	**32%**
Math	Measurement	4%	23%	63%	10%
	Numeracy	4%	42%	35%	18%
	Operations	2%	37%	46%	15%
	Patterns and Functions	1%	2%	36%	61%
	Total:	**3%**	**26%**	**45%**	**26%**

WINTER

Domain	Concept	Score			
		Below Expectation (1)	Approaching Expectation (2)	At Expectation (3)	Above Expectation (4)
Literacy	Phonemic Awareness	13%	46%	23%	18%
	Reading	6%	17%	30%	46%
	Writing Mechanics	0%	41%	46%	13%
	Total:	**7%**	**35%**	**33%**	**26%**
Math	Measurement	19%	26%	50%	6%
	Numeracy	9%	35%	32%	24%
	Operations	1%	12%	32%	56%
	Patterns and Functions	2%	13%	67%	18%
	Total:	**7%**	**22%**	**45%**	**26%**

SPRING

Domain	Concept	Score			
		Below Expectation (1)	Approaching Expectation (2)	At Expectation (3)	Above Expectation (4)
Literacy	Phonemic Awareness	8%	45%	31%	15%
	Reading	4%	16%	32%	47%
	Writing Mechanics	2%	30%	27%	42%
	Total:	**5%**	**30%**	**30%**	**35%**
Math	Measurement	10%	42%	31%	17%
	Numeracy	5%	47%	35%	14%
	Operations	5%	13%	14%	69%
	Patterns and Functions	5%	19%	38%	38%
	Total:	**6%**	**30%**	**29%**	**34%**

Grade 2 Score Distributions

FALL

Domain	Concept	Score			
		Below Expectation (1)	Approaching Expectation (2)	At Expectation (3)	Above Expectation (4)
Literacy	Phonemic Awareness	2%	34%	34%	31%
	Reading	2%	9%	32%	57%
	Writing Mechanics	1%	12%	44%	43%
	Total:	**2%**	**18%**	**36%**	**44%**
Math	Measurement	1%	54%	39%	5%
	Numeracy	8%	34%	32%	27%
	Operations	3%	74%	18%	6%
	Patterns and Functions	1%	9%	45%	46%
	Total:	**3%**	**43%**	**33%**	**21%**

WINTER

Domain	Concept	Score			
		Below Expectation (1)	Approaching Expectation (2)	At Expectation (3)	Above Expectation (4)
Literacy	Phonemic Awareness	6%	30%	22%	42%
	Reading	4%	22%	17%	58%
	Writing Mechanics	18%	32%	36%	14%
	Total:	**9%**	**28%**	**25%**	**38%**
Math	Measurement	6%	45%	29%	20%
	Numeracy	3%	23%	40%	34%
	Operations	4%	16%	57%	23%
	Patterns and Functions	9%	46%	27%	18%
	Total:	**5%**	**32%**	**38%**	**24%**

SPRING

Domain	Concept	Score			
		Below Expectation (1)	Approaching Expectation (2)	At Expectation (3)	Above Expectation (4)
Literacy	Phonemic Awareness	3%	18%	31%	49%
	Reading	9%	55%	16%	21%
	Writing Mechanics	8%	20%	51%	21%
	Total:	**6%**	**31%**	**33%**	**30%**
Math	Measurement	22%	41%	27%	10%
	Numeracy	8%	16%	23%	54%
	Operations	7%	43%	37%	13%
	Patterns and Functions	3%	41%	47%	9%
	Total:	**10%**	**35%**	**33%**	**21%**

Grade 3 Score Distributions

FALL

Domain	Concept	Score			
		Below Expectation (1)	Approaching Expectation (2)	At Expectation (3)	Above Expectation (4)
Literacy	Reading Mechanics	0%	5%	37%	57%
	Reading Comprehension	1%	16%	42%	41%
	Writing Mechanics	1%	24%	46%	29%
	Total:	**1%**	**15%**	**42%**	**42%**
Math	Measurement	2%	45%	37%	17%
	Numeracy	2%	17%	72%	8%
	Operations	7%	24%	44%	25%
	Algebraic Functions	0%	2%	38%	60%
	Total:	**3%**	**22%**	**48%**	**28%**

WINTER

Domain	Concept	Score			
		Below Expectation (1)	Approaching Expectation (2)	At Expectation (3)	Above Expectation (4)
Literacy	Reading Mechanics	7%	43%	28%	23%
	Reading Comprehension	2%	19%	25%	55%
	Writing Mechanics	3%	30%	50%	17%
	Total:	**4%**	**31%**	**34%**	**32%**
Math	Measurement	15%	25%	47%	14%
	Numeracy	1%	11%	60%	28%
	Operations	5%	13%	45%	36%
	Algebraic Functions	5%	16%	35%	44%
	Total:	**6%**	**16%**	**47%**	**31%**

SPRING

Domain	Concept	Score			
		Below Expectation (1)	Approaching Expectation (2)	At Expectation (3)	Above Expectation (4)
Literacy	Reading Mechanics	9%	61%	25%	4%
	Reading Comprehension	6%	42%	38%	15%
	Writing Mechanics	8%	40%	40%	12%
	Total:	**8%**	**48%**	**34%**	**10%**
Math	Measurement	21%	26%	46%	7%
	Numeracy	5%	28%	42%	25%
	Operations	5%	16%	35%	43%
	Algebraic Functions	9%	37%	33%	21%
	Total:	**10%**	**27%**	**39%**	**24%**

Evidence of Internal Consistency

Factor analyses were conducted on all individual concepts within each domain (early literacy and mathematics) across all grades (Pre-K – Grade 3) and all administrations (fall, winter, spring). This was done to evaluate internal consistency and confirm that all concepts (e.g., phonemic awareness, listening, phonics, reading) are statistically related to the relevant domain (e.g., literacy) and are indeed assessing student understanding of that domain.

The tables below display data from the factor analyses for the literacy and mathematics concepts across the fall, winter, and spring assessments. Note that (1) only one factor is derived through the factor analysis, and (2) that each concept loads onto that single factor. All domains for all grades across all administration periods have Eigenvalues equal to or greater than 0.8 - with the majority of Eigenvalues greater than 1.0. Moreover, all concepts load onto the single factor for the relevant domain with values greater than 0.4 – the majority having loading factors greater than 0.5. These results provide evidence of the internal consistency of the CPAA and allow for a rigorous test of the instrument's reliability. The analysis revealed that all concepts in literacy loaded onto a single domain, as did all concepts in mathematics.

PRE-KINDERGATEN (N = 120)

		FALL		WINTER		SPRING	
		Eigenvalue	Load	Eigenvalue	Load	Eigenvalue	Load
Literacy	Listening	1.5	0.69	1.5	0.61	1.5	0.68
	Phonemic Awareness		0.56		0.61		0.55
	Phonics		0.58		0.68		0.5
	Reading		0.63		0.55		0.72
Math	Numeracy	0.81	0.6	0.95	0.54	0.71	0.52
	Patterns & Functions		0.46		0.5		0.58
	Measurement		0.49		0.64		0.32

KINDERGATEN (N = 650)

		FALL		WINTER		SPRING	
		Eigenvalue	Load	Eigenvalue	Load	Eigenvalue	Load
Literacy	Listening	1.46	0.56	1.64	0.55	1.53	0.42
	Phonemic Awareness		0.63		0.61		0.61
	Phonics		0.6		0.65		0.68
	Reading		0.62		0.75		0.72
Math	Numeracy	1.4	0.71	1.33	0.6	1.27	0.68
	Patterns & Functions		0.49		0.56		0.5
	Measurement		0.55		0.53		0.56
	Operations		0.59		0.61		0.49

GRADE 1 (N = 686)

		FALL		WINTER		SPRING	
		Eigenvalue	Load	Eigenvalue	Load	Eigenvalue	Load
Literacy	Phonemic Awareness	1.34	0.6	1.1	0.56	1.05	0.65
	Phonics		0.71		0.62		0.64
	Reading		0.71		0.63		0.47
Math	Numeracy	1.49	0.74	1.4	0.7	1.24	0.52
	Patterns & Functions		0.59		0.57		0.55
	Measurement		0.54		0.49		0.59
	Operations		0.55		0.62		0.56

GRADE 2 (N = 683)

		FALL		WINTER		SPRING	
		Eigenvalue	Load	Eigenvalue	Load	Eigenvalue	Load
Literacy	Phonemic Awareness	0.92	0.5	0.84	0.61	0.83	0.49
	Writing Mechanics		0.62		0.38		0.58
	Reading		0.53		0.58		0.5
Math	Numeracy	1.25	0.62	1.17	0.54	1.19	0.56
	Patterns & Functions		0.58		0.49		0.51
	Measurement		0.52		0.58		0.58
	Operations		0.5		0.55		0.53

GRADE 3 (N = 273)

		FALL		WINTER		SPRING	
		Eigenvalue	Load	Eigenvalue	Load	Eigenvalue	Load
Literacy	Writing Mechanics	0.92	0.62	0.87	0.51	0.83	0.57
	Reading Mechanics		0.62		0.52		0.66
	Reading Comp.		0.54		0.58		0.56
Math	Numeracy	1.25	0.49	1.2	0.61	1.19	0.65
	Patterns & Functions		0.54		0.53		0.5
	Measurement		0.59		0.52		0.54
	Operations		0.54		0.53		0.61

Evidence of Reliability

The reliability of the assessment rests on the accuracy, consistency, and stability of results across situations and across time. As previously mentioned, the CPAA consists of three different content banks (fall, winter, and spring) that cover the same content areas with increasing difficulty throughout the year. Therefore, it is important to examine the reliability and stability of the assessment across an entire school year. This renders the reliability analysis more rigorous compared to that of traditional measures and looks at three (rather than just two) distinct points.

To examine the reliability of the CPAA, a Cronbach's alpha was computed for the assessment in each grade and across the three administration periods (fall, winter, spring). Reliability alphas of 0.9, 0.92, 0.92, 0.89, and 0.91 were found overall for the Pre-Kindergarten, Kindergarten, Grade 1, Grade 2, and Grade 3 assessments, respectively.

In sum, across all grades and both subjects, the CPAA demonstrated adequate reliability of 0.89 or higher. Additionally, the analyses revealed reliability alphas of 0.8 on all but one of the domains (mathematics in PK, with a reliability alpha of 0.75). This is especially significant, considering that the reliability of the instrument was examined across an entire year with students completing three different versions of the assessment.

The tables below provide a breakdown of reliability ratings for each grade and concept. These analyses were conducted on the CPAA scores of students who took all three assessments (fall, winter and spring).

PRE-KINDERGATEN (N = 120)

		FALL		WINTER		SPRING		ALPHA
		Mean	SD	Mean	SD	Mean	SD	
Literacy & Math		**53.4**	**19.4**	**61.9**	**19.2**	**69**	**16.7**	**0.9**
Literacy	**Overall**	**47.3**	**21.6**	**56.4**	**22.2**	**63**	**20.1**	**0.89**
	Listening	48.3	30.1	50.2	30.6	61.9	27.2	0.8
	Phonemic Awareness	41.2	25.4	44.8	28.3	53.5	27.1	0.72
	Phonics	58.7	35.6	74.2	33.1	75.1	28.1	0.77
	Reading	41.3	24.6	56.4	28.7	61.7	28.7	0.66
Math	**Overall**	**62**	**20.4**	**69.5**	**19.3**	**77.3**	**15.9**	**0.75**
	Numeracy	60.9	28.9	67.2	26.9	74	20.6	0.67
	Patterns & Functions	48.8	29.4	65.9	29.7	68.4	28.4	0.58
	Measurement	76.2	24.5	75.6	19.2	89.3	16	0.58

KINDERGATEN (N = 650)

		FALL		WINTER		SPRING		ALPHA
		Mean	SD	Mean	SD	Mean	SD	
Literacy & Math		**58.6**	**15.9**	**65.3**	**14.7**	**65.2**	**14.2**	**0.92**
Literacy	**Overall**	**54.2**	**18.4**	**60**	**17.7**	**61.1**	**16**	**0.88**
	Listening	60.4	26.9	74.1	23.5	77.6	21.8	0.65
	Phonemic Awareness	50.7	22.3	52.5	24.9	56.2	21.8	0.69
	Phonics	70.7	25.7	67.8	19.5	55.9	16.5	0.75
	Reading	35.1	24.6	45.3	25.3	54.8	26.2	0.81
Math	**Overall**	**63.3**	**16.2**	**70.7**	**14.1**	**69.4**	**14.9**	**0.84**
	Numeracy	58.1	20.4	57.9	20.4	66.2	20.2	0.78
	Patterns & Functions	58.9	28.2	74.1	24.1	82.3	23.5	0.58
	Measurement	78.2	17.7	81.8	11.6	74.5	20.4	0.59
	Operations	57.4	23	69.2	20.7	54.7	19.8	0.59

GRADE 1 (N = 686)

		FALL		WINTER		SPRING		ALPHA
		Mean	SD	Mean	SD	Mean	SD	
Literacy & Math		**65.8**	**13.7**	**65.7**	**12.9**	**65.8**	**14.3**	**0.92**
Literacy	**Overall**	**66.8**	**16.5**	**65**	**15.7**	**68.5**	**15.7**	**0.88**
	Phonemic Awareness	60.4	21.7	55.6	19.6	70.7	20	0.71
	Phonics	74.1	14.8	62.6	17.7	78.7	20.6	0.71
	Reading	65.8	23.7	76.8	22.5	56	20	0.68
Math	**Overall**	**65.1**	**14**	**66.3**	**13.2**	**63.7**	**15.5**	**0.85**
	Numeracy	60.4	21.5	62	21.5	51.1	19	0.72
	Patterns & Functions	81.4	18.2	72.6	14	77	24.5	0.57
	Measurement	60.6	17.3	57.7	19	58.4	21.1	0.57
	Operations	58.9	16	73.1	16.8	68.5	22.1	0.57

GRADE 2 (N = 683)

		FALL		WINTER		SPRING		ALPHA
		Mean	SD	Mean	SD	Mean	SD	
Literacy & Math		**66.6**	**11.9**	**66**	**13**	**62.5**	**12.2**	**0.89**
Literacy	**Overall**	**75.8**	**14.3**	**69.9**	**15.4**	**68.6**	**14.1**	**0.82**
	Phonemic Awareness	69.1	20.1	81.9	20.3	79.4	18.7	0.6
	Writing Mechanics	73.6	18.6	55.7	19.6	63.6	16.1	0.63
	Reading	63	22	72	22.4	63	22	0.58
Math	**Overall**	**59.7**	**13.2**	**63.1**	**13.7**	**57.8**	**13.6**	**0.83**
	Numeracy	62.7	24.3	69	19.1	72	21.6	0.66
	Patterns & Functions	73	18.1	64.1	20.9	57.9	15.5	0.52
	Measurement	53	15.1	62.5	21.2	47.3	22.2	0.58
	Operations	50.2	15.5	57	16.2	54.5	17.3	0.53

GRADE 3 (N = 273)

		FALL		WINTER		SPRING		ALPHA
		Mean	SD	Mean	SD	Mean	SD	
Literacy & Math		**70.2**	**12.1**	**71.2**	**13.1**	**64.2**	**13.3**	**0.91**
Literacy	**Overall**	**78.8**	**14.9**	**69.7**	**15.2**	**65.3**	**15.5**	**0.85**
	Writing Mechanics	72.7	17.6	81.1	24.1	68.4	18.8	0.64
	Reading Mechanics	82.8	17.8	55.3	19.2	64.4	15.8	0.6
	Reading Comprehension	80.9	22.2	72.9	17.5	63.2	25.9	0.63
Math	**Overall**	**63.6**	**12.9**	**72.3**	**13.6**	**63.6**	**14.4**	**0.85**
	Numeracy	62.4	16	65.6	16.1	66.8	18.1	0.64
	Patterns & Functions	80.5	13.4	78.8	21.6	64.2	20.4	0.56
	Measurement	58.6	21.6	73.1	18.3	52	22.2	0.64
	Operations	53.2	21.5	73.7	21.6	71.2	20	0.69

Evidence of External Validity

In addition to demonstrating appropriate score distribution, internal consistency, and reliability, it is also essential for the CPAA to display evidence of external validity - confirming that it actually measures what it is intended to measure. External validity is assessed through an analysis of the CPAA's relationship to other instruments designed to measure similar constructs.

Using a concurrent validity design, three separate studies were conducted using the CPAA in five schools. A total of 828 students in Grades 1 through 3 in the Maricopa School District in Arizona provided data for external validation. The CPAA was measured against the Dynamic Indicators of Basic Early Literacy Skills (DIBELS) with 393 students in Grade 1, against the Terra Nova Achievement Test (TN) with 269 students in Grade 2 and against the Arizona Instrument to Measure Standards (AIMS) with 166 students in Grade 3. All studies were conducted in the spring of 2006.

Correlation with DIBELS

The Dynamic Indicators of Basic Early Literacy Skills (DIBELS) is a fluency assessment comprising a developmental sequence of one-minute measures: recognizing initial sounds, naming the letters of the alphabet, segmenting the phonemes in a word, reading nonsense words, oral reading of a passage, retelling, and word use. These measures assess phonological awareness, the alphabetic principle, vocabulary, accuracy and fluency in reading connected text, and comprehension. Each measure has been researched and demonstrated to be a reliable and valid indicator of early literacy development.

The letter naming, nonsense word, and phonemic segmentation components of DIBELS and the CPAA were administered to students in the spring of 2006. The results of the CPAA were compared to the raw score and risk categorization metrics provided by the DIBELS measures. Overall, there were significant

correlations observed between DIBELS and the literacy components of the CPAA, providing evidence of the CPAA's external validity.

The overall results of DIBELS (collapsing letter naming fluency, phonemic segmentation fluency, and nonsense word fluency into a single variable) were examined against the overall results for the literacy section of the CPAA. A correlation of 0.55 was discovered, demonstrating that there is a significant positive relationship between the two measures.

Correlation matrix for CPAA Literacy raw score and overall DIBELS Risk Categorization and Index

Grade 1 (N=393)	CPAA Literacy
DIBELS Risk Categorization	0.55
DIBELS Index	0.55

Each subtest of DIBELS was further compared to the relevant literacy sub-concepts of the CPAA and the general literacy domain. The DIBELS letter naming fluency subtest was compared to (1) the CPAA literacy domain, and (2) the CPAA phonics concept sub-assessment. A correlation of 0.46 was found between the CPAA literacy domain and DIBELS letter naming and of 0.33 between the CPAA phonics sub-assessment and DIBELS letter naming.

Correlation matrix for CPAA Literacy and Phonics scores and DIBELS Letter Naming sub-tests

Grade 1 (N=393)	CPAA Literacy (domain)	CPAA Phonics (concept)
Letter Naming Fluency	0.46	0.28
Letter Naming Risk	0.46	0.33

Similarly, the DIBELS nonsense word fluency assessment was compared to (1) the CPAA literacy domain and (2) the CPAA reading concept sub-assessment. A correlation of 0.56 was found between the overall CPAA literacy assessment and the DIBELS nonsense word fluency sub-test. Looking more closely at the CPAA reading sub-assessment (ostensibly, the most closely related concept to DIBELS nonsense word fluency), a correlation of 0.5 was found.

Correlation matrix for CPAA Literacy and Reading scores and DIBELS Nonsense Word fluency sub-tests

Grade 1 (N=393)	CPAA Literacy (domain)	CPAA Reading (concept)
Nonsense Words Fluency	**0.56**	**0.5**
Nonsense Words Risk	**0.55**	**0.48**

Finally, the DIBELS phonemic segmentation fluency sub-test was compared to (1) the CPAA literacy domain and (2) the phonemic awareness concept sub-assessment. A correlation of 0.38 was found between the overall CPAA literacy domain and the DIBELS phonemic segmentation sub-test. A weaker - but still statistically significant - correlation of 0.16 was found between the DIBELS phonemic segmentation fluency sub-assessment and the CPAA phonemic awareness concept. This could be due to the fact that the CPAA phonemic awareness assessment consists of a number of different question types, of which phonemic segmentation is just one.

Correlation matrix for CPAA Literacy and Reading scores and DIBELS Phonemic Segmentation fluency sub-tests

Grade 1 (N=393)	CPAA Literacy (domain)	CPAA Phonics (concept)
Phonemic Segmentation Fluency	**0.38**	**0.16**
Phonemic Segmentation Risk	**0.34**	**0.12**

Correlation with the Terra Nova Achievement Test

The Terra Nova Achievement Test (TN) is a series of achievement tests designed to assess student proficiency in reading, language arts, and mathematics. The TN is one of the most widely used standardized achievement tests in the U.S. and has been thoroughly validated in the field.

The CPAA and the TN were administered to 269 students in Grade 2. A comparison of overall performance on the TN math and the CPAA math uncovered a significant correlation of 0.69. Additionally, significant correlations were observed between the TN math and the mathematics components of the CPAA (numeracy, patterns and functions, measurement, and operations), providing evidence for the external validation of the CPAA.

Correlation matrix for CPAA math assessment (and relevant concept sub-assessments) and the overall Terra Nova math sub-test

Grade 2 (N=269)	CPAA Math	CPAA Numeracy	CPAA Patterns & Functions	CPAA Measurement	CPAA Operations
TN Math	0.69	0.49	0.38	0.63	0.47

The literacy concepts of the CPAA were compared with TN language arts and reading scores. A high correlation was found between the overall CPAA literacy score and the TN language arts and reading subtests. Furthermore, a high degree of correlation was observed between each of the CPAA literacy concepts (phonemic awareness, writing mechanics, and reading) and the TN language arts and reading subtests.

Correlation matrix for CPAA literacy assessment (and relevant concept sub-assessments) and the overall Terra Nova in language arts and reading sub-tests

Grade 2 (N=269)	CPAA Literacy	CPAA Phonemic Awareness	CPAA Writing Mechanics	CPAA Reading
TN Language Arts	0.49	0.36	0.38	0.37
TN Reading	0.55	0.43	0.39	0.42

Correlation with the Arizona Instrument to Measure Standards (AIMS)

The Arizona Instrument to Measure Standards (AIMS) is a state-wide test administered to all third graders in Arizona. The AIMS measures student skills in language arts, reading, and mathematics. The CPAA and the AIMS were administered to 166 students in Grade 3. The results of the CPAA overall raw scores were compared to the overall percentile scores provided by the AIMS across language arts, reading, and mathematics, revealing a correlation of 0.76. Overall, significant correlations were

observed between the Arizona Instrument to Measure Standards (AIMS) and the literacy and mathematics components of the CPAA, providing additional evidence of the CPAA's external validity.

A thorough analysis of the concepts of the CPAA math assessment and the AIMS math assessment led to a discovery of significant relationships.

Correlation matrix for the CPAA math assessment (and relevant concept sub-assessments) and the AIMS math sub-test

Grade 3 (N=166)	CPAA Math	CPAA Numeracy	CPAA Patterns & Functions	CPAA Measurement	CPAA Operations
AIMS Math	0.65	0.54	0.35	0.4	0.59

In a parallel analysis of the CPAA literacy assessment and the AIMS language arts and reading sub-tests, a similar pattern of results was discovered. A high degree of correlation was found between the CPAA literacy components and the AIMS language arts and reading sub-tests.

Correlation matrix for the CPAA literacy assessment (and relevant concept sub-assessments) and the AIMS language arts and reading sub-test

Grade 3 (N=166)	CPAA Literacy	CPAA Writing Mechanics	CPAA Reading Mechanics	CPAA Reading Comprehension
AIMS Language Arts	**0.67**	**0.58**	**0.39**	**0.49**
AIMS Reading	**0.67**	**0.54**	**0.36**	**0.53**

About Children's Progress

Children's Progress (www.childrensprogress.com) is an award-winning educational technology company. We specialize in the development of engaging computer-adaptive programs for young children that help educators pinpoint how to best support and challenge each student. The company grew out of decades of research at Columbia University and patented its products in collaboration with MIT. Children's Progress assessments have been used by schools, districts, and state agencies nationwide.

Scientific Advisors

A dedicated board of scientific advisors provides guidance and assistance to Children's Progress as we continue to develop solutions to the challenges of early childhood assessment.

- ***Literacy***: Reid Lyon, PhD is the former Chief of Child Development at the National Institute of Child Health and Human Development at the National Institutes of Health (NIH). Dr. Lyon was instrumental in the development of the Reading First legislation and has worked extensively to bring phonemic awareness to the forefront of early childhood literacy. Dr. Lyon has provided oversight in the development of the literacy components of the CPAA.
- ***Mathematics***: Herman Chernoff, PhD is Professor of Mathematics and Statistics at Harvard University and MIT. Dr. Chernoff is a member of the National Academy of Sciences and the American Academy of Arts and Sciences and has written extensively on teaching basic algebra to children who are just beginning to learn arithmetic. Dr. Chernoff provides oversight in the development of the mathematics components of the CPAA.
- ***Dynamic Approach***: Robert Sternberg, PhD is Provost at Oklahoma State University, and has previously served at Dean of Arts and Sciences at Tufts University, Executive Director of the PACE Center, and President of the American Psychological Association. Dr. Sternberg developed the Theory of Successful Intelligence and has published more than 1,000 books and articles on the subject of human competencies. Dr. Sternberg provides oversight in the application of the scaffolding procedures used by the CPAA.
- ***Psychometrics***: Drew Gitomer, PhD is the Distinguished Presidential Appointee at the Educational Testing Service (ETS) and is the former Vice President of Research and Development at ETS. Dr. Gitomer is currently researching how assessments can improve the effectiveness of the teaching force. Dr. Gitomer provides oversight in the psychometric analysis of data collected by the CPAA.
- ***Special Education****:* Steven Mark is the former Chief Advisor of the Office of General Counsel for the Chandra Smith Consent Decree Unit (the organization responsible for special education oversight) and the former Assistant Superintendent for Special Education for the Los Angeles Unified School District. Mr. Mark provides oversight in the procedures used to apply the CPAA to the special education population.
- ***Computer Science***: Sam Madden, PhD is Professor of Computer Science at MIT. Dr. Madden researches database systems, focusing on query processing over streams, and was instrumental in the development of the technology that underlies the CPAA.

References

Galanter, E (1959). *The ideal teacher*. In Automatic Teaching: The State of the Art, E. Galanter (Ed). John Wilely and Sons: New York.

International Reading Association and National Council of Teachers of English (1996). *Standards for the English Language Arts.* NCTE.

National Council of Teachers of Mathematics (2000) *Principles and Standards for School Mathematics*. NCTM.

Piaget, J. (2002). *The language and thought of the child*: Jean Piaget: Selected works. London: Routledge.

Vygotsky, L. S. (1962). *Thought and language*. Cambridge, MA: MIT Press.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.