

Why Should Cognitive Learning Models Be Used as the Foundation for Designing Next Generation Assessment Systems?

Topic 1 White Paper

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Acknowledgments

This white paper is based on discussions that occurred at the Invitational Research Symposium on Learning Maps and Learning Progressions, held at SRI in Arlington, Virginia, on July 21–22, 2011. The symposium was inspired by the participating researchers' interest in the context of the national movement toward more rigorous and higher academic expectations for all students, particularly as reflected in the Common Core State Standards and in the newly funded U.S. Department of Education consortia involving two General Supervision Enhancement Grants and two Race to the Top programs. All the consortia referenced learning progressions or learning maps in their proposals, and their related assessments under development are intended to allow for monitoring growth and measuring achievement for accountability. Symposium participants sought to better understand how learning progressions/learning maps apply to students in special populations and how they can be used to develop assessments that are equitable and reliable and yield valid outcomes for these students.

The meeting brought together a group of researchers engaged in research involving learning progressions and maps for instruction and/or assessment, students with disabilities, and educational measurement. Accordingly, the symposium addressed three specific themes: (1) using learning progressions and maps as the foundation for designing next-generation assessment systems, (2) critical considerations for students with disabilities and English language learners, and (3) technical considerations in the development of learning progressions and learning maps for assessment and special populations. Three white papers were produced as a result of the symposium discussions on these themes. The symposium participants and contributing authors share their understanding of these issues and offer insights to researchers applying or planning to conduct studies on new inclusive assessment systems.

We thank the authors of the white papers for their contributions and commitment to this project. Special thanks go to the symposium organizers, facilitators, and lead authors, Renée Cameto, Edynn Sato, Patricia Almond, Neal Kingston, Sue Bechard, and Karin Hess, for their expertise in moving the work from discussion to publication and to SRI staff in carrying out the critical logistics with such thoroughness and grace. We also acknowledge the financial support of the Center on Educational Testing and Evaluation (CETE) at the University of Kansas and the in-kind support provided by WestEd and the Center for Assessment.

Audience and Purpose

Target audiences for this paper are researchers, cognitive scientists, instructional design experts, test developers, and practitioners. Researchers with expertise in the cognitive sciences will be needed to help increase understanding of cognitive pathways. Instructional design experts can help translate what is known about the cognitive pathways into learning progressions. Instructional experts can help design learning environments that maximize the effective implementation of learning progressions. Test developers will need to draw on research findings and the expertise of cognitive scientists, technology and instructional designers, psychometricians, and engineers to develop reliable and valid assessments. Ultimately, practitioners who work with the students will need expertise in diagnosis, intervention, and assessment. Clearly, a teamwork approach is required to realize the potential of the research agendas proposed in the papers to strengthen the validity of next-generation assessments that are appropriately inclusive of special student populations.

SRI/CETE Invitational Symposium

Using Cognitive Learning Models to Inform the Development of Assessments for Students in Special Populations

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Abstract

A symposium on understanding learning progressions and learning maps to inform the development of assessments for students in special populations was held in July 2011. The symposium posed the following major question for work group 1's consideration: "Why should learning progressions/learning maps be used as a foundation for new generation assessment systems?" Underlying issues discussed included why there is a need for a different approach to assessment, characteristics of cognitive learning models (CLMs), and how CLMs can be used to inform assessment design. This white paper reports the substance of the work group's deliberations.

Beginning with a description of traditional standards-based assessments, this paper presents a case for using cognitive learning models as a foundation for designing next-generation assessment systems. It describes how new assessment initiatives intended to measure achievement on the Common Core State Standards (CCSS) have promise for new assessment system design. Next, definitions and comparisons of several cognitive learning models (learning progressions and learning maps) are presented, differentiating them from grade-level content standards and curricular progressions in terms of their content descriptors and development processes. The purposes and uses of formative, interim, and summative assessments are explained, with suggestions as to how underlying cognitive learning models might be used as the foundation for a comprehensive assessment system. Advances in the use of CLMs for test and item design have the potential of providing greater validity in assessments for all students, as well as improving interpretation and use of assessment results for the benefit of teaching and learning.

Introduction

Traditionally, neither content standards nor summative assessments have been developed on the basis of cognitive research or a central theory of learning. Yet there are implications and potential benefits for assessment systems from designing assessments of learning using research-based hypotheses about how students typically build expertise in a content domain. This paper explores how learning progressions and learning maps—jointly referred to here as *cognitive learning models*—can contribute to the development of truly comprehensive assessment systems. Specifically, we describe how cognitive learning models can establish a foundation for the design of instructionally sensitive assessments for both general education students and students in special populations (those with disabilities and English language learners) that provide more useful and valid data at the classroom, school, district, and state levels about students' progress in learning.

This paper begins with a description of standards-based assessments traditionally used to measure academic skills and knowledge and current assessment initiatives intended to measure achievement of the Common Core State Standards. We address limitations of the current assessment system in developing a more sophisticated understanding of learning, and consequently teaching, especially for students in special populations. The second section presents definitions and comparisons of learning progressions and learning maps and describes

how they are different from grade-level content standards and curricular progressions in terms of both their content descriptors and development processes. The last section explores the purposes and uses of formative, interim, and summative assessments and posits how underlying cognitive learning models might be used as the foundation for a more comprehensive assessment system. Such advances in test and item design have the potential to facilitate valid interpretation and use of assessment results for the benefit of teaching and learning and consequently improve the quality of instruction for all students. Finally, we propose an alternative vision for assessment design and identify new research questions that should be addressed to ensure that the next generation of assessments provide for valid inferences that inform the instruction of all students.

Current State of Standards and Assessments and New Possibilities

What is the Current State of Student Assessment and Why is There a Need for a Different Approach?

The United States is currently engaged in the most substantially funded educational reform in a generation with the goal of ensuring access to high-quality educational opportunities for every student. Student assessment has taken center stage in these reform efforts. The development of Common Core State Standards (CCSS) in English language arts (ELA) and mathematics and the initiatives being pursued through the Race to the Top (RttT) (and General Supervision Enhanced Assessment consortia) are dramatically changing how assessments and assessment systems will be designed and used in the future. The time is right to consider the variety of ways that new assessment systems can be envisioned and how assessment results will be used to gauge learning, monitor progress, and make decisions about students, teachers, and schools. Moreover, it is essential that the unique learning and assessment needs of students with disabilities and English language learners be taken into account as research and development efforts go forward.

Standards-based assessments. Since the passage of the *No Child Left Behind Act of 2001* (NCLB), states have been using standards-based assessments designed to portray the performance status of subgroups of students¹ at the school, district, and state levels for each grade level tested. Under this model, states use three to four or five performance levels (i.e., *advanced, proficient, partially proficient, basic, below basic*) to describe and categorize a range of student achievement. Based on the percentages of students who score at the proficient and advanced levels, schools are judged on whether they have made adequate yearly progress in raising achievement for *all* students. Tests created for NCLB accountability purposes strive to both sample the academic content described by the content standards at each grade level and maximize the number of test items around the partially proficient-proficient decision point (determined by standard setting) so that a large amount of data are available for making accountability judgments. Annual public reports display the outcomes for each student subgroup for each content area and grade level and compare previous years' results with those for the current year. Several of the consequences of this design are noteworthy:

- Assessment data provide little reliable information about what students performing at the highest and lowest achievement levels actually know and can do;

¹ Subgroups of students include Major Racial & Ethnic groups, Students with Disabilities, Limited English Proficient, Economically Disadvantaged, Migrant, Gender (U.S. Department of Education, 2003).

- Although information may exist on individual student performance from year to year, there is often little coherence among the knowledge and skills tested at adjacent grade levels; and
- It is not yet clear whether states understand and are able to apply data resulting from the use of various growth models to improve instruction and support academic learning over time.

The state content standards that high-stakes assessments are built on define the order in which and the time or grade level by which students are expected to learn specific content and skills as evidenced by satisfactory performance levels; this makes the standards more prescriptive than descriptive (Daro, P., Mosher, F., & Corcoran, T., 2011). State mathematics standards, which are the subject of the CPRE report, “have not been deeply rooted in empirical studies of the ways children’s thinking and understanding of mathematics actually develop in interaction with instruction” (p. 16). In other words, the standards have typically included a list of mathematics topics but do not address how the topics are related or how students develop an understanding of core concepts of mathematics.

Similar observations have been made about other content areas. In an investigation of state science standards, researchers at the Fordham Institute (Finn, Jr., Schwartz, Lerner, Haack, Gross, Schwartz & Goodenough, 2005) concluded that “most state standards have serious problems” (p. 6), including excessive length and poor navigability, thin disciplinary content, and an overemphasis on constructivist learning. In a subsequent review of state standards (Carmichael, Wilson, Porter-Magee, & Martino, 2010), the Fordham Institute researchers declared that “several states made great improvements to their math standards since we last reviewed them in 2005. However, similar progress was generally not visible for ELA” (p. 8).

Common Core State Standards. The national response to the lack of coherence and comparability among state content standards has led to the creation of the Common Core State Standards (CCSS) and federally funded consortia projects to develop a new generation of assessments that expand testing opportunities to include formative, interim, and summative assessments of the content described. In addition, these initiatives propose to use growth-based models of accountability, applying longitudinal individual student data in new and perhaps more useful ways.

The CCSS represent the first standards-based effort to bring national alignment to ELA and mathematics curricula. The CCSS have been adopted by most of the states across the country.

The Common Core State Standards Initiative establishes a shared set of clear educational standards for English language arts and mathematics that states can voluntarily adopt. The standards have been informed by the best available evidence and the highest state standards across the country and globe and designed by a diverse group of teachers, experts, parents, and school administrators, so they reflect both our aspirations for our children and the realities of the classroom. These standards are designed to ensure that students graduating from high school are prepared to go to college or enter the workforce and that parents, teachers, and students have a clear understanding of what is expected of them. The standards are benchmarked to international standards to guarantee that our students are competitive in the emerging global marketplace.

(Common Core State Standards Initiative, 2010,
<http://www.corestandards.org/frequently-asked-questions>)

Although the Fordham Institute does not endorse any products, its 2010 review of the CCSS concludes that improvements have been made; and despite their imperfections, the CCSS for ELA and mathematics are far superior to those standards now in place in many states, districts, and classrooms. The report states that the CCSS are ambitious and challenging for students and educators alike. Accompanied by a properly aligned, content-rich curriculum, they provide K–12 teachers with a sturdy instructional framework for the most fundamental of subjects (pp. 27–32).

Many may agree that the CCSS are an improvement over most states' current content standards. Yet the CCSS do not describe the pathways students are expected to progress along, nor do they address how the knowledge and skills necessary for learning core concepts in the content areas develop within and across grades (Renaissance Learning, Inc., 2011). As a matter of fact, the CCSS avoid suggesting that there is any optimal pathway for teaching and learning the content standards:

[J]ust because topic A appears before topic B in the standards ... does not necessarily mean that topic A must be taught before topic B. A teacher might prefer to teach topic B before A, or might choose to highlight connections ... of her own choosing that leads to A or B. (CCSSM, 2010, p. 5)

Each individual teacher is therefore left to decide how and what content to teach at any given time during the school year, resulting in widely varying learning opportunities for all students.

Four consortia have been funded through Race to the Top and the Office of Special Education Programs (OSEP) to develop assessments of the CCSS; summative, interim/benchmark, and formative assessments, as well as curricular materials, are currently in development. The two RTTT comprehensive Assessment Consortia² are developing assessments for 99% of all students, including approximately 90% of students with disabilities. The two OSEP Alternate Assessment Consortia (General Supervision Enhancement Grants, GSEGs) are developing alternate assessments based on alternate achievement standards for students with significant cognitive disabilities.³ Additionally, all these assessments will include some students who are English language learners.

Growth models. Some education researchers have argued for moving away from using achievement status, the current accountability approach, to using students' achievement growth (Betebenner, 2009; Hanushek & Raymond, 2005). The rationale for using achievement growth rather than status arises from two concerns. Measuring growth would hold schools accountable for achievement outcomes that they can control—*how much* students learn during a given school year—rather than on their past achievement of different content and skills. Under status models, schools do not receive credit for student growth that occurs within a given performance level. Consequently, status models tend to encourage schools to focus more on moving students from “approaching proficiency” to “proficiency” rather than focusing on the achievement growth of all students, including those in special populations (Ladd & Lauen, 2009). Educators need to be able to articulate students' academic progress in both qualitative and quantitative ways,

² The Partnership for Assessment of Readiness for College and Careers (PARCC) and the Smarter Balanced Assessment Consortium (SBAC)

³ The Dynamic Learning Maps (DLM) Consortium and the National Center and State Collaborative (NCSC).

especially for the heterogeneous groups of students identified with a range of disabilities and students who are English language learners. Currently, these subgroups are disproportionately functioning below proficient status in virtually all states.

In his seminal paper, Carlson (2001) outlined a framework for conceptualizing accountability system design, particularly considering the relationship of growth-based to status-based systems. He described four conceptually distinct types of school performance: status, improvement, growth, and acceleration. Each view of performance involves different types of measurement, different criteria for determining “good enough” performance, and different implications for accountability systems. Whereas state accountability has directed most attention to status and improvement, in the past several years more attention has been paid to growth and acceleration and the interactions among these four types of performance.

The broadening of attention to growth models in school *accountability* has taken place concurrently with attention to *assessment* of student longitudinal growth. Perhaps even more significantly, there has been a parallel development of *content specifications* that describe development of student expertise and performance over time to go with the interest in measurement of student growth and the incorporation of growth in accountability models. For example, *value-added and growth models* (e.g., Betebenner, 2009) are quantitative approaches for measuring and depicting change in student performance over time; these differ from single-point-in-time status measures. Similarly, *learning progressions* are qualitative approaches for describing possible changes in student knowledge and skills over time; these differ significantly from typical end-of-year content standards.

Any model of growth, whether quantitative such as growth models or content based such as learning progressions, should be empirically validated. Typically, models are validated for the most typical or largest group of students. A widely postulated challenge is that special populations, such as students with disabilities and English language learners, may have different developmental patterns of learning and performance than other students. Therefore, growth models—quantitative or content based—must be explicitly validated for use with special populations, especially when some students’ growth may be atypical and idiosyncratic (Gong, in process).

How can Cognitive Learning Models Reshape Our Thinking About Learning and Assessment?

Cognitive learning models—often referred to in the literature as learning progressions (in science), learning trajectories (in mathematics), developmental continuums (in reading), or learning maps—hold promise for improving the utility of assessment results and better informing instructional decisions. For the purpose of this paper, the term *cognitive learning models* is used to encompass empirically based descriptions of the learning pathways that most students take as they develop understanding from novice to higher levels of expertise in concepts and skills.

What distinguishes expert from novice performers is not simply general mental abilities, such as memory or fluid intelligence, or general problem-solving strategies. Experts have acquired extensive stores of knowledge and skill in a particular domain. But perhaps most significant, their minds have organized this knowledge in ways that make it more retrievable and useful. ... Most important, they have efficiently coded and organized (chunks of) this information into well-connected schemas ... which helps them to notice features and meaningful

patterns ... that might be overlooked by less competent learners. The schemas enable experts, when confronted with a problem, to retrieve the relevant aspects of their knowledge. ... Doing so effectively moves the burden of thought from limited capacity of working memory to long-term memory. (Pellegrino, Chudowsky, & Glaser, 2001, pp. 72–73)

In other words, long-term memory (and achievement of content standards) is not about accumulating a collection of skills and knowledge but making meaningful connections among skills and knowledge built on over time. Further, “while it is recognized that competence can develop along multiple pathways to reach the same understandings, we are learning that some pathways will be followed more often than others. These typical paths provide the basis for developing learning progressions” and learning maps (Hess, 2012c, p. 2).

Cognitive learning models are distinguished from a scope and sequence, pacing guide, or a curricular progression based on end-of-year standards in that they are developed based on research syntheses and conceptual analyses (Smith, Wiser, Anderson, & Krajcik, 2006). Learning models (such as learning progressions) articulate a central theory of learning, visually and verbally representing hypothesized pathways to increased understanding of the learning targets (Hess, Kurizaki, & Holt, 2009), articulating successively more sophisticated ways of thinking (Wilson & Bertenthal, 2005). Unlike standards, learning models reflect the systematic consideration of interactions among the learner, the content, and the context for learning (e.g., situational, sociocultural, nature of support/scaffolding), as well as the dynamic, cumulative outcomes of these interactions (Cameto, Bechard, & Almond, 2012).

Further, the measurement objectives of end-of year assessments and cognitive learning model assessments also differ. For a standards-based assessment, the key objective is to examine whether or not students are proficient relative to agreed-on expectations at each grade level. Cognitive learning model assessments seek to identify where a student falls along a learning progression while also maintaining the ability to determine how proficient the student is on a given grade level standard. Therefore, learning models can “represent a framework for developing meaningful assessments, allowing both large-scale and classroom-based assessments to be grounded in models of how understanding develops in a given domain” (Alonzo & Steeldle, 2008). Finally, cognitive learning models provide understandable points of reference for designing assessments for summative, interim, and formative uses that can report where students are in terms of those steps, rather than reporting only in terms of where students stand relative to their peers (Daro, Mosher, & Corcoran, 2011).

Exhibit 1 illustrates the difference between end-of -year content standards and how students might develop and demonstrate expertise in those standards over time or across the school year (Hess, 2008). Two grade 3 mathematics standards from the CCSS are listed below. These standards represent *end points* for learning during the third-grade school year.

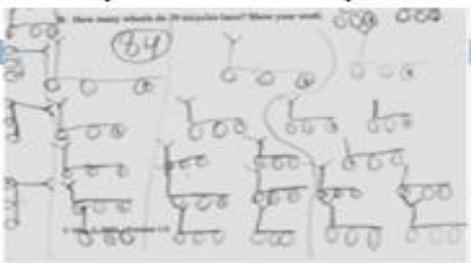
- **3.OA-1:** Interpret products of whole numbers, e.g., interpret 5×7 as the total number of objects in 5 groups of 7 objects each. *For example, describe a context in which a total number of objects can be expressed as 5×7 .*
- **3.OA-5:** Apply properties of operations as strategies to multiply and divide.

Students generally enter grade 3 with a solid understanding of some, but probably not all, grade 2 mathematics content standards. As teachers begin to present problems that require

“interpreting products of whole numbers,” they will typically see many students using an additive strategy— not multiplication—to arrive at the correct answer. Later in the school year, students will begin to transition to use of multiplicative strategies, which may not look exactly like what is expected by the end of school year. Near the end of the school year, not only will students be using multiplication, but many will also be appropriately applying order of operations when multiplying or dividing. This is a progression of learning.

Exhibit 1. Formative assessments can uncover student thinking and reasoning, demonstrating how understanding is becoming more sophisticated as described along a learning continuum (Hess, 2008).

One tricycle has three wheels.
How many wheels do 29 tricycles have?



Additive Strategy

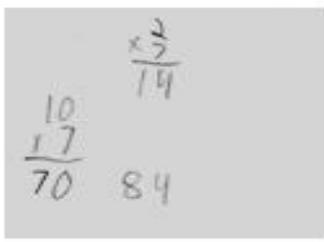
Transitional Multiplicative Strategy

Write an equation to match this picture.



Multiplicative Strategy

Farmer Brown donated 7 dozen eggs to the senior center.
How many eggs did he donate?



Source: OGAP 2008

Studies have begun to show that tracking student progress using formative assessments and a learning progressions schema can have a positive effect on teaching practices in terms of more strategic use of formative assessments, deeper understanding of the content, and teacher perceptions of the lowest performing students (Hess, 2012a). Corcoran, Mosher, and Rogat (2009, p. 8) presented a case for using learning progressions to inform more adaptive practices in assessment and instruction in order to achieve the current ambitious education reform goals:

We are convinced that it is not possible for the reform goals with respect to “all students’ to be met unless instruction in our schools becomes much more adaptive. That is, the norms of practice should shift in the direction in which teachers and other educators take responsibility for continually seeking evidence on whether their students are on track to learning what they need to if they are to reach the goals, along with tracking indicators of what problems they may be having, and then for making pedagogical responses to that evidence designed to keep their students on track, or to get them back on track, moving toward meeting

the goals. This, of course, is a description of a formative assessment process in action. We are additionally convinced that teachers will not be able to engage in such processes unless they have in their minds some idea about how students' learning in the subjects they are teaching develops over their time in school, as well as some idea of the ways of responding to evidence of their progress or problems that are likely to be effective. We have been looking for promising ideas about what this metaphor of "on track" (or its obverse – "off track") might mean in terms that could be accessible to and useful for teachers and their students. One such idea that has attracted growing attention in education reform circles is the concept of learning progressions.

Characteristics of Cognitive Learning Models

What are Cognitive Learning Models and How do They Articulate Learning Pathways?

Several important concepts are embedded in the various descriptions of cognitive learning models: (a) the pathways reflect what we know about typical—or most—learners, (b) the pathways are hypothesized and rely on ongoing revisions as empirical evidence accumulates, (c) the pathways do not reflect strictly developmental progress—some seem to be universal, others logical, while others may depend highly on prior experience, and (d) learning is dynamic and interactive—what is learned in one content area is likely to influence what is learned/built on in other content areas. In all cases, focused instruction plays a key role in empirically based cognitive learning models, meaning that deeper understanding of skills and concepts does not happen naturally but is supported by targeted instruction.

In addition, cognitive learning models can differ in grain size, scope, and breadth (Heritage, 2010; Hess, 2008); and while they do not determine or predict the pace of learning, descriptors of a smaller grain size suggest that progress will be seen within a shorter time than when the model describes a greater scope or breadth of learning. Learning model descriptors can be specified at various grain sizes that range from discrete skills and knowledge typically developed in a linear manner (e.g., learning to recognize letters and sounds before reading/decoding words) to broader networks of related concepts and skills, developed in tandem en route to mastery. Grain size can also be a function of content area, as mathematics is generally seen as having descriptors of a smaller grain size and English language arts tends to be coarser grained (William, 2011).

To illustrate grain size differences in learning model descriptors, Exhibit 2 depicts very fine-grained skills that students typically acquire as they develop understanding of geometric transformations in mathematics. This is an example of a small section pulled from the learning map developed at the University of Kansas by the Dynamic Learning Maps (DLM) GSEG, which in its current version has more than 2,500 learning targets with over 3,500 connections representing the relationships among learning targets. The DLM uses the learning map to drive assessment item development and ultimately to make inferences about what students know and can do from assessment data. Exhibit 2 provides a limited view of the hypothesized conceptual development associated with spatial abilities. It was developed on the basis of available research on how mathematics concepts and skills are typically acquired. At the top are some of the necessary precursors (describe, recognize, and represent rotation, translation, and reflection) to "describe the properties of lines and line segments in transformations"; through words, drawings,

models, etc., students communicate that in rotations, reflections, or translations, lines remain lines and that line segments remain line segments of the same length. Exhibit 2 also shows how that seminal skill then leads to increased understanding and sophistication involving two-dimensional figures and other geometric relationships. An important feature of this visual is that it shows the interconnectedness of skill acquisitions that accumulate to allow an important concept to develop, not necessarily in a linear manner.

One limitation to viewing an isolated section of the learning map is that other ideas that typically develop synergistically may not be visible apart from the larger map. For example, in creating this section of the learning map various theories and perspectives were drawn on in an effort to propose how spatial understanding develops over time. Clements, Battista, and Sarama (2001) described how mathematical understanding of geometric concepts can be explained using theories proposed by Piaget and the Van Hiele. They contended that children need to explore the components and attributes of shapes in a concrete way to provide a foundation for understanding geometric concepts. “Merely seeing and naming pictures of shapes is insufficient” (Clements et al., p. 3). The “describe” learning targets in Exhibit 2 represent a student’s ability to communicate what he or she knows about the geometric concepts derived from concrete experiences, which in turn leads to “recognizing” or identifying and naming the concept followed by the ability to “construct a representation” of the concept. The DLM learning map will continue to undergo validation studies leading to revisions, as the hypothesized cognitive learning models are refined.

Exhibit 2. Section of the DLM Mathematics Map - Transformations



DLM (in progress)

In contrast, Exhibit 3 depicts a larger set of related skills and learning targets that students build on in becoming proficient readers of informational texts. Larger grained progress indicators (grades K–8) are organized around a big idea of reading (*Reading is making meaning at the text level and understanding the unique features, structures, and purposes of print and non-print informational texts.*) and describe the progressively more complex skills and concepts students might typically demonstrate along a general learning progression at each grade span.

Exhibit 3. Excerpt From K-12 Reading Informational Text Strand of the ELA Learning Progressions Framework (Hess, 2011)

Enduring Understanding for Reading Informational Texts (RI): Reading is making meaning at the text level and understanding the unique features, structures, and purposes of print and non-print informational texts.

(K–4) Elementary School Learning Targets

E.RI Recognize and use knowledge of expository text structures (e.g., sequence, description, definition, compare-contrast, cause-effect) and genre-specific features to read and comprehend informational texts: Identify, compare, and draw inferences about concepts, central ideas, point of view, and supporting details.

Grades K–2

Students comprehend informational texts...

E.RI.a offering a basic emotional response to informational texts read, texts read aloud, or texts viewed

E.RI.b demonstrating basic concepts of print (e.g., follows words/pictures left-right, top-bottom; matches spoken words to print words; distinguishes words from sentences; book parts)

E.RI.c recognizing organization and features of informational texts (e.g., describes a topic, finds facts in visual information)

E.RI.d approaching informational texts with a question to answer; identifying key details and main topic

E.RI.e locating/interpreting information using a variety of text features (e.g., title, illustrations, bold print, glossary)

E.RI.f making connections among pieces of information (e.g., sequence events, steps in a process, cause-effect, compare-contrast relationships)

E.RI.1g exploring the differences among texts and recognizing author's purpose: texts to "teach" us about...

Grades 3–4

Students comprehend informational texts...

E.RI.h locating relevant key ideas using text features (e.g., table of contents, diagrams, tables, animations) to answer questions and expand understanding

E.RI.i identifying, paraphrasing, or summarizing central ideas and supporting details; determining importance of information

E.RI.j attending to signal words, text structure, and semantic cues to interpret and organize information (e.g., sequence, description, compare-contrast, cause-effect)

E.RI.k using supporting evidence to analyze or compare texts or parts of texts: author's purpose, points of view, key ideas/details, different accounts

E.RI.l using evidence to show how graphics/ visuals support central ideas

E.RI.m using a variety of sources to research a topic; determining relevance of information; making connections within or across texts

E.RI.n analyzing how authors use facts, details, & explanations to develop ideas or support their reasoning

(5–8) Middle School Learning Targets

M.RI Use content knowledge, knowledge of expository text structures (e.g., compare-contrast, cause-effect, proposition-support, critique), and genre-specific features, to read, comprehend, and analyze a range of informational texts, including textbooks and on-line texts: Explain, compare, and analyze concepts, events, central ideas, point of view, relevant details.

Grades 5–6

Students comprehend informational texts ...

M.RI.a flexibly using strategies to derive meaning from a variety of print/non-print texts

M.RI.b using text structures (e.g., cause-effect, proposition-support), search tools, and genre features (e.g., graphics, captions, indexes) to locate and integrate information

M.RI.c using background knowledge of topics to ask and refine questions and summarize central ideas using relevant details

M.RI.d using supporting evidence to draw inferences or compare content presented within or across texts

M.RI.e identifying author's purpose, viewpoint, or potential bias and explaining its impact on the reader

M.RI.f determining relevance or comparability of concepts and supporting details from multiple sources and integrating them to research a topic

M.RI.g analyzing how an author develops ideas and supports a thesis or reasoning

Grades 7–8

Comprehend informational texts...

M.RI.h flexibly using strategies to derive meaning from a variety of print/non-print texts

M.RI.i utilizing knowledge of text structures and genre features to locate, organize, or analyze important information

M.RI.j using supporting evidence to summarize central ideas, draw inferences, or analyze connections within or across texts (e.g., events, people, ideas)

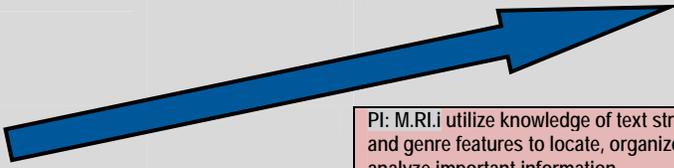
M.RI.k analyzing and explaining why and how authors: organize, develop, and present ideas; establish a point of view; or build supporting arguments to affect the text as a whole

M.RI.l comparing or integrating information from multiple sources to develop deeper understanding of the concept/topic /subject, and resolving conflicting information

Exhibit 4 focuses on one grade level (grade 7), indicating how a teacher might plan instruction and assessments using progress indicators (PIs). The descriptors in the progression can be thought of as a set of steps that students might take on the way to mastering a more distant curricular aim (standards). Beneath each step are possible subskills, instructional building blocks that enable learning. For example, if a standard calls for students to become skilled readers, a learning progression might include the subskills of taking texts apart in order to understand how and why authors put the texts together in just that way. The complete learning progression for becoming a skilled reader will include many possible subskills targeted to address different student needs. Reading each new type of informational text requires students to “go up and down the steps” repeatedly to learn a strategy that will help them in understanding the text, take the text apart to see how the smaller pieces connect (e.g., introduction + body + conclusion), and put the text back together for more complete and deeper understanding (summarize key ideas, make inferences, analyze reasoning, etc.) (Hess, 2012c).

Exhibit 4 is an excerpt from the ELA Learning Progressions Framework (LPF)⁴ (Hess, 2011). It displays PIs linked to *parts* of Common Core standards that show the steps that many students take along a learning path within and across grades. The PIs help teachers unpack standards based on how understanding develops, identifying precursor skills needed for success. Links to the Common Core can include related reading, language, and speaking-listening standards to guide instruction (as in the exhibit).

Exhibit 4. Excerpt From the Grade 7 LPF: Progress Indicators (PI) for Reading Informational Texts, With grade 7 Common Core-Related Standards, and Possible instructional Building Blocks for Each Step (PI) That Guide Learning at Each Step



<p>PI: M.RI.h flexibly use strategies to derive meaning from a variety of print/non-print texts 7.RI-4; 7.L-4, 5a; 7.SL-2</p> <p>Instructional Building Blocks for this PI might begin with</p> <ul style="list-style-type: none"> • Listen for key ideas in news/media stories 7.SL-2 • Interpret and connect information presented in visuals of print/non-print informational texts (e.g., arrows in a graphic organizer showing how a plant grows or how water evaporates) 7.SL-2 • Answer the question: what is the intended meaning of this word or phrase? 7.RI-4; 7.L-4 	<p>PI: M.RI.i utilize knowledge of text structures and genre features to locate, organize, or analyze important information 7.RI-5</p> <p>Instructional Building Blocks for this PI might include:</p> <ul style="list-style-type: none"> • Locate & use informational text features to answer questions (captions, titles, headings, etc.) • Develop schemas of text purposes and types by identifying the kind of information found in different informational texts (newspaper versus magazine) • Recognize structures that help to organize information (e.g., introduction, body, conclusion; signal words for compare-contrast, proposition-support) 7.RI-5 	<p>PI: M.RI.j use supporting evidence to summarize central ideas, draw inferences, or analyze connections within or across texts (e.g., events, people, ideas) 7.RI-1, 2, 3, 9</p> <p>Instructional Building Blocks for this PI might include:</p> <ul style="list-style-type: none"> • Locate text evidence to support inferences about the central idea presented in the text 7.RI-1 • Summarize key ideas 7.RI-2 • Draw inferences from or make connections about what is stated or implied in one text 7.RI-3 • Find similar OR different information about a topic in two or more texts/sources 7.RI-9
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Hess, 2011

⁴ The LPF was collaboratively developed by researchers and educators for use in both general education and special education classrooms. The National Center and State Collaborative (NCSC) GSEG has further broken down each PI for instruction and assessment purposes.

Both smaller and larger grained learning models depict learning pathways that are believed to support the mastery of skills applied to highly valued core concepts and larger enduring understandings (Wiggins & McTighe, 2001). Implicit in learning models is the importance of building on prerequisite skills and knowledge and the development of deeper understanding over time.

Improving student learning and achievement happens in the immediacy of an individual lesson ... or it doesn't happen at all. Teachers design the "right" learning target for (each daily) lesson when they consider where the lesson resides in a larger learning trajectory and identify the next steps students must take to move toward the overarching understandings described in the standards and the unit goals. (Moss & Brookhart, 2012, p. 2)

Small studies with K–8 teachers are beginning to show that preassessments designed and used formatively to determine whether students have essential prerequisite skills can help teachers better focus instruction at the start of a unit of study and decrease instructional time that might have been spent on skills that students either do not need or are not ready for (Hess, 2012a). While individual learning rates will always vary to some degree, learning models can make instructional time more efficient and probably more effective.

Prerequisite skills, mastery over time, and varying rates of learning have important implications for the design of assessments that are grounded in hypotheses of how students develop expertise in a content domain. By identifying both the intermediate and "end" points (e.g., learning goals for the end of the grade level) along a learning progression, key targets for assessment can be established. For students who appear not to have reached an intermediate or end point within a progression, the skills and knowledge that typically precede critical developmental points can become the focus of assessment. Additionally, when known misconceptions or common misunderstandings are associated with prerequisite understandings, assessments can be designed to be sensitive to the extent to which a specific misconception or common misunderstanding is interfering with a student's ability to demonstrate progress. In contrast to today's summative and large-scale assessments, which sample a broad array of grade-level end points for learning, assessments designed to measure development along a learning progression can focus on critical developmental points, providing instructionally relevant information about acquisition of critical skills and knowledge and/or misconceptions that may be interfering with a student's ability to show growth.

What are the Similarities and Differences Between Learning Progressions (LPs) and Learning Maps (LMs) and How are They Developed?

The development of both learning progressions and learning maps begins with examining content and current best practices but also entails synthesizing content-specific research, cognitive science, and empirically based learning theory. These syntheses form the basis for the learning model. The development and validation approaches of content standards and learning models differ in two key ways: establishing the end goals (e.g., skills for college and career readiness) and exploring how expertise develops in each content domain and continuing to gather data to modify the model. Whereas the CCSS have been validated by the authority of expert judgment and international benchmarking, cognitive learning models are validated by empirical evidence gathered through targeted instruction over time, strategic assessments that uncover thinking and reasoning, and observations and examinations of student work samples.

The assumptions underlying the learning model pathways are open to refinement; they are hypotheses about learning to be tested and refined with data.

One example of the steps used in developing a learning model comes from the DLM project, described here to contrast the development of the CCSS. The development of the dynamic learning maps for ELA and mathematics on the DLM GSEG project is an ongoing iterative process of four major steps: internal development, external reviews, hypothesis testing with simulated data, and collection of empirical data for validation. Revisions to the maps occur throughout the process and are expected to continue as long as new information is collected on student learning.

The first step of development begins with teams of developers creating initial drafts of the learning maps. In this step, they identify the learning targets (called *nodes*) and the relationships (*connections*) among the learning targets (see Exhibit 2), determine how to represent them visually, and document pertinent information about each node on a spreadsheet. A thorough review of the empirical research is conducted. In particular, the development teams identify seminal research in each content strand and synthesize these findings with the guidance of content experts. During this process, the development team records the CCSS code (content/grade level), the node label and description, and relevant literature citations.

After nodes are identified, they are placed on the map. Beginning with the most foundational learning targets, the DLM teams determine how each node represents a significant step in development, considering the literature on cognitive development, curricular patterns, and instructional strategies. As the map is built, the node connections are represented visually and documented on the spreadsheet. These connections constitute a predicted relationship between skills, which may occur in a single direction (such as seen in unidimensional learning progressions) or with multiple connections that resemble networks. The outcome represents an integrated approach to skill development and increasing understanding and complexity.

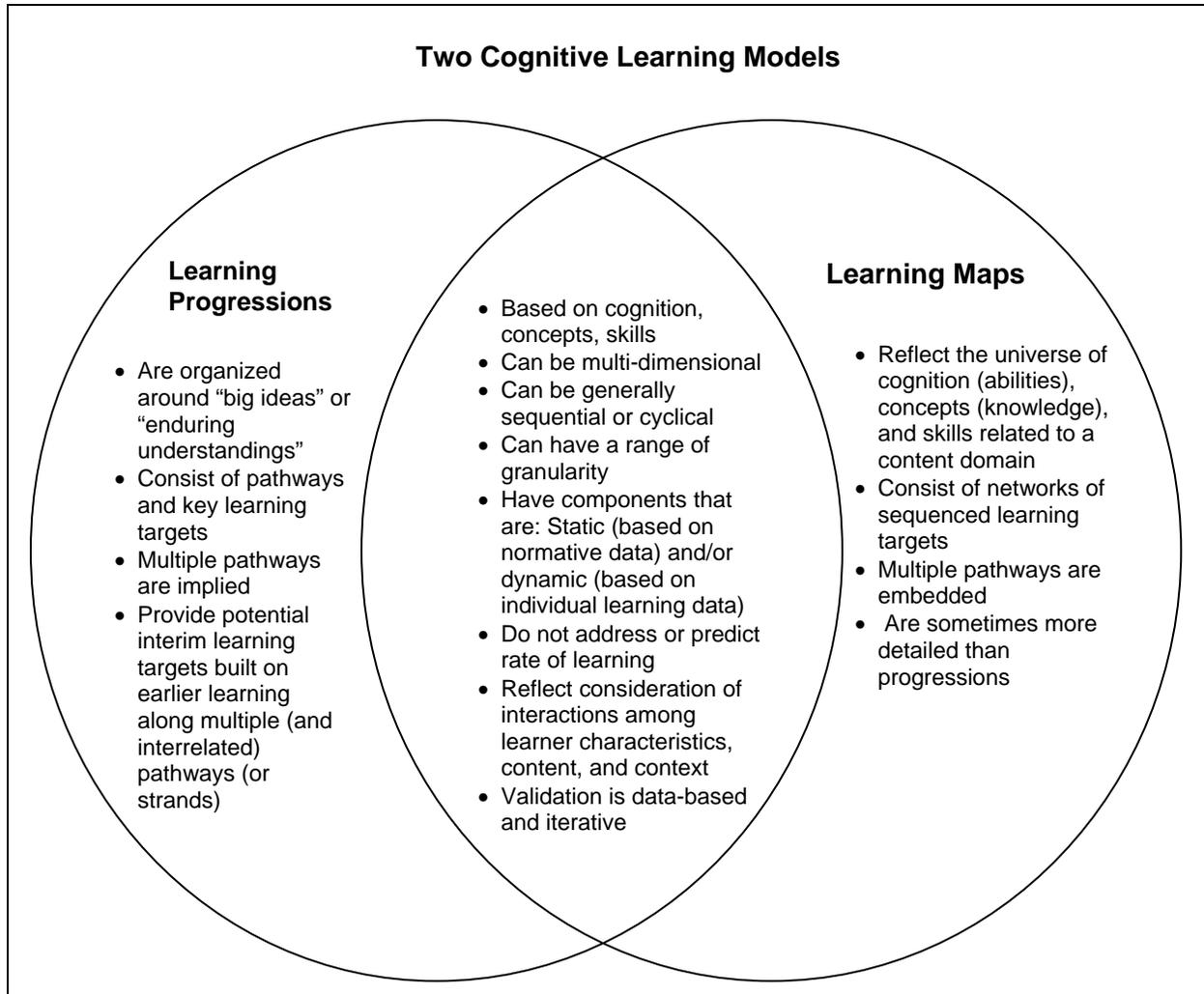
The second step in the development process involves external reviews by three different groups of experts and revisions after each review. First, content experts—experienced general educators and content specialists—provide input on how students typically acquire the knowledge and skills represented in the maps. Next, related service providers and special and general educators with experience with diverse populations provide information on alternate pathways that may be necessary for some students to reach important learning targets (i.e., students who have sensory disabilities will need additional and different skill sets to access and understand print). Finally, cognitive scientists review the maps from the perspective of construct development, focusing on how information is represented, processed, and transformed, from low-level learning and decision mechanisms to high-level logic and planning.

The third and fourth steps apply student achievement data to the maps to test the predictions and gather evidence to validate the hypotheses about learning represented by the nodes and the connections. Information from previous assessments of similar knowledge and skills is used to inform the statistical prediction model, followed by field-testing of large samples of students to observe how the maps operate for the target population.

Both learning progressions and learning maps are derived from cognitive science and theories of learning, and both represent hypotheses about how learning will progress for most students. Unlike content standards that describe the end points for learning at each grade level, learning models suggest an intentional mapping of how to teach and build on earlier concepts to

reach the intended learning goals (Hess, 2012a). That said, several distinct differences also exist between the two types of models. Exhibit 5 shows key similarities and differences between learning progressions and learning maps.

Exhibit 5: Cognitive Learning Models: Characteristics of Learning Progressions and Learning Maps



New Approaches to Assessment System Design

What are the Components of a Comprehensive Assessment System?

The RTTT and GSEG assessment development proposals all included new testing strategies that constitute a more comprehensive approach to assessment, driven by general dissatisfaction about the reliance on one large-scale assessment used to serve multiple purposes. For example, the Smarter Balanced Assessment Consortium’s (SBAC) Content Specifications for ELA and Literacy (Hess, 2012d, pp. 8–9) states:

The Consortium’s Theory of Action calls for full integration of the learning and assessment systems, leading to more informed decision-making and higher-quality instruction, and ultimately to increased numbers of students who are well prepared for college and careers. To that end, SBAC’s proposed system features rigorous Common Core State content standards; common adaptive summative assessments that make use of technology-enhanced item types, and include teacher-developed performance tasks; computer adaptive interim assessments—*reflecting learning progressions*—that provide mid-course information about what students know and can do; instructionally sensitive formative tools, processes, and practices that can be accessed on-demand; focused ongoing support to teachers through professional development opportunities and exemplary instructional materials; and an online, tailored, reporting and tracking system that allows teachers, administrators, and students to access information about progress towards achieving college- and career-readiness as well as to identify specific strengths and weaknesses along the way. Each of these components serve to support the Consortium’s overarching goal: *to ensure that all students leave high school prepared for post-secondary success in college or a career through increased student learning and improved teaching*. Meeting this goal will require the coordination of many elements across the educational system, including but not limited to a quality assessment system that strategically “balances” summative, interim, and formative components (Darling-Hammond & Pecheone, 2010; SBAC, 2010).

Darling-Hammond (2010) outlined five critical characteristics of high-quality comprehensive assessment systems:

1. **Assessments are grounded in a thoughtful, standards-based curriculum and are managed as part of an integrated system** of standards, curriculum, assessment, instruction, and teacher development. Together, they guide teaching decisions, classroom-based assessment, and external assessment.
2. **Assessments include evidence of student performance on challenging tasks that evaluate Common Core Standards of 21st century learning.** Instruction and assessments seek to teach and evaluate knowledge and skills that generalize and can transfer to higher education and multiple work domains. They emphasize deep knowledge of core concepts and ideas within and across the disciplines, along with analysis, synthesis, problem solving, communication, and critical thinking. This kind of learning and teaching requires a focus on complex performances as well as the testing of specific concepts, facts, and skills.

3. **Teachers are integrally involved in the development and scoring of assessments.** While many assessment components can and will be efficiently and effectively scored with computer assistance, teachers will also be involved in the interim/benchmark, formative, and summative assessment systems so that they deeply understand and can teach the standards.
4. **Assessments are structured to continuously improve teaching and learning.** Assessment *as, of, and for* learning is designed to develop understanding of what learning standards are, what high-quality work looks like, what growth is occurring, and what is needed for student learning.
5. **Assessment, reporting, and accountability systems provide useful information on multiple measures that is educative for all stakeholders.**

Three levels of assessment constitute comprehensive assessment systems and have been described, using somewhat different terminology: (a) progress monitoring/formative/embedded assessment to track individual student progress over time, (b) interim/benchmark assessments to monitor performance following units of study to determine whether students are on track toward major learning targets, and (c) summative assessments given at the end of a year for accountability purposes. Along with this expanded collection of new assessments designed for different purposes and use, different designs and delivery methods are currently under construction. For example, all four projects developing assessments aligned with the CCSS intend to deliver their tests online. Two projects, SBAC and DLM, propose one or more adaptive assessments that will include a range of items along a hypothesized progression in order to better capture the achievement of students who are functioning at the lower and higher ends of their current grades.

For purposes of this discussion, the following frequently cited definitions of assessment types are used:

- **Formative assessment**—As defined in the RTTT RFP (U.S. Department of Education, 2009, p. 37811), “formative assessment means assessment questions, tools, and processes that are embedded in instruction and are used by teachers and students to provide timely feedback for purposes of adjusting instruction to improve learning.”
- **Interim assessment**—As defined in the RTTT RFP (US. Department of Education, 2009, p. 37811), “interim assessment means an assessment that is given at regular and specific intervals throughout the school year, is designed to evaluate student’s knowledge and skills relative to a specific set of academic standards, and produces results that can be aggregated (e.g., by course, grade level, school, or LEA) in order to inform teachers and administrators at the student, classroom, school, and LEA levels.”
- **Summative assessment**—As defined by Perie, Marion, and Gong (2009, p. 6), “summative assessments are given at the end of instruction to provide information on what was learned. They are generally administered once a semester or year to measure students’ performance against district or state content standards.”

These assessments have been designed to provide different types of data for different purposes. Summative assessments are typically given statewide as part of a school accountability system and are often additionally used to make decisions about student graduation, teacher financial rewards, and teacher and principal evaluations. At the other extreme, formative

assessments are administered by the teacher and are designed to make frequent “minute-by-minute” instructional adjustments for individual students and classrooms (Wiliam, 2009). Somewhere in the middle lie interim or benchmark assessments that are usually administered at the school or district level to monitor progress toward proficiency, identify students/schools in need of extra support, and to give district administrators data with which to make decisions, for example, about programs and professional development needs.

Exhibit 6 summarizes the key features of these assessment purposes and uses.

Exhibit 6: Components of a Comprehensive Assessment System

Assessment Type	Purpose	When Given	Attributes	Origin of Data	Level of Data Aggregation
Formative	<ul style="list-style-type: none"> • Provide feedback for teachers to modify subsequent learning activities and experiences (Huhta, 2010) • Identify and remediate group or individual deficiencies (Huhta, 2010) • Move focus away from achieving grades and to learning processes so as to increase self-efficacy and reduce the negative impact of extrinsic motivation (Shepard, 2005) • Improve students' metacognitive awareness of how they learn (Shepard, 2005) • Fine-tune instruction and student focus on progress (Cauley & McMillan, 2010) 	<ul style="list-style-type: none"> • During the learning process • Embedded at key points during instruction • Minute by minute 	<ul style="list-style-type: none"> • Based on learning progressions that clearly articulate the subgoals of the ultimate learning goal. • The learning goals and criteria for success are clearly identified and communicated to students. • Students are provided with descriptive evidence-based feedback that is linked to the intended instructional outcomes and criteria for success. • Both self- and peer assessment are important for providing students an opportunity to think meta-cognitively about their learning. • Teachers and students are partners in learning. (McManus, 2008) 	Classroom activities Examples: <ul style="list-style-type: none"> • Analysis of student work • Teacher questioning, classroom discourse, and observations • Model-generating activities • Short-term small- group activities • Peer and self-assessments (Garrison & Ehringhaus, 2007) 	Student Group Classroom
Interim/ benchmark	<ul style="list-style-type: none"> • Instructional—improve curricular programs, inform decisions at both the classroom level and beyond • Evaluative—evaluate students' knowledge and skills relative to a specific set of academic goals, typically within a limited time frame • Predictive—determine a student's likelihood of meeting some criterion score on the end-of-year tests (Perie, Marion, Gong, & Wurtzel, 2007) 	<ul style="list-style-type: none"> • Three to four times a year • At the end of curricular units 	Based on standards or building blocks: <ul style="list-style-type: none"> • Clear and appropriate standards • Accurate assessment results • Results revealing how each student did in mastering each standard (Arter, 2010) 	<ul style="list-style-type: none"> • Performance tasks • Unit and classroom tests • Group projects • Related item sets (including multiple choice, constructed response items) (Perie, et al, 2007) 	Student Group Classroom School District
Summative	Accountability	Annually or biannually	Based on state standards: <ul style="list-style-type: none"> • Accurate evidence of how each student did in mastering each standard, aggregated over students • Percentage of students mastering each standard (Arter, 2010) 	<ul style="list-style-type: none"> • Standardized tests • Performance tasks • Final exams 	Student Group Classroom School District State

How Cognitive Learning Models Can Inform the Development of Comprehensive Assessment Systems by Connecting Learning to Multiple Assessments, Purposes, and Uses

A challenge in developing a comprehensive assessment system as described above has been the lack of a unifying cognitive framework or central theory of learning to anchor the components. The consequences of this are manifold. For example, data from formative, interim, and summative assessments are often not interpretable or useful across different levels of the educational system. Educators often find summative assessments inadequate for informing high-quality teaching, usually stating that they tend to receive the results too late to apply them to classroom instruction. They report that a focus on summative assessment hinders good classroom teaching because it drives the instructional emphasis toward tested materials and typically does not have the granularity needed to individualize instruction (Wilson, 2010). Similarly, formative and interim/benchmark assessments tend to focus on the acquisition of skills and knowledge specified by content standards, and the data often do not contain the psychometric properties and technical rigor needed to justify high-stakes decisions. In short, summative assessment data do not easily scale down to the classroom, and formative assessment data do not easily scale up to the district/state level.

The lack of reference to any conceptual model of how student knowledge and understanding develop brings into question the utility of an assessment system that claims to effectively advance student learning. Current assessment instruments tend to provide information about the status of achievement at a point in time but lack information about what knowledge and skills students actually have or the reasons a student may be struggling with a skill or concept.

Cognitive learning models have the potential to provide the cohesive foundation for all levels of assessment. First, they can describe what students need to learn in order to meet the expectations expressed in the standards.

The idea is to provide a way of clarifying what is meant by a standard by describing links between the knowledge represented in the standards and what can be observed and hence assessed. Learning performances are a way of enlarging on the content standards by spelling out what one should be able to do when one masters that standard. (Wilson, 2010, p. 9)

Second, cognitive learning models can identify the important learning targets across grade levels that can be investigated with all levels of assessment.

By focusing on the identification of significant and recognizable clusters of concepts and connections in students' thinking that represent key steps forward, [mathematics] trajectories offer a stronger basis for describing the interim goals that students should meet if they are to reach the common core college and career ready high school standards. In addition, they provide understandable points of reference for designing assessments for both summative and formative uses that can report where students are in terms of those steps, rather than reporting only in terms of where students stand in comparison with their peers. (Daro, Mosher, & Corcoran, 2011, p.12).

Finally, using the same framework (e.g., learning progressions and maps) to inform curriculum, standards, and achievement-level descriptors affords opportunities for alignment between curriculum, instruction, and assessment (National Research Council, 2006).

Cognitive Learning Models as a Foundation for All Components of the Assessment System

Cognitive learning models are generally accepted as an important, even necessary, foundation for formative assessment processes (Daro et al., 2011; Heritage, 2008; Hess, 2008, 2012a; Schwiengruber, 2006). The rationale is that a learning progression clearly articulates the trajectory students are expected to progress along to improve in an area of learning and thus acts as a touchstone for formative assessment development (Heritage, 2008). In addition, using learning progressions to guide classroom-based assessment helps develop teachers' clinical understanding of students' learning in ways that can inform their interpretations of and responses to student progress and their implementation of the curricula they use. Formative assessment helps teachers determine next steps during the learning process as the instruction approaches the summative assessment of student learning (Garrison & Ehringhaus, 2007).

Currently, there are few references to the use of cognitive learning models for the development of interim/benchmark or summative assessments; but this concept is central to an evidence-centered design approach for the next generation of assessments required by the RTTT and GSEG consortia. Although the use of learning models is seen as the ideal, when considered as the foundation for assessments that require data aggregation above the classroom level and for high-stakes decisions, researchers acknowledge that this is a new frontier and that several issues need to be resolved before a seamless comprehensive system of assessment can be realized.

One of the issues mentioned by Daro et al. (2011) is the grain size differences in the levels of assessment and thus the use of the data for different purposes. Teachers operating day-by-day need more detail about student progress than summative assessments can provide. Large-scale assessments, sampling a broader set of skills and concepts, tend to reference larger intervals of learning to inform policy and the larger system, as well as to inform more consequential accountability decisions about students, teachers, and schools.

Alonzo (2007) raised several considerations in thinking about the use of cognitive learning models as a foundation for assessments designed for accountability purposes.

- Tests used for accountability measure “what could be” as described by rigorous standards, but learning models describe “what is.” Therefore, there needs to be an acknowledgement of the distance between these and a determination of how gaps are considered in test design.
- Because of their finer grain size, learning models can address the multiple and alternate pathways that students might use to reach the same learning targets and can be adapted to various instructional emphases and students' prior experiences. The choice of the learning progression to be used as a basis for large-scale assessment development will influence the inferences that can be made about student achievement.
- Learning progressions are intended to describe what learning looks like as students gain expertise along a continuum. Because of this, there is little clarity about the types of claims that can be made for how learning progressions might influence the development of achievement-level descriptors from *below basic* to *advanced performance*. Validity

evidence must be gathered for learning progressions to be used as part of a high-stakes accountability system, especially at higher grade levels where student achievement is highly influenced by prior instruction.

Although a strong desire exists to build assessment systems based on a cohesive cognitive framework, it is crucial for there to be coherence between the interpretations of student progress teachers use in their classrooms and those that underlie the designs of large-scale assessments. The conceptual framework informing the assessment designs would help teachers focus instruction and progress monitoring on more clearly articulated learning pathways. Cognitive learning models provide understandable points of reference for designing assessments for both summative and formative uses that describe or report where students are in terms of what has been learned and what still needs to be learned. Standards and assessments organized around learning progressions may have to take on an educative function for education professionals and the public who are not experts on children's learning. In moving forward, a challenge will be to convey both the power of building standards, curricula, instruction, and assessments around learning research and the logic of learning progressions (Schweingruber, 2006).

Summary and Recommendations for Future Research

Summary

By building a comprehensive assessment system based on cognitive learning models, many of the shortcomings of our current assessment system might be addressed. If formative, interim, and summative assessments are developed using a common cognitive learning model, then data collected from each type of assessment can be used to inform decisions at the classroom, school, district, and state levels. Such a unified comprehensive assessment system may be able to provide educators with diagnostic information that can illuminate misconceptions that students may have through interim and summative assessments and provide valid, reliable, and scalable data from formative and interim assessments. Further, administrators may be able to aggregate data from all of these sources to make high-stakes decisions about student advancement, teacher promotion, and school performance. That is, a comprehensive assessment system built on a unifying cognitive learning model can be developed to scale up or scale down data to serve instructional purposes at different levels of analysis. Many important questions remain to be investigated as development continues.

Questions for Future Research

Hess (2012b) suggests four broad areas for future research using learning progressions for assessment and instruction of students in special populations: (1) identifying whether there is essential content to learn and assess; (2) examining time for learning time and under what optimal conditions, such as sequencing of instruction; (3) connecting cognitive models of learning with assessment design and interpretation of assessment results; and (4) examining potential effects of learning progressions use on educator knowledge, classroom practice, or perceptions of students as learners.

Each of these future research areas is discussed in more detail below.

1. **Essential content.** While the CCSS were developed to focus on the most essential expectations for learning, there remains extensive content to cover at each grade level to achieve those expectations. Some of the standards assume a significant amount of learning will occur in order to meet proficiency, whereas others describe smaller chunks of knowledge, information, and skills necessary for proficiency. Future investigations should address the following questions:
 - Can cognitive learning models inform our decisions about essential content? Is there content that is most essential to learn and be built on over time? Can some chunks of content be skipped and not become insurmountable learning gaps later on? Are there high-leverage learning targets that are critical for progress toward more advanced targets?
2. **Learning time and conditions.** These questions are especially pertinent for students with disabilities and students learning academic English because their learning rates and pathways to learning grade-level skills tend to differ.
 - How much content is reasonable to learn in a school year? How can individual student differences be taken into account in instruction and monitored by classroom assessment?
 - Is there optimal sequencing of content or instructional approaches to support learning? Empirically-based learning models reflect not only typical developmental processes, but also learning based on optimal instructional sequences, especially after foundational skills are acquired. How can research on cognitive learning models investigate optimum pathways?
 - How can we enhance our understanding of multiple and alternate pathways? There are often various routes to the same destination. What methods of investigation can discover these?
3. **Assessment design and use.** States' accountability systems are moving toward measuring individual student progress and growth over time.
 - How can knowing more about what to teach and how best to teach it change the design and interpretation of assessment evidence, progress monitoring, and descriptions of learning growth?
 - Should grade-level achievement descriptions be reevaluated if empirical evidence demonstrates different pathways to learning? What connections do we expect to see between knowledge acquisition described in cognitive learning models and expectations in grade-level content standards?
 - Given the different grain sizes and purposes of formative, interim/benchmark, and summative assessments, what methods can be used to interpret and integrate assessment data across items and tasks within a cohesive cognitive framework?
4. **Effects on educator knowledge, practice, or perceptions.** Cognitive learning models can visually and verbally make explicit next steps for teaching and learning.
 - To what degree can use of learning progressions in the classroom change educator practice (deeper content knowledge, increased and strategic use of formative assessment, lesson planning, teacher perceptions about special needs learners, etc.)?

- Which professional development strategies are most effective in helping teachers design learning experiences based on cognitive learning models for the diverse population of students in their classrooms?
- Are there unintended consequences (both positive and negative) of using cognitive learning models to guide instruction and classroom-based assessment?

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