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Models of Cognition for Students With Significant Cognitive Disabilities: Implications for Assessment

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This article addresses the application of the assessment triangle developed by the National Research Council (Pellegrino, Chudowsky, & Glaser, 2001), most specifically the cognition vertex of that triangle, to the unique learning characteristics of students with significant cognitive disabilities in developing and demonstrating academic competence. Given the inclusion of all students, including students with significant cognitive disabilities, in measures of large-scale educational assessment and accountability under the No Child Left Behind Act, it is essential to examine how the primary elements of knowledge representation and competence identified by Pellegrino et al. for all students have special ramifications for students with significant cognitive disabilities. It is only in the development of such a model of competence that it is possible to construct alternate assessments for these students that validly represent what these students know and can do.

Keywords: accountability, assessment, high-stakes testing, performance assessment, special education, student cognition.

With the advent of the Individuals with Disabilities Education Act Amendments of 1997 (IDEA) and the No Child Left Behind Act of 2002 (NCLB), all students, including students with significant cognitive disabilities, must be included in state and district educational assessment and accountability systems. The primary mechanism for the participation of students with significant cognitive disabilities in measures of educational assessment and accountability is through alternate assessment (Kleinert & Thurlow, 2001; Thompson, Quenemoen, Thurlow, & Ysseldyke, 2001).[1] Although all states were required to have alternate assessments in place by July 1, 2000, the concept of alternate assessments is still very much evolving. Alternate assessments must now be linked to grade-level content standards for all students (U.S. Department of Education, 2004). This new emphasis on instruction and progress on grade-level content gives added importance to ensuring that alternate assessments are grounded in coherent theories of how students with significant cognitive disabilities gain academic and subject matter competence.

A conceptual model of how such assessments might be developed can be taken from the work of the National Research Council's Committee on the Foundations of Assessment (Pellegrino, Chudowsky, & Glaser, 2001), namely, the committee's work on the "Assessment Triangle." According to Pellegrino et al. (2001), assessment is a process of reasoning from evidence; their assessment model links the key elements of good assessments. As described by Pellegrino et al., the triangle consists of three elements on which every assessment must rest: "a model of how students represent knowledge and develop competence in the subject domain, tasks or situations that allow one to observe students' performance, and an interpretation method for drawing inferences from the performance evidence thus obtained" (2001, p. 2). Pellegrino et al. have suggested that the elements or vertices of this triangle—cognition, observation, and interpretation—must be articulated and aligned for inferences drawn from the assessment to have integrity.

This article addresses the first vertex of the assessment triangle, that of cognition, to examine characteristics of students with significant cognitive disabilities in representing what they know. While all three vertices are, of course, critical to establishing the validity of an assessment for its stated purpose, the development of domain competence (the first vertex) has received little attention in the literature for students with significant cognitive disabilities. We will discuss the primary elements of knowledge representation and domain competence identified by Pellegrino et al. (2001) for all students, and then for each of these elements, we will discuss how they may have special ramifications or considerations for alternate assessments of students with significant cognitive disabilities. Before we do this, we will briefly describe what alternate assessment is, who it is designed for, and the research that exists to date on which students are actually participating in alternate assessments.

What Is Alternate Assessment?

As noted above, alternate assessment, based on alternate achievement standards, is the primary mechanism through which students with the most significant cognitive disabilities participate in measures of educational assessment and accountability. Alternate achievement standards are "an expectation of performance that differs in complexity from a grade-level achievement standard" (U.S. Department of Education, 2005). Although alternate achievement standards may differ in complexity from grade-level achievement standards, alternate achievement standards must still be linked to grade-level content. In its NCLB Peer Review Guidance for states, the U.S. Department of Education (2004) has made this linkage to grade-level context explicit:

> For alternate assessments in grades 3 through 8 based on alternate achievement standards, the assessment materials should show a clear link to the content standards for the grade in which the student is enrolled although the grade-level content may be reduced in complexity or modified to reflect prerequisite skills. (p. 15)

Thompson and Thurlow (2003) have reported that most states offer one type of alternate assessment based on alternate achievement standards, while a small number of states offer two or even three alternate assessment options. However, states vary considerably in the approaches that they use for alternate assessments based on alternate achievement standards, and these approaches typically vary greatly from those used for states' general assessments (Lehr & Thurlow, 2003).

Three basic alternate assessment approaches have been developed thus far. The first is a portfolio or body of evidence approach. A portfolio is a purposeful and systematic collection of student work that is evaluated and judged against predetermined scoring criteria. The second approach is a checklist or rating scale. This approach requires teachers to identify if students are able to perform certain skills or activities rated dichotomously or on a Likert-type scale. Finally, there is the performance assessment approach, which is a direct measure of a skill in a typically one-on-one assessment format (e.g., responding to questions about a reading passage in language arts). Performance assessments range from being highly structured, with very prescribed directions for administration and scoring, to a more flexible approach tailored to students' needs (Roeber, 2002). It is important to note that portfolios or performance events may again vary considerably from state to state.

For Whom Are Alternate Assessments Designed?

Alternate assessments, based on alternate achievement standards, are designed for a very small percentage of students for whom traditional assessments, even with appropriate accommodations, would be an inappropriate measure of student progress within the general education curriculum. The number of students within a state who currently participate in alternate assessment is generally less than 1% of the total student population (i.e., students with the most significant cognitive disabilities). Indeed, federal regulations permit states to count no more than 1% of all students as proficient under NCLB through their alternate assessments on alternate achievement standards (U.S. Department of Education, 2003). Students participating in alternate assessments may have a variety of special education labels, including autism, mental retardation, deaf-blindness, or multiple disabilities (National Alternate Assessment Center [NAAC], 2005), though certainly not all students in these categories will need an alternate assessment. It is important to note that students in other disability categories may meet the requirements to participate in the alternate assessment as well.

For each student with a disability, the student's Individualized Education Program (IEP) team decides how the student will participate in the state assessment system. The process of choosing the appropriate assessment for an individual student (e.g., regular assessment, regular assessment with accommodations, or alternate assessment) again varies considerably from state to state. State participation guidelines for the alternate assessment typically direct the IEP team to ensure that each student "participates in a way that accurately portrays the student's achievement of knowledge and skills so as to hold accountable the educational system responsible for the student's learning" (National Center on Educational Outcomes, 2003). Students should always be considered for participation in the general assessment system with appropriate accommodations prior to their consideration for the alternate assessment.

What Do We Know About the Characteristics of Students Currently Participating in Alternate Assessments?

As we have noted, students currently participating in alternate assessments based on alternate achievement standards typically have such special education labels as autism, mental retardation, or multiple disabilities (NAAC, 2005). However, the label a student receives to qualify for special education services may not accurately or fully describe the educationally relevant characteristics of the student. There is currently little research that identifies characteristics of students taking alternate assessments, although two studies have provided preliminary data. The Colorado Alternate Assessment Collaborative (Almond & Bechard, 2005) collected information from teachers in four major categories of student performance: academics, assistive technology, communication, and need for supports in physical movement. Findings in each of these categories are summarized below:

- Demographics: Of the 165 students in the study, 142 had mental retardation,but more than one third also had two or more significant disabling conditions.
- Academics: Most students' instructional objectives fell into two categories: (a) functional living and communication skills or (b) language arts and mathematics.
- Assistive technology: A total of 49 students used 1 to 4 assistive technologies during day-to-day instruction, 41 students used 5 to 7 technologies, and 46 used 8 to 11 assistive technologies. Most frequently reported assistive technologies included printed or picture schedules and word cards, a word book, and/or a word wall.
- Communication: While 10% of students did not use words to communicate, almost 40% used 200 words or more in functional communication.
- Need for supports in physical movement: There was a range of levels of physical support required by students in this study, from students not able to perform any components of the task due to severe motor deficits to students able to perform the task without any supports (Almond & Bechard, 2005).

During the 2005–2006 school year, Kearns, Towles-Reeves, Kleinert, and Kleinert (2006) conducted a survey of all teachers who had students in one state's alternate assessment (Kentucky). There were approximately 1,394 students from Grades 4, 8, and 12 in the state alternate assessment that year; teachers were requested to complete a Learner Characteristics Inventory for each student. Teachers completed the Learner Characteristics Inventory for 1,120 students, with a statewide response rate of 80.3%. Key findings included the following:

- In the area of Expressive Communication, 71.3% of the students used symbolic language to communicate expressively; 17.2% used intentional communication with pictures/objects and/or gestures but not at the symbolic language level; and 8.2% had no clear use of words, pictures, objects, or signs to communicate expressively.

- In the area of Receptive Communication, 46.7% of the students could follow one- to two-step directions presented through words only; 41.2% could follow oral instructions when provided additional cues; 9.7% alerted to sensory input from another individual; and 1.2% showed inconsistent responses to sensory stimuli.
- In Reading Skills, 2.4% of the sample read fluently in print or Braille; 13.7% read with basic literal understanding; 67.3% read basic sight words or demonstrated awareness of print or Braille; and 15.4% demonstrated no awareness of print or Braille.
- In Mathematics Skills, 2.6% could apply computational procedures to solve real-life word problems in a variety of contexts; 57.2% could do computational problems with or without a calculator; 18.8% could count with 1:1 correspondence to at least 10, with an additional 6.8% who could rote count to at least 5; and 12.9% had no observable awareness of or use of numbers.

While these two studies provide but a snapshot of the students in state alternate assessments, these are currently among the only studies to date regarding characteristics of students participating in such assessments. Further research is necessary to better describe the characteristics of these students. Students taking alternate assessments have highly individualized capabilities and needs for support (as is evident from both of these studies), making both instruction and assessment a challenge. This challenge further accentuates our need for an integrated framework of learning and assessment for these students; this becomes especially critical for those students whose communication and academic skills are at a basic awareness level. It is for this reason that we will focus on what we know about how these students learn, that is, the cognition vertex of the "assessment triangle."

A Framework for Approaching Models of Cognition for Students With Significant Cognitive Disabilities

There are essentially two approaches for explicating the cognition vertex for students with significant cognitive disabilities. The first method would be to directly generate that cognition model ourselves. Although there is a certain attractiveness to developing a model from scratch, there are some immediate difficulties with such an approach. For one thing, precisely because of the history and power of behavior analysis in shaping the foundations of the field of special education, professionals have not given a great deal of thought to how students with severe cognitive disabilities think. Rather, educational progress has occurred through teaching measurable and observable behaviors that enable students to be as independent as possible. Also, past efforts to apply cognitive theories to the education of students with significant cognitive disabilities have been unsatisfactory. For example, developing assessments and educational goals based on early Piagetian stages (Robinson & Robinson, 1978), although the best thinking at the time they were developed, were later found to yield educational programs that were not appropriate to students' chronological age and that ignored the students' need to acquire skills of daily living. Cognitive models may also have been ignored because they seemed to promote a deficit model (i.e., what these students lacked) rather than a capacity-building model (i.e., what students could do with education and support). However, *not* relying on a cognitive framework for building assessments makes it difficult to develop an understanding of how students with significant cognitive disabilities actively construct knowledge and apply mental models and processes to the problems they encounter. Such a framework may yield especially helpful implications for addressing academic content with this population because alternate assessments must now reflect learning linked to grade-level content standards for all students. While general education large-scale assessments have also typically not relied on coherent frameworks for learning (Pellegrino et al., 2001), the problems in constructing an underlying cognitive theory for students with significant cognitive disabilities are even more formidable.

Given the conceptual distance to be traveled in developing a cognitive framework for students with severe disabilities, we think the best starting point is to use the elements in the cognition vertex developed for *all* students by Pellegrino et al. (2001), to see how they apply, and how they differ, for students with significant cognitive disabilities. In doing so, we will build bridges to what we have learned about how this population learns, which to date comes primarily from a behavioral perspective. We will also try to avoid past pitfalls in applying cognitive theory to students with significant cognitive disabilities, including (a) promoting deficit models that describe at length what this population cannot do or (b) stigmatizing school-aged students with significant disabilities by describing them like infants or toddlers. We also recognize from the onset that these students' communication challenges will make understanding how they construct knowledge and the nature of what they know and understand especially difficult and that great care must be taken in making inferences about these students' cognition.

Finally, we should note that although the National Research Council's assessment triangle applies to all types of educational assessments (from teacher-made tests on daily lessons to large-scale educational assessments for school accountability and improvement), we will frame our discussion largely in terms of assessment used for accountability. We do this because of the immediate need, under the IDEA and NCLB, to include all students, even students with the most significant cognitive disabilities, in indices of school accountability. With this caveat, we now turn to the cognition vertex of that triangle.

Four Perspectives on the Nature of Human Learning and Knowing

Pellegrino et al. (2001) proposed four basic perspectives for understanding the nature of human learning and knowing. Each of these perspectives has important implications for the assessment of students with significant cognitive disabilities.

The *differential perspective* (which is also the perspective that has most guided the development of tests of intellectual aptitude and academic performance) focuses on measuring and describing individual differences in the processes and products of human learning and knowing, with an emphasis on the products. While the theory of measurement within this perspective is consistent with behavioral theories of learning (Pellegrino et al., 2001) that have been so instrumental in developing successful learning strategies for students with significant disabilities, this model also emphasizes the concepts of relatively stable mental traits and intellectual competence that can be reliably measured. It is, of course, primarily in these traits that students with significant cognitive disabilities "score" most poorly (at times even rated as "untestable" or excluded from testing altogether; see Kleinert & Thurlow, 2001; McGrew, Thurlow, & Spiegel, 1993). Professionals have questioned the validity of using these assessments for educational planning for the last two decades (Sigafoos, Cole, & McQuarter, 1987). For example, a student's "mental age" is no longer considered an appropriate criterion for curriculum planning (Browder et al., 2004). For students with significant cognitive disabilities, a cognition model that focuses strictly on the differential perspective would severely limit a conception of what these students are capable of learning and understanding. Indeed, the very assumptions within this perspective of the stability of these mental traits and the reliability associated with their measurement would lead one to conclude that relative gains in cognition for this population would be minimal even with the best interventions.

The second perspective, the *behaviorist perspective*, was described by Pellegrino et al. (2001) as the "organized accumulation of stimulus-response associations that serve as the components of skills" (p. 61). As Pellegrino et al. noted, this perspective has had significant influence on our understanding of both learning and assessment. The behaviorist perspective is reflected in the task analyses of curricula, in the organization of steps within those analyses from simple to complex, and in the careful consideration of prerequisite skills. Within assessment, the influence of this perspective occurs in the systematic analysis of the components required for domain competence and in the careful sampling of those component skills within test development. The behaviorist perspective has also had a profound influence on the history of education of students with significant disabilities; much of what we know about the "technology of teaching" and the organization of life skills and functional academic curricula for these students is the direct result of the application of this perspective (Snell & Brown, 2006). Most of the options for measuring IEP progress for this population, such as task-analytic, repeated-trial assessment, permanent product, and time-based observations rely on principles of applied behavior analysis to define and measure observable responses (Browder, 2001). The behaviorist perspective also has ongoing implications for the understanding of alternate assessment; for example, most state alternate assessments for these students require the demonstration of clearly measurable and observable targeted skills, many of which are broken down into subskills for both teaching and measurement (Browder, Ahlgrim-Delzell, et al., 2005). However, as Pellegrino et al. have noted, the behaviorist perspective, by itself, does not focus on *how* students construct, organize, and/or use the knowledge they attain (e.g., the mental models they construct for problem solving). For this additional understanding, we must consider other perspectives.

The third model, the *cognitive perspective*, focuses more on understanding *how* people construct or represent knowledge, the strategies used for connecting new knowledge to prior knowledge, and the formal processes for problem solving. As Pellegrino et al. (2001) noted, cognitive theorists are interested not so much in how much knowledge one has accumulated (as measured by a more differential approach) but in the quality and organization of that knowledge and the ways in which it can be meaningfully applied. This model also emphasizes the concept of growth over time in developing increasingly sophisticated knowledge structures and problem-solving approaches. The cognitive perspective has important implications for students with significant disabilities. First, we know that although these students often lack systematic approaches to identifying and solving problems, there are problem-solving strategies that can be directly taught to students with even the most significant cognitive disabilities (Agran, Blanchard, & Wehmeyer, 2000; Agran, King-Sears, Wehmeyer, & Copeland, 2003). Second, although students with significant disabilities often develop competence in a domain at a slower rate than other students, the concept of growth for these students is essential. It would appear that for this highly diverse group of students, a one-time snapshot of what they know might not capture the significant gains in how they have learned to represent their knowledge over time. Even data collected over time to demonstrate effective teaching may not reflect the in-depth growth of conceptual knowledge unless explicitly developed to do so. For example, over the course of a year, a student may show progress in acquiring many sight words but no true growth in understanding their meaning and use, which is the ultimate test of literacy.

The fourth model of learning and knowing, the *situative perspective* (or sociocultural perspective), has additional implications for learners with significant disabilities. Learning, from a situative perspective, is considered mediated by one's place in a community of learners, or as Pellegrino (2005) has referred to this concept, as "distributed cognition," that is, the capacity of individual learners to contribute to each other's understanding. According to Pellegrino et al. (2001), "from the situative perspective, assessment means observing and analyzing how students use knowledge, skills, and processes to participate in the real work of the community" (p. 64). For students with the most significant cognitive disabilities, the situative perspective introduces two essential concepts for both learning and assessment. First, students with significant disabilities benefit from instruction with typical peers in inclusive settings. Research has shown not only social benefits for this inclusion (Cole & Meyer, 1991; Fryxell & Kennedy, 1995) but also attainment of educational goals (Brinker & Thorpe, 1984; Hunt, Staub, Alwell, & Goetz, 1994). Second, students with significant disabilities, if they are to acquire usable skills that will contribute to competence in the real world, must be able to perform those skills in the settings in which they will be needed (Brown, Nietupski, & Hamre-Nietupski, 1976; Heward, 2006). Students with the most significant cognitive disabilities often experience difficulty in generalizing skills to new settings and situations; both instruction and assessment must address effective strategies for ensuring that students are able to transfer what they have learned (Westling & Fox, 2004).

Components of Cognition: How These Elements Apply to Students With Significant Disabilities

Pellegrino et al. (2001) have identified several elements critical to the construction of a model of student cognition. We consider each of these elements briefly here and their implications for students with the most significant cognitive disabilities.

Components of Cognitive Architecture

Although it is not within the scope or intent of this article to propose that students with significant cognitive disabilities have a "cognitive architecture" substantially different from their typical peers, there is some research that would suggest that students with intellectual disabilities as a group do experience some very specific challenges with how they process information. The goal of special education is to provide students with the supports and strategies needed to compensate for these challenges.

Working or short-term memory. Pellegrino et al. (2001) have noted Baddeley's (1986) definition of working or short-term memory as that which "people use to process and act on information immediately before them" (p. 65). Pellegrino et al. have described the key variable in this type of memory as capacity, but this is not the type of physical capacity analogous to filling up a plastic container until it reaches the top. Rather, the functional capacity of working memory can be expanded through the use of intentional learning strategies to chunk or code information. This is critical for students with intellectual disabilities. Although there is research that indicates that students with intellectual disabilities do experience more limitations in short-term memory capacity (Bergeron & Floyd, 2006; Bray, Fletcher, & Turner, 1997), there are specific strategies for teaching students with disabilities how to chunk and organize information into more coherent and encodable forms (see Mastropieri & Scruggs, 2004). Learning strategies that systematically teach chunking or mnemonic strategies should be an essential feature of instruction for students with significant cognitive disabilities, and assessments for these students should encourage them to use these encoded chunks in novel situations to solve new problems. It is crucial that assessments for these students be designed so that limitations in short-term memory (e.g., the capacity to remember a multistep direction) do not result in the student *not* being able to demonstrate skills that are a part of that student's learned repertoire. Unless adequate supports for understanding the dimensions of the assessment task are clearly built into the assessment itself, potential deficits in short-term memory may result in inaccurate assessments of what students do know.

Long-term memory. As Pellegrino et al. (2001) have noted, long-term memory "contains two distinct types of information—semantic information about 'the way the world is' and procedural information about 'how things are done'" (p. 67). Both types of long-term memory are crucial for students with significant cognitive disabilities. For example, being able to identify words or symbols in the same ways understood by most readers of English implies semantic information about the way the world is. Being able to use symbols or words on an augmentative communication device to influence a conversational partner implies procedural information on how things are done. The importance of this distinction between conceptual knowledge (the way the world is) and procedural knowledge (how things are done) has been highlighted by Geary (1995), who has also noted that procedural knowledge can be gained only by sustained, explicit practice across the range of exemplars or situations in which the student would be expected to learn the skill.

Older research seems to suggest that individuals with intellectual disabilities retain information in long-term memory about as well (or as poorly) as the general population (Ellis, 1963). More recent research (Bergeron & Floyd, 2006) suggests that children with intellectual disabilities may have relative deficits in both short-term memory and long-term retrieval. Most significantly for our discussion, we do know that we can enhance retention by ensuring that students have opportunities to learn skills that are applicable across contexts and learning settings, thus ensuring that this knowledge will be encoded in a way that is readily recognized and retrievable for the student. Assessments should also measure those skills that will substantially add to a student's knowledge of how the world is and how things (that are truly important) are done. For procedural knowledge, this also means assessing students' capacity to apply the skill across a range of exemplars.

Metacognition

Metacognition, or "thinking about thinking," refers to the capacity not only to select a problem-solving strategy but also to monitor and evaluate one's use of that strategy and to self-correct as necessary (Pellegrino et al., 2001). As such, metacognitive strategies are closely aligned with some of the most important components of self-determination and self-directed models of learning (Agran et al., 2003; Wehmeyer & Schwartz, 1998) that have been addressed in the literature for students with intellectual disabilities and that have been identified with more positive life outcomes for these students (Wehmeyer & Palmer, 2003; Wehmeyer & Schwartz, 1998). For students with significant cognitive disabilities, metacognitive strategies can include explicit steps in setting goals (e.g., completing a science project), developing action steps to reach that goal, and evaluating one's progress toward that goal (see Agran et al., 2003).

Pellegrino et al. (2001) have noted that strong metacognitive skills separate the performance of experts from novices in specific domains and that the assessment of metacognitive strategies should be an important component in determining domain competence. Black and Wiliam (1998a, 1998b) have noted that self-assessment is critical to improved student performance and that self-assessment must include a knowledge of one's learning goal, the status of one's present performance, and the way to close the gap between the two. It is essential to note that even students with significant cognitive disabilities can be taught the component skills that promote metacognition, including setting personal goals, planning one's own learning (e.g., the strategies that work best for a student in learning a particular subject or the order in which one will do a set of prescribed learning activities), and monitoring and evaluating that learning (Agran et al., 2003; Kleinert et al., 2001). The metacognitive skills of planning, monitoring, and self-evaluation can also be embedded into the context of daily instruction based on grade-level content standards (see Kleinert & Kearns, 2004, for examples).

Closely aligned with metacognition are strategies for self-instruction (Agran et al., 2003; Hughes & Agran, 1993). Agran et al. (2003) defined the purpose of self-instruction as "enabling students to control their *own* behavior using their own language or verbal instructions" (p. 29). An example of a self-instruction reading strategy would be for the student to internally verbalize the following steps when presented with a comprehension question to a class reading passage: (a) Look for key words in the question; (b) search for those same key words in the reading passage; (c) reread very carefully those sentences in which the key words appear; and (d) write a response to the question. Certainly, the extent to which students can monitor their approach to tasks through self-instruction increases both their independence and generalization of these tasks to novel settings (Heward, 2006). While self-instruction represents an important element in instruction for students with significant cognitive disabilities, it should also be a part of assessment practices.

Pellegrino et al. (2001) stated that "assessment practices should focus on making students' thinking visible to themselves and others by drawing out their current understanding so that instructional strategies can be selected to support an appropriate course for future learning" (pp. 90–91). Alternate assessments should thus provide evidence of students' metacognitive strategies (e.g., self-evaluation and self-instruction) to successfully problem solve.

Closely related to metacognition, and specifically to problem solving, are the cognitive demands of alternate assessments, or as Webb (1997) has described, "depth-of-knowledge" demands. Flowers, Browder, and Ahlgrim-Delzell (2006) applied Webb's cognitive demands in terms of four levels, from simple recall to complex planning requiring "students to make several connections and apply one approach among many to solve the problem" (Level 4; p. 206). In a study of three states' alternate assessments, these researchers found that the majority of alternate assessment items in math and language arts scored in the lowest two levels of cognitive demands. Higher order problem-solving skills are critical for all students and should be reflected in alternate assessments as well.

Development and Learning

Pellegrino et al. (2001) made a distinction between the concepts of development and learning. According to these authors, "some types of knowledge are universally acquired in the course of normal development, while other types are only learned with the intervention of deliberate teaching" (Pellegrino et al., 2001, p. 80). Among the types of knowledge that Pellegrino et al. rated as part of development are language and a basic sense of numbers and causality. This distinction between development and learning is echoed by the theoretical framework proposed by Geary (1995), who has posited the existence of "biologically primary cognitive abilities" and "secondary cognitive abilities." Whereas primary cognitive abilities are cross-cultural, "wired" into our cognitive functioning, and typically developed through active play in young children, secondary cognitive abilities require sustained effort to learn, are primarily acquired through formal schooling, and require extensive and explicit practice. Yet for students with significant disabilities, these more developmental or primary cognitive forms of learning are often *not* acquired incidentally, but rather require very intentional and focused instruction as well. Sometimes, explicit instruction is required on basic tasks because students with significant cognitive disabilities have higher incidences of sensory or physical disabilities than students with less severe disabilities. Such attendant sensory or physical disabilities result in fewer opportunities for imitative and incidental learning or increased difficulties in performing skills with high motoric strength or coordination demands. At other times, explicit instruction is required because the student does not assimilate the cognitive demands of the task without such instruction.

A larger question is whether these more basic skills, such as communication, personal care, and physical mobility, should be a focus of large-scale educational assessments for these students. The U.S. Department of Education (2004, 2005) has specified that alternate assessments for students with significant cognitive disabilities be aligned with grade-level content standards. This does not preclude using the IEP to target additional functional and therapy goals that may represent critical skills for individual students. The context for learning, and for ongoing assessment, may thus be broader for the IEP than for the alternate assessment, which will necessarily be targeted toward academic content as specified by NCLB.

The federal requirements that alternate assessments be linked to grade-level content standards is a reflection of the belief that all students should have access to the general curriculum and should be challenged with appropriately high standards. What is less known is how practitioners can ensure that alternate assessments, linked to grade-level content standards, fairly represent the learning of students who may not have yet acquired symbolic forms of communication, whose knowledge representation is still at the presymbolic level. At least one state study (Kentucky; Kearns et al., 2006) found that 8.2% of the students in that state's alternate assessment had no clear use of words, pictures, objects, or signs to communicate expressively and that even larger percentages of students had no awareness of print or Braille (15.4%) or observable awareness of numbers (12.9%). On a very practical level, schools will clearly need to teach reliable, symbolic modes of communication for these students while simultaneously engaging them in academic content in order to meet the goals of NCLB. It should also be noted that the choice between academic or more basic life-skill instruction is not necessarily an either/or proposition. For example, Collins, Kleinert, and Land (2006) have provided several excellent examples of how academic and functional applied life-skills can be taught concurrently.

Practice and Feedback

Pellegrino et al. (2001) considered two elements of learning for all students that have particular implications for learners with significant disabilities. These are the *power law of practice* and *knowledge of results*. We will consider each of these. First, Pellegrino et al. noted that with

> each repetition of a cognitive skill—as in accessing a concept in long-term memory from a printed word, retrieving an addition fact, or applying a schema for solving differential equations—some additional knowledge strengthening occurs that produces continual small improvements. (2001, p. 85)

For students with significant cognitive disabilities, the challenge often is in providing sufficient opportunities for active responses so that students have adequate practice to first acquire and then develop fluency in critical skills (Heward, 2006; Snell & Brown, 2006). For these students, the issue is not slowing down the pace of instruction, but rather *increasing* the rate of learning trials within an instructional lesson. Formative examples of assessment for these students, such as continuous assessment of daily performance, should reflect this essential need for adequate instructional opportunities on targeted skills. The second major law of learning—knowledge of results—is also important for all learners. Pellegrino et al. (2001) indicated that "individuals acquire a skill much more rapidly if they receive feedback about the correctness of what they have done" (p. 84). As noted by Black and Wiliam (1998a, 1998b), formative assessment must involve the learner as an active participant in evaluating his or her own learning, and the quality of feedback is a key variable in learning both the task at hand and the skill of self-evaluation. For students with disabilities, positive and specific corrective feedback is especially essential (Konold, Miller, & Konold, 2004). Positive reinforcement for correct responses is critical for establishing a skill in a student's repertoire, especially in the initial stage of student learning, and systematic and immediate correction of student errors is essential to prevent students from learning erroneous information or incomplete skills (Snell & Brown, 2006; Westling & Fox, 2004). In contrast, the type of feedback described by Pellegrino et al. assists the learner's development of metacognition, rather than simply promoting accurate responding. A parallel used with students with significant cognitive disabilities is the use of instructive feedback (Werts, Wolery, Holcomb, & Gast, 1995). With instructive feedback, rather than simply giving feedback on the accuracy of the response (e.g., "Good, you selected a dollar"), additional information is provided about the task to help the student make connections (e.g., "You could also use four quarters").

Adequate, active practice and accurate, immediate feedback are both hallmarks of effective instruction for students with significant disabilities. Assessment for these students should also provide both opportunities for skill practice and timely feedback on the accuracy of the assessed skills. While large-scale assessments are typically "summative" assessments, for students with significant cognitive disabilities the value of these assessments is minimized without the availability of timely feedback. Of course, the absence or delay in feedback from large-scale assessments is problematic for all students; for students with significant cognitive disabilities we would suggest that this feedback should be built into the assessment tasks themselves, in order to maximize their instructional value for these students and their teachers. In this way, states might even be able to use alternate assessments as a "testing ground" for innovative assessment strategies that could benefit all students.

Transfer of Knowledge

Pellegrino et al. (2001) recognized that a "critical aspect of expertise is the ability to extend the knowledge and skills one has developed beyond the limited contexts in which they were acquired" (p. 87). Indeed, for students with significant disabilities, this problem of transfer or generalization of skills to new settings and situations is a critical dimension of instruction (Westling & Fox, 2004). Authorities in the field have referred to the concept of a "zero degree of inference" (Brown et al., 1976) in teaching students with significant cognitive disabilities—we cannot infer that a student can apply a newly learned skill in a new situation or setting unless we specifically test whether the student can perform that skill in the new context. It is for this reason that practitioners have developed specific strategies for systematically teaching skill generalization, including general case programming (Sprague & Horner, 1984) and naturalistic teaching strategies (Kaiser & Grim, 2006). These strategies involve the presentation of multiple exemplars or representations of a skill or concept, with the purpose of ensuring that the student can then apply that skill or concept to a novel situation. It is not surprising that nearly half of all states (43%) responding to a national survey by Browder, Ahlgrim-Delzell, et al. (2005) indicated that they included a measure of student skill generalization in their alternate assessments for students with significant cognitive disabilities. What is less certain is whether these assessments address generalization *only* across materials, contexts, and people or also address generalization of an academic concept. For example, a student might be able to select the numeral "3" in different contexts or materials but not comprehend that it represents a quantity of 3 when that numeral is applied to different real-life problems. What is also less certain is whether generalization is considered in ways that measure a fundamental understanding of the underlying concept, such as the ability to recognize how and when to apply numerical quantities to solve everyday problems or whether we choose to restrict our "measurement" of transfer to a simple listing of the different settings in which a student can perform a targeted skill (e.g., can the student count with one-to-one correspondence in the classroom, gym, and cafeteria?).

The Role of Social Context

Although we have discussed the importance of a community of learners and practice within the situative perspective, a few additional comments are warranted here. Kleinert et al. (2001) and Kleinert and Kearns (2004) have provided examples of how even students with severe cognitive disabilities can represent, graph, and evaluate their performance and participate in a community of practice with their peers. Pellegrino et al. (2001) noted that

> studies of the social context of learning show that in a responsive social setting, learners can adopt the criteria for competence they see in others and then use this information to judge and perfect the adequacy of their own performance. (p. 89)

Clearly, this point needs to be emphasized for learners with significant cognitive disabilities, for whom the power of modeling in supportive, integrative settings provides a rich source for both motivation and improved results. For example, Ryndak, Morrison, and Sommerstein (1999) have provided a case study illustration of how a student's literacy skills improved with the opportunity to learn in a general education setting.

That motivation is a key aspect of the role of social context is clear. For example, Ryndak et al. (1999) found that the use of meaningful and familiar content (e.g., photographs and note of the student's activities at home) could assist the student and peers in constructing a story that the student could then use for expanding literacy skills. Geary (1995) has also noted the importance of presenting conceptual knowledge in familiar contexts and relating those concepts to personal experiences in the student's life. While this may represent best practice for all students, personalizing learning and placing it in a social context drawn from the student's direct experience may be crucial for students with significant cognitive disabilities if they are to achieve academic competence that goes beyond mere rote recall.

From the consideration of social contexts, we can draw several conclusions for students with significant disabilities. First, as Pellegrino et al. (2001) have noted, "reading, writing, quantitative reasoning, and other cognitive abilities are strongly integrated in most environments" (p. 89). For students with significant disabilities, instruction should focus on how to integrate these skills into daily instruction and how to measure them in the context of authentic life tasks. Second, instruction for students with significant disabilities needs to take advantage of the powerful impact of modeling within integrated environments. Given the importance of peer-mediated performance, alternate assessments should also reflect the extent to which students with significant disabilities can participate in a community of practice and adjust their performance based on the models and feedback provided by their peers. Third, closely related to the concept of social contexts is that of individualized supports.

Vygotsky's (1993) perspective that the "higher" psychological functions can be attained by individuals with intellectual disabilities, and that such development is predicated on educational, social, and communicative supports, suggests that we should ensure that both learning and assessment are mediated through these supports, including assistive technology, that enable students to show what they have learned. Vygotsky introduced the concept of the zone of proximal development (see Gindis, 1999; Vygotsky, 1993) to illustrate the importance of emerging concepts that students learn through the process of scaffolding, or carefully planned individualized supports through the mediation of peers and adults.

Methods of Observation and Inference: Microgenetic Analysis

Pellegrino et al. (2001) ended their reflections on the advances in the science of learning with "a discussion of some of the methods of observation and inference that underlie our current thinking of cognition" (p. 97). One of these methods, microgenetic analysis, may have special importance for students with significant cognitive disabilities. According to Pellegrino et al.,

> the properties of microgenetic analysis include: (1) observations that span as much as possible the period during which rapid change in competence occurs; (2) a density of observations within this period that is high relative to the rate of change in the phenomenon; and (3) observations that are examined on an intensive, trial-by-trial basis, with the process of understanding the process of change in detail. (2001, p. 100)

This description will be immediately recognized by practitioners in the field of severe disabilities as elements of the principles of systematic instruction and continuous assessment of student performance (see Snell & Brown, 2006; Westling & Fox, 2004; Wolery, Ault, & Doyle, 1992) that characterize effective instructional programs for these learners. Indeed, the trial-by-trial analysis referred to in Pellegrino et al. (2001) is remarkably similar to the importance of data-based decision rules to enhance instructional effectiveness (Browder, 2001; Farlow & Snell, 1994). Systematic instruction, continuous assessment, and the use of data-based decision making have implications for alternate assessments as well. While the literature on microgenetic analysis describes intensive, often trial-by-trail measures within concentrated time periods of maximum behavioral change (Lemke, 2000), we suggest that the principles for rigorously examining increments of change inherent in microgenetic analysis can be extrapolated to broader scales of time for students with significant cognitive disabilities. For example, the use of these principles can result in more effective student learning over *macro periods*; certainly within many states' alternate assessments, growth models (or how much new knowledge or how many skills a student has gained) play an important part in both the observation and interpretation parts of the assessment triangle. Second, providing training to teachers in these principles can result in enhanced state alternate assessment scores for their students (Browder, Karvonen, Davis, Fallin, & Courtade-Little, 2005). For example, Browder, Karvonen, et al. (2005) found that teachers who received a training package that included a clear definition of measurable instructional objectives and the systematic application of data-based decision rules had students who scored higher on both their state alternate assessments and in the overall rate of growth on their IEP objectives.

Domain-Specific Competence: Acquiring Reading and Math Skills

In this next section, we apply the general principles of knowledge construction and representation that we have noted above to what we know about *specific* domain competence for students with significant cognitive disabilities in the domains of reading and math. Finally, we present examples from an actual state alternate assessment of fourth-grade reading and math tasks and discuss how those tasks mirror our present knowledge of how students with significant cognitive disabilities learn and represent grade-level academic content.

What we know about reading. In a comprehensive review of reading instruction for students with significant cognitive disabilities, Browder, Wakeman, Spooner, Ahlgrim-Delzell, and Algozzine (2006) have noted that there is considerable evidence for effectively teaching sight word vocabulary for these students through the use of systematic instructional and fading procedures. These researchers confirmed that the majority of what we know about literacy for students with significant cognitive disabilities has been achieved through studies that closely followed the behavioral model of learning, including explicit, repeated instruction in a massed trial format and the use of carefully designed cues, prompts, and error correction procedures. However, as these authors have noted, there are no present studies that address the comprehensive development of literacy across the National Reading Panel's (2000) five components of reading: (a) phonemic awareness, (b) phonics, (c) fluency, (d) vocabulary, and (e) comprehension. For these students, Browder et al. noted that there is a general lack of studies addressing phonemic awareness and phonics and that comprehension studies have focused largely on functional applications in daily life settings (e.g., reading recipe words for cooking), as opposed to higher level, more generalizable comprehension strategies (e.g., question generating and summarizing). Bradford, Shippen, Alberto, Houchins, and Flores (2006) found that for three adolescents with moderate intellectual disabilities, systematic instructional procedures did result in these students learning phonemic and decoding skills and resulted in short passage reading (fluency). However, Bradford et al. did not formally assess comprehension skills. Although the field is providing more emphasis to longitudinal literacy instruction for students with significant cognitive disabilities, our knowledge about reading for these students is characterized more by what we don't know than what we do.

What we know about math. For students with significant cognitive disabilities, the focus on math instruction has addressed applications primarily related to money management, time, and measurement (Browder, Spooner, Ahlgrim-Delzell, Harris, & Wakeman, 2008). Again, although we have individual examples of how teachers might teach more complex numeracy, data, and algebraic principles (see Collins et al., 2006), to date there are no studies that focus on the longitudinal development of mathematic skills for students with significant cognitive disabilities. As a result, practitioners and policy makers do not have an effective research base to provide instruction to students with significant cognitive disabilities on grade-level mathematics content standards and to adequately assess these students on math tasks linked to grade-level content standards.

Pellegrino et al. (2001) have noted that students without disabilities may achieve domain competence through a variety of cognitive or progress maps and that large-scale assessments for these students are very frequently not grounded in a coherent theory of learning. It is reasonable to expect that students with significant cognitive disabilities, given the heterogeneity of their learning characteristics, would have at least as many "roads" to domain competence. The research agenda in this area is thus two-fold: (a) to elucidate progress maps in reading, math, science, and other subjects for students with significant cognitive disabilities and (b) to develop alternate assessments across grade spans that are consistent with these progress maps.

Examples From One State's Fourth-Grade Alternate Assessment

While states are presently making significant changes in their alternate assessments to reflect the requirements of the IDEA and NCLB, we believe it will be illustrative to show how one state (Kentucky) has used the principles discussed in this article to redesign its alternate assessment. Specifically, we will focus on examples from the fourth-grade alternate assessment in reading and math for that state. Our aim is not to hold up this state's work as a model for other states but simply to illustrate how the guiding principles discussed in this article are being put into practice.

Fourth-grade reading.

- Example of fourth-grade state reading standard: Student will identify main ideas and details that support them.
- Example of measurable/observable skills in the alternate assessment: After the teacher and the student together identify the main idea of a grade-level passage (the passage can be presented orally), the student will correctly select three supporting details from a set of five possible responses (including three actual supporting details and two distractors written as short phrases or pictorial representations).

Note here that the alternate assessment standard is linked to the grade-level content state standard but is reduced in complexity and breadth. The intent of this standard is to ensure that students can identify supporting details for a main idea; *how* the student makes that identification can be reduced in complexity from how students demonstrate competence on that standard in the regular state assessment. First, the reading selection (while on grade level) can be personalized to the student's interest (e.g., a passage about a favorite topic in science or even an event in the student's own life). Individualized supports can also be provided, as long as the supports do not compromise the standard being measured (e.g., the passage could be read to the student via computerized text-to-speech because this standard addresses not decoding skills but rather the student's comprehension of the difference between the main idea and supporting details). Moreover, in keeping with the principles of formative and repeated assessment (e.g., microgenetic analysis), many states allow for repeated measures of student work on this skill (scoring the amount of student progress, final accuracy, or both) and build in opportunities for the student to generalize the skill across different passages, subject areas, and classes. Learning supports (to assist students with short-term memory deficits) can be provided by explicitly teaching students to develop their own concept maps or graphic organizers (Heward, 2006) that might visually display the main idea in the center of a diagram and the supporting details as attached "spokes" around the center. Such concept maps can actually be included as supporting evidence in several states' assessments as attached work samples and are currently being used as such. Students can be taught such metacognitive strategies as self-instruction (generating their own questions about what "this is about," and what "things" I learned about it) and self-evaluation strategies ("How many details did I identify? Did I find all the supporting details?"). As noted by Pellegrino et al. (2001), such metacognitive strategies distinguish competent from less proficient learners; again, several states allow students to actually include the metacognitive strategies they used in their alternate assessment task as an attached work sample.

Fourth-grade math.

- Example of fourth-grade state math standard: Student will identify, analyze, and make inferences from data displays (drawings, tables, charts, tally, pictographs, bar graphs, circle graphs, line plots, Venn diagrams).
- Example of measurable/observable skills in the alternate assessment: Given either a bar chart or pictograph illustrating frequency data in the student's experience (e.g., fourth-grade class's favorite music or local rainfall per month), the student will use the chart to indicate the first, second, and third highest values.

Note here that the alternate assessment standard is again linked to the grade-level content standard but is reduced in complexity and breadth. The intent is to make appropriate selections based on the visual representations of the data. Although not part of the assessment task itself, the student could also participate in constructing the tables or charts with his or her classmates (as part of a community of learners), perhaps through the use of an adaptive keyboard that allows students to tally and manipulate data with fewer keystrokes and a simplified keyboard. This social context of participating in a class project provides a sense of ownership and motivation for what is being learned and gives a real-life meaning to what the numbers or bars represent. The data displays could further be personalized by developing charts that illustrate things directly relevant to the student's experience: the class's favorite foods, games, or ice cream flavors! Generalization could be built into both instruction and assessment by using visual displays across subjects (e.g., math, science, and social studies) and using different types of data displays (e.g., bar graphs, tally charts, and pictographs). As with the fourth-grading reading task noted above, many states require repeated assessments of the student's performance on the targeted skill across different setting and subjects, allow the student to receive timely feedback on that performance, and enable the student to self-evaluate his or her own learning through an attached work sample. Although not all state alternate assessments allow teachers to choose the materials or activity context for the assessment, many states do provide teachers with this latitude, so long as the targeted skill is clearly linked to grade-level content standards. What is scored, then, is the degree to which the student evidences mastery of the targeted skill, the extent to which the student was able to demonstrate the skills without prompts or assistance, and, in some states, the degree of complexity of the targeted skill itself (Kentucky Alternate Portfolio Project, 2006; Kohl, McLaughlin, & Nagle, 2006).

Future Directions: Implications for Instruction and Assessment

In this article, we have attempted to explicate the principles of thinking and learning discussed by Pellegrino et al. (2001) as a part of the cognition vertex of the assessment triangle for *all* students. We have attempted to discuss the particular relevance of these principles for the assessment of students with the most significant cognitive disabilities, especially in the context of large-scale alternate assessments. For students with the most significant cognitive disabilities, we have seen these distinctions not so much as fundamental differences in how these students learn and think, but as matters of degree in how they process information that result in a need for more intensive supports and specialized instructional strategies. For students to accurately portray what they know and can do, these supports also need to be present within the assessment process itself (e.g., memory supports or pictorial cues to offset potential limitations in short-term memory that can obscure learned concepts in long-term memory). In this final section, we attempt to provide some future considerations for large-scale alternate assessments for students with the most significant cognitive disabilities, based on our explication of the cognition vertex. Because the purpose of assessment for students with significant disabilities, as it should be for all students, is to not only show what students know and can do, but also to actually enhance instruction and student outcomes (Commission on Instructionally Supportive Assessment, 2001; Kleinert & Thurlow, 2001), we suggest the following guidelines in instructional and assessment practices for students with significant cognitive disabilities:

1. Some alternate assessment tasks should be familiar. Students with significant disabilities are most likely to demonstrate new knowledge in assessments that require the least amount of transfer and are situated in familiar, meaningful contexts. For example, tasks presented with the same materials and context used for daily instruction are most likely to reveal the student's typical performance.
2. Some alternate assessment tasks should be novel and challenging. As with all assessments, alternate assessments should also be developed to provide the student with opportunities to demonstrate knowledge beyond current expectations. Consideration should also be given to how students are able to demonstrate acquisition of different types of information if given supports or strategies to compensate for potential deficits in short-term memory. Cognitive support strategies should be built into the directions and format of the assessment itself to ensure that the assessment truly measures what it was intended to measure. For example, providing a student with a set of guiding questions (e.g., "What is the main idea?" "What did I learn about the main idea?") may assist the student in focusing attention on comprehending the material and not exclusively on holding the task directions in memory. Similarly, novel tasks should also assess transfer or generalization of learning to new situations (see Black & Wiliam, 1998a), an especially critical

dimension for students with significant cognitive disabilities. Indeed, generalization or transfer of learning has been noted as an important issue for *all* students (Pellegrino et al., 2001); it is quite possible that well-designed alternate assessments could elucidate strategies for creating large-scale assessment tasks that measure transfer to novel situations for all students and in contexts of direct application to students' lives.

3. Some alternate assessment tasks should be developed to understand how students think about the task. Another aspect of the student's knowledge and competence is metacognition. Both instruction and assessment should make students' problem-solving processes explicit to themselves and to others, and students should have ample opportunities within both instruction and assessment for the application of metacognitive strategies, including self-correction, self-evaluation, and self-instruction. It may be helpful to know if students can make a correct response if given access to additional information. For example, one state's alternate assessment, in addition to requiring specific accuracy data on the targeted skill, requires a work sample for that skill (Kentucky Alternate Portfolio Project, 2006). That work sample can provide an opportunity for students to demonstrate their own problem-solving process or an evaluation of their own performance and could also provide the opportunity for receiving immediate feedback on that performance.
4. Some alternate assessment tasks should be developed to determine how students respond with social and other supports. An important aspect of the student's knowledge is how the student responds to the social context for learning, which is also linked to the motivation for that learning. Within both instruction and assessment practices for students with significant cognitive disabilities, opportunities should be provided for students to work as a community of practice, and assessment observations and scoring interpretations (or rubrics) should reflect how well students with significant disabilities function in interactive, problem-solving tasks with their typical age peers. This really involves two issues: first, how students with significant cognitive disabilities learn to become members of a community practice (e.g., the community of practice of mathematicians), including learning to use the tools and technology of that practice (Lave & Wenger, 1991). For students with significant cognitive disabilities, these tools and technology can include appropriate assistive technology (see Denham & Lahm, 2001). The second element of this dimension is how students with significant disabilities function as a part of a group of their peers in problem-solving novel problems within that discipline. Both types of support—social and technological—are essential in determining what students know. Thus, alternate assessment tasks, whenever possible, should include the opportunity for the student to document targeted skills within a social learning context with his or her peers. The sample fourth-grade math task that we described earlier in this article illustrates the importance of social context.
5. Alternate assessment tasks need to be designed so that students at a presymbolic level of communication have the opportunity to nevertheless demonstrate meaningful growth. Presymbolic students are those who do not demonstrate a clear use of words, pictures, objects, or signs to communicate expressively; preliminary data indicate that they may make up approximately

10% or more of the population of students in the alternate assessment (Kearns et al., 2006). These students presently do not have the foundational skills for numeracy and literacy, and this fact creates tremendous challenges in building alternate assessments that (a) capture meaningful skills that these students have achieved and (b) are linked to grade-level content standards. Teachers need research-based strategies to incorporate instruction on basic communication skills for these students into activities linked to the grade-level curriculum. Balancing the life needs of these students with the demands of alternate assessment linked to the general curriculum is an urgent research issue.

Limitations

There are important limitations to the approach we have taken in explicating the cognition vertex of the assessment triangle for students with significant cognitive disabilities. First, we have largely described these cognitive elements in a *domain-general* way, focusing on those areas of knowledge representation that might be particularly problematic for students with significant cognitive disabilities, irrespective of the academic core content area. To fully appreciate the power of these elements in understanding how students represent knowledge, and in constructing valid assessments based on those knowledge representations, it is important to consider how these concepts are applied to *domain-specific* knowledge representation for students with significant disabilities, especially in such areas as reading and math. Yet as we have noted, we simply do not have adequate theories, founded in research, of how students with significant cognitive disabilities acquire domain-specific academic knowledge. There is a critical need to explore the application of these elements to domain-specific or subject-area knowledge if we are to construct coherent alternate assessments linked to grade-level content standards. Without a firm research base on how students with significant cognitive disabilities develop longitudinal literacy and numeracy skills, it is doubtful that our assessments for these students can truly measure what they are purported to measure. In this sense, alternate assessments are similar to large-scale assessments for students without IEPs. As noted by Pellegrino et al. (2001), there is a clear need to establish domain-specific progress or cognitive maps for all students, and quite naturally, we should not assume that students, whether they have significant cognitive disabilities or not, take similar trajectories to domain proficiency.

Second, this article has described how these elements of cognition, as they have been identified for all students, may pose particular challenges for students with significant cognitive disabilities. Yet this is a tremendously heterogeneous population, and any attempt to describe a model or models of cognition for such a population must recognize from the onset that we can at best describe patterns of learning characteristics for students with significant cognitive disabilities. There are grave dangers in assuming that these patterns hold true for all students within this population. Clearly, an examination of these patterns is useful only if it improves our ability to make valid inferences about what these students have learned in the context of the academic standards we value for all children.

Conclusion

This article has addressed the first vertex of the assessment triangle, that of cognition, to examine the unique characteristics of students with significant cognitive disabilities in developing academic competence and representing what they know. We first discussed the primary elements of knowledge representation and domain competence identified by Pellegrino et al. (2001) for all students, and then for each of these elements, based on our current knowledge of instruction and learning in the field of severe disabilities, we discussed how these elements have special ramifications or considerations for students with significant cognitive disabilities. We have extrapolated what we currently know about how students with significant cognitive disabilities learn literacy and math skills to provide domain-specific examples of assessments at the elementary level. Finally, we have presented, for each of these elements, what we believe to be the essential considerations if alternate assessments based on alternate achievement standards are to be truly aligned to this first vertex of the National Research Council's assessment triangle.

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[1]We use the term *alternate assessment* throughout this article because this is the term used for large-scale educational assessments for students with significant cognitive disabilities in both the Individuals with Disabilities Education Act Amendments (1997) and the No Child Left Behind Act (2002). Alternate assessment is distinct from *alternative assessment*, which refers to a broader set of assessment measures (e.g., portfolio assessment) than standardized or more traditional pen and paper measures and is not specific to students with disabilities.

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