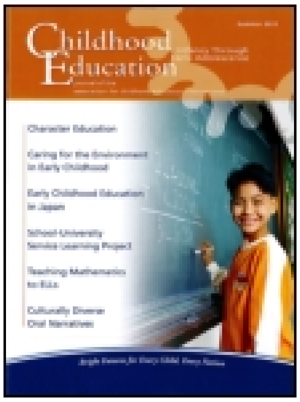

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A New Theoretical Perspective of Cognitive Abilities

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A New Theoretical Perspective of Cognitive Abilities

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Defining intelligence is a puzzle that has challenged educators and researchers for years. Such theorists as Rousseau, Pestalozzi, Froebel, Montessori, and Piaget developed various frameworks demonstrating that children learn as a result of environmental factors, "sensitive periods," and developmental stages (Warner & Sower, 2005). More recently, professionals are acknowledging that individuals possess many facets of intelligence and that learning is a complex combination of genetic factors, environmental influences, and life experiences that affect learning in unique ways (Salvia, Ysseldyke, & Bolt, 2010).

Howard Gardner's (1983) theory of multiple intelligences has provided many teachers with insights about their students' diverse ways of learning and expressing themselves. The Cattell-Horn-Carroll (CHC) theory is an emerging model of multiple intelligences. Named for the three men who contributed to its progression—Raymond Cattell, John Horn, and John Carroll (Flanagan, Ortiz, & Alfonso, 2007; McGrew, 2009)—it is based on years of empirical factor analytic research.

Basically, the CHC model conceptualizes intelligence as a constellation of distinct cognitive abilities, in which learners experience intellectual growth based on innate abilities, environmental opportunities, background of experiences, and emerging abilities in each of 10 cognitive areas (Flanagan et al., 2007). This article will describe the components of the CHC model so that practitioners can translate its principles into practice in the classroom.

CHC theory has evolved over a number of decades, as each aforementioned theorist researched human cognitive abilities using factor analysis. In 1941, Cattell originally proposed the existence of both fluid and crystallized intelligence (McGrew, 2005). Carroll and Horn conducted their research in the 1960s, although their work was more widely accepted and applied during the 1990s. In 1993, John Carroll developed a Three-

Stratum Factor Analytic Theory, defining three strata of intelligence: narrow abilities, broad abilities, and general intelligence, all of which varied in degrees of processing abilities, content acquisition, and responses to information (Carroll, 2005; Flanagan et al., 2007). Later, Horn (1994) expanded Carroll's theory to include eight or nine broad abilities that make up intelligence.

Eventually, CHC theory highlighted 10 broad abilities that emerged as a scientific model for cognitive abilities. These 10 broad abilities also include more than 70 narrow factors that further describe human cognitive ability (Carroll, 2005; McGrew, 2009). The next section of this article will explain these broad abilities and provide suggestions of how teachers can use this information to maximize student learning. Table 1, based on the descriptions contained in the work of Flanagan et al. (2007), describes these 10 broad abilities.

Description of the Broad Factors' Impact on the Classroom

Perhaps the easiest cognitive factors for teachers to relate to are auditory and visual processing, since these areas have been addressed in much of the research on information processing (Floyd, 2005), and many teachers are aware of the need to present lessons using multisensory methods (Lynch & Warner, 2008). With the increased use of digital media, children are surrounded by visual images from an early age. Lessons that include pictures, video, and images via technology are more likely to engage children than are traditional "tell-read-write" lessons (Westera, 2011). Auditory processing, used throughout the school day as teachers present lessons involving listening skills, enables children to develop phonemic awareness, phonological processing skills, phonics skills, and beginning decoding for reading (Floyd, Keith, Taub, & McGrew, 2007).

Crystallized intelligence requires children to use language to reason and acquire new information, providing the foundation for the background knowledge required in reading comprehension and math problem solving (McGrew, 2009). Much academic learning (e.g., basic reading skills, reading comprehension, mathematics, and written expression) relies on background knowledge and vocabulary. All of these academic skills require crystallized intelligence, and children who are strong in this area usually are academically successful (Wendling & Mather, 2009). These skills can be strengthened in language-rich classrooms where children ask questions, discuss concepts, and exchange information throughout the day (Mather & Jaffe, 2002).

In language-rich classrooms, teachers also engage students in many activities that incorporate short-term memory. When teachers give directions, require students to take notes, and present sequential information, they are building on students' short-term memory. Short-term memory is momentary and fleeting, as opposed to long-term retrieval. In order to translate information

Definition of Broad Abilities

Intellectual Process	Definition of Abilities
Auditory Processing	Using the sense of hearing to recognize and discriminate among different types of information
Visual Processing	Using sight to recognize and interpret information
Crystallized Intelligence	Comprehending and using language; knowledge acquired from the environment; social and cultural knowledge
Short-Term Memory	Recalling information that was learned recently
Long-Term Memory	Storing information learned and retrieving the knowledge when it is needed
Processing Speed	Automatically performing relatively easy cognitive tasks with fluency
Decision Speed	Making quick and accurate decisions in given situations
Fluid Intelligence	Solving novel problems using reasoning with materials and processes that are new
Quantitative Reasoning	Comprehending mathematical and numerical concepts and conducting basic operations
Reading/Writing	Comprehending written language (decoding) and expressing concepts in writing (encoding)

Table 1

from short-term memory to long-term memory for later retrieval, teachers can teach students specific strategies, such as rehearsal, chunking, and visualization (Mather & Jaffe, 2002).

One specific facet of short-term memory, working memory, has been found to be important across content areas, including math, reading, writing, and science (Yuan, Steedle, Shavelson, Alonzo, & Oppezzo, 2006). Working memory requires individuals to remember and manipulate information with an intervening task. Short-term memory, including working memory, provides for temporary storage of information before it is encoded into long-term memory. Classroom activities that incorporate long-term retrieval include learning and retrieving factual information, recalling information on tests, word retrieval during vocabulary lessons, and memorization of poems or math facts.

Processing speed is one facet of cognition that facilitates classroom performance (Dehn, 2008). It allows students to take in and assimilate information quickly, and it contributes to the ability to complete assignments in a timely manner. When students make quick comparisons of information, processing speed enables them to make subsequent judgments. Processing speed also is required when students copy information or take timed tests. Classroom activities that promote processing speed include performing simple tasks quickly, teaching skills to the fluency level, and timed math-skill performance.

Decision speed is the newest of the broad factors and is still being researched for its impact on learning and achievement (Flanagan, Ortiz, Alfonso, & Mascolo, 2006). However, we do know that classroom settings require children to make continual, multiple decisions that affect their academic performance. This broad ability also influences test-taking facility (Wendling & Mather, 2009).

Fluid intelligence is very important for learning in the areas of mathematics (Flanagan et al., 2006) and science (Yuan et al., 2006). When teachers use the principles endorsed by the National Council of Teachers of Mathematics, for example, they focus on meaningful problem solving and application to real-life situations (Kalchman, 2009). Lessons with this focus rely on fluid reasoning, since this broad area of intelligence involves the ability to reason both inductively and deductively. Teachers build on students' fluid reasoning when they provide math and science instruction that requires students to make inferences, solve abstract problems, think conceptually, and apply principles. This type of instruction differs substantially from models that rely heavily on memorization, rote skills, and simply matching or reproducing a stimulus.

Quantitative reasoning involves the ability to understand number concepts and manipulate numerical symbols (Taub, Floyd, Keith, & McGrew, 2008). Mathematics instruction relies heavily on these skills, since students must understand both math symbols and terminology, comprehend quantitative concepts, and recognize relationships among quantities. Students with strong quantitative reasoning typically perform well in math tasks (Taub et al., 2008).

In the CHC model, reading and writing are not viewed as separate from intelligence, but rather as integral parts of cognitive ability (Evans, Floyd, & McGrew, 2002). Although some argue that reading and writing are learned rather than innate, when we consider the various broad areas of intelligence, many of these facets result from experience within the environment and learning. Much of crystallized intelligence is learned, and most of the broad areas are influenced by exposure and practice within the home, school, and community. Reading and writing are conceptualized as the later developing cognitive areas (Tusing, 2004). Classrooms that provide opportunities for children to apply reading and writing skills beyond the formal instructional period can help children to consolidate and transfer their literacy skills. This can be done by encouraging free reading time, allowing children to check out library books to read at home, reading aloud to the class, and providing books in areas of interest to the children in a classroom reading center (Mather & Jaffe, 2002). Children also may use their writing skills in centers, such as a restaurant center or a message center; they also can write notes or write on chalkboards or slates. Some researchers recommend that all centers incorporate reading and writing (Kostelnik, Soderman, & Whiren, 2011).

Academic Performance and the CHC Abilities

Reading

Reading achievement relies on multiple broad areas of cognitive ability, and on a few specific narrow abilities within crystallized intelligence (Floyd et al., 2007; Vanderwood, McGrew, Flanagan, & Keith, 2002). The narrow abilities of language development, lexical or word knowledge, and listening ability are correlated with reading achievement. Phonetic coding, found within auditory processing, is critical for reading during the elementary years. Reading also involves long-term recall, and rapid automatic naming is associated with beginning reading skills. Working memory, which entails the ability to remember information and manipulate it with an intervening task, is important for reading achievement at all levels. Perceptual speed, a narrow ability within the area of processing speed, is also essential for achievement in reading.

Written Expression

Writing achievement is dependent on some of the same underlying language abilities involved in reading (Vanderwood et al., 2002). Language development and lexical knowledge are important for writing skills, as is general information—an additional ability within crystallized intelligence. Two component skills within short-term memory—memory span and working memory—are both essential for the development of writing ability (Flanagan et al., 2007). Processing speed, particularly perceptual speed, is vital for acquiring basic writing skills and written expression throughout the school years (McGrew & Wendling, 2010).

Mathematics

Although mathematics is not typically considered to be a linguistic area, two narrow abilities within crystallized intelligence nonetheless are associated with mathematics achievement: lexical knowledge and listening ability (McGrew, 2009). Fluid intelligence—specifically, inductive and general sequential reasoning abilities—is central to mathematics achievement at all grade levels. Working memory, within the area of short-term memory, is important for mathematics achievement. Finally, perceptual speed is involved in successful mathematics performance (Dehn, 2006).

In summary, several narrow abilities impact multiple academic areas of achievement. Language development and lexical knowledge are component skills within crystallized intelligence that are associated with success in reading, writing, and math (Flanagan & Alfonso, 2010). Both working memory, within the broad area of short-term memory, and perceptual speed, within the broad area of processing speed, affect all three academic areas. Some areas have been found to be moderately correlated with academic achievement as well, but this article focuses on the narrow abilities found to have strong association with academic achievement (McGrew, 2009).

Classroom Activities to Promote Cognitive Growth

Auditory and Visual Processing

Auditory processing is critical for beginning reading skills, and young children need to experience activities that promote phonemic awareness and phonological processing (Dehn, 2006). Word games, rhymes, breaking words into their sounds, and blending sounds together to form words all involve auditory processing. Songs, such as a "name game" or those with rhymes, also promote auditory processing. As young struggling readers often have difficulty with auditory processing, engaging activities with songs, sound activities, and rhymes can provide additional practice and help with the auditory skills that are foundational for beginning decoding (Mather & Jaffe, 2002).

Visual processing is important for higher level mathematics. Some activities that enhance this area include drawing, using manipulatives, reading maps and charts, and using geometric patterns in artwork. To promote visual processing abilities, teachers can provide tracing, copying, and drawing activities, and ask students to verbally describe visually based concepts (Dehn, 2006).

Crystallized Intelligence

Crystallized intelligence also is important for academic skills, particularly reading. This facet of intelligence includes verbal abilities and the capability to apply acquired knowledge when solving familiar problems (Flanagan et al., 2007). Activities that promote the use of crystallized intelligence include reading to children, engaging them in meaningful conversation about what they have learned, and talking about experiences before, during, and after they occur (Mather & Jaffe, 2002). Teaching new vocabulary through meaningful activities also enhances children's abilities in this area (Mather & Jaffe, 2002).

Fluid Intelligence

Fluid intelligence involves the ability to solve novel problems using processes and information that are not familiar to the child (Flanagan et al., 2007). When teachers challenge children with brain teasers, math problems that require novel problem solving, or projects that require creative thinking, they are providing opportunities for student growth in the area of fluid reasoning (Mather & Jaffe, 2002). Fluid reasoning also may be promoted by children working together in cooperative learning groups to solve a problem. However, as with all group work, teachers need to supervise to ensure that all children have the opportunity to participate and work within the group.

Memory

Short-term memory is a skill that some believe to be relatively innate (Dehn, 2008). However, many students have not had experiences in promoting memory skills. Short-term memory is immediate; stimuli fade quickly, unless the information is encoded into long-term memory for later recall (Dehn, 2008). Such activities as repeating words to songs, rhymes, and poems help to promote short-term memory. In addition, children can replicate patterns from a picture or model after removing the visual stimulus, using blocks, Legos, chalk, markers, or other materials. Children who struggle with short-term memory can use compensatory aids, such as writing directions; note taking; and such memory strategies as verbal rehearsal of material, repetition, chunking material into meaningful groups, and visual imagery (Dehn, 2008).

Long-term memory is enhanced when children are encouraged to review, rehearse, and repeat information that they have learned previously (Mather & Jaffe, 2002). When information is presented in a meaningful context, it also aids in promoting long-term retrieval. Other ways to assist with long-term memory include multisensory learning and limiting new information within a single lesson (Wendling & Mather, 2009). For children who have persistent difficulty with long-term recall, the use of mnemonic strategies and verbal rehearsal of material is helpful (Dehn, 2008).

Processing Speed

Processing speed works together with memory as the individual takes in information quickly and processes it for storage in memory (McGrew, 2009). Processing speed is involved with activities that increase rate and fluency, such as speed drills. These types of activities are helpful for the child who has difficulties in processing speed, but the focus should be on improvement rather than a single performance. For children with slower processing speed, the teacher also can provide extended time for tests or reduce the length of assignments (Dehn, 2006). Table 2 describes how preschool and primary-level teachers can enhance each broad ability through classroom activities.

How Teachers Can Use CHC Theory Effectively

Knowledge of CHC theory is beneficial to teachers, because they can use information about cognitive abilities to plan instruction that can enhance children's learning (Fiorello, Thurman, Zavertnik, Sher, & Coleman, 2009). Many of the activities suggested in this article can serve to strengthen students' knowledge, memory, and processing speed. Initially, teachers need to consider children's strengths and weaknesses in the areas of cognitive development. Although many adherents of CHC theory evaluate children's abilities using standardized tests, and many schools provide appropriate testing for enrollees, teachers' good observational skills within the school context can assist in differentiating students' abilities in fluid and crystallized intelligence, quantitative knowledge, visual and auditory processing, and reading and writing readiness (Wendling & Mather, 2009). School assessment personnel, such as education diagnosticians and school psychologists, are excellent resources for helping teachers to understand CHC theory and its relationship to school achievement and standardized test results. CHC theory is widely used by assessment specialists when selecting standardized tests, interpreting results, and diagnosing learning disabilities; the Individuals with Disabilities Education Improvement Act of 2004 characterizes learning disabilities as a disorder of basic psychological processing (McGrew & Wendling, 2010).

Additionally, cumulative records passed from grade to grade will inform teachers about students' strengths and weaknesses. Many end-of-year achievement tests and state-mandated test scores are recorded in cumulative records, and this information can serve to help teachers become aware of children's strengths and weaknesses. Reading tests, specifically, provide teachers with insights about children's abilities that are important to classroom instructional planning.

With primary-age students, the emphasis should be on comprehending content across all subject areas and on being able to solve simple problems. As children progress through the elementary grades, their ability to process information with speed becomes more important, because students need to be able to perform cognitive tasks fluently and make quick and accurate decisions. Once teachers become aware of students' strengths and weaknesses, they can organize lessons to meet the diverse needs of their group and of specific children.

Understanding CHC theory does imply that teachers will individualize instruction when it is necessary. For example, a 3rd-grade teacher may acknowledge that all of her students comprehend the multiplication facts. However, if she recognizes that three of her students have not yet mastered the ability to quickly answer multiplication problems, this situation requires spending some time with the three children in a small group (or individually) to ensure that the children can process the information quickly and automatically, to the point that the essential knowledge is stored in long-term memory.

In summary, teachers' understanding of CHC theory and the concepts presented in the article

Enhancing Broad Abilities With Classroom Activities

Broad Ability	Classroom Examples to Incorporate Abilities
Crystallized Intelligence	*Teaching oral vocabulary in context *Teaching reading vocabulary in context *Drawing on background knowledge in discussion to promote reading comprehension *Using KWL charts to promote reading comprehension *Solving mathematics word problems using verbal descriptions and diagrams *Promoting language skills as children progress through school
Auditory Processing	*Direct instruction to promote understanding of phonological awareness *Teaching spelling through sound-symbol association *Changing sounds within words to make new words *Completing rhymes and jingles
Short-Term Memory	*Playing games that require children to see objects and name them immediately (such as Concentration) *Remembering and repeating instructions for an assignment *Repeating tongue twisters, rhymes, and poems *Being able to match patterns after having seen them just one time
Long-Term Recall	*Teaching students to use mnemonic strategies to learn sequential steps in math, reading, and writing *Reviewing material learned several weeks earlier to promote recall *Application of math facts without the use of calculators *Reciting rote material (e.g., Pledge of Allegiance, state motto, seasonal songs) *Singing songs from memory without the use of written words
Fluid Intelligence	*Solving problems by using inductive and general reasoning skills *Solving oral and written dilemmas and mysteries *Completing puzzles and manipulative tasks *Cooperative learning tasks to solve a problem
Processing Speed	*Working to increase the rate and speed at which simple problems are solved *Using a timer to complete simple math problems

Table 2

can assist in planning lessons that: 1) broaden students' knowledge base, 2) enhance students' abilities to comprehend and use language, 3) help students become more attentive to auditory and visual information, 4) encourage children to be more fluent with cognitive tasks and decision making, 5) provide information that can be recalled quickly, and 6) store information that is essential for later learning (Wendling & Mather, 2009). Each cognitive process is important to learners' intellectual development, and they can be strengthened through classroom activities and projects that are engaging and thought-provoking.

Activities that engage children cognitively include in-class discussions, debates, role-playing, intellectual games (such as chess sets or Pictionary), bringing in musical or theatrical groups to perform, taking field trips to local museums, encouraging families to visit the public library and obtain library cards, and asking children to do creative writing (Lynch & Warner, 2008). Using children's interests as a springboard to Internet searches and reading books is a must. A child who is interested in baseball would benefit by looking up information about a favorite sports hero and reading about his statistics and his journey to the big leagues. Assisting children in developing a classroom recycling center would help them use mathematics skills in weighing and measuring newspapers, as an example, and to use lexical knowledge when recording information about the contributions made. Additionally, teachers need to find the joy of learning and model it for their children.

Conclusion

The definition of intelligence will continue to challenge educators and researchers in years to come, and CHC theory may evolve to another level of description as we come to know cognitive abilities in novel ways through more refined, research-based understandings. We hope that the concepts presented in this article will provide readers with another way of considering children's diverse abilities, and ideas for how to vary instruction based on the diversity of the learners in their classrooms. Concentrating on *how* children reason and comprehend information is a delightful pursuit, one that can only make classroom learning rewarding for students and teachers alike.

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