Webs of Skill: How Students

Identifying the complex and variable ways that students learn and develop can help educators provide differentiated instruction.

Kurt W. Fischer and L. Todd Rose

Two bright, energetic 7-year-olds, Clara and Scott, want to read well, but they differ greatly in their patterns of skills. Clara can read the words "dog," "black," and "waffle" (as well as many others), and she can make rhymes with them and sound out the letters to pronounce the word. Scott can read those words, too, but he struggles with the rhyming and sounding out, especially for "black" and "waffle." Scott's performance changes dramatically when his teacher helps him. She provides a choice of words that rhyme with "black" or shows Scott how to sound out the word, and he performs perfectly for a while. Then, after a few minutes without her support, he again struggles with the rhyming and sounding out.

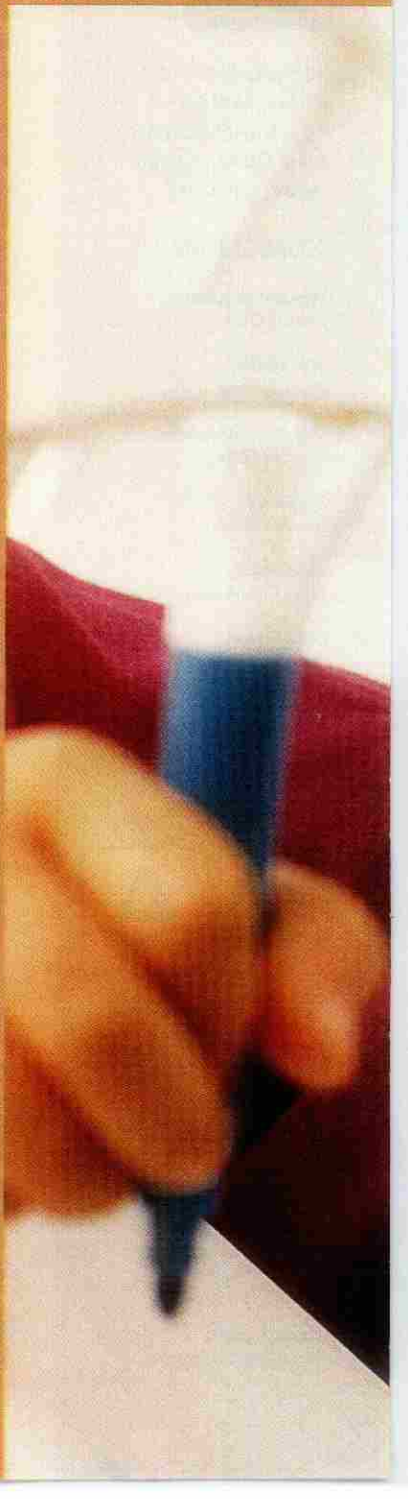
To understand and explain these variations in learning and development, we must detect the patterns behind Clara's and Scott's actions. When faced with the task of explaining such complexity, scientists and educators have typically retreated into oversimplifications. Most focus on a single factor to explain variation—typically, intelligence, developmental stage, or developmental norm. "Clara is smarter than Scott," or "Clara is at a higher stage than Scott," or "Scott is below grade norm, and Clara is at norm." But why can Scott perform the tasks correctly with his teacher? There is more to the differences than can be explained by a one-factor ladder of increasing competence, knowledge, or intelligence.

As researchers, educators, and parents, we are keenly aware, and often painfully reminded, that students do not all climb the same ladder. Their individual academic and social skills do not develop at the same time or in the same manner but in much more interesting and complex ways. A dynamic analysis of how students construct their skills offers a richer understanding of their learning differences—both the diverse pathways of different children, such as Clara and Scott, and the large variations in skills of an individual child that occur as a function of context and emotional state, as in Scott's activities with his teacher.

Each student constructs distinct pathways in every important learning domain, including reading, mathematics, and social interaction. At the same time, each student possesses a different level of skill in the learning domains; these variations in performance are a function of the student's emotional state and how much immediate support the student receives.

Constructive Webs of Development

An alternative framework for understanding learning and development is a dynamic approach that moves beyond the static one-dimensional ladder and builds on the concept of a constructive web of skills (Fischer & Bidell, 1998). Seeing learning as a dynamic construction of webs facilitates understanding the complex patterns of development and learning. Figure 1 depicts a small-scale version of this web; the strands represent potential



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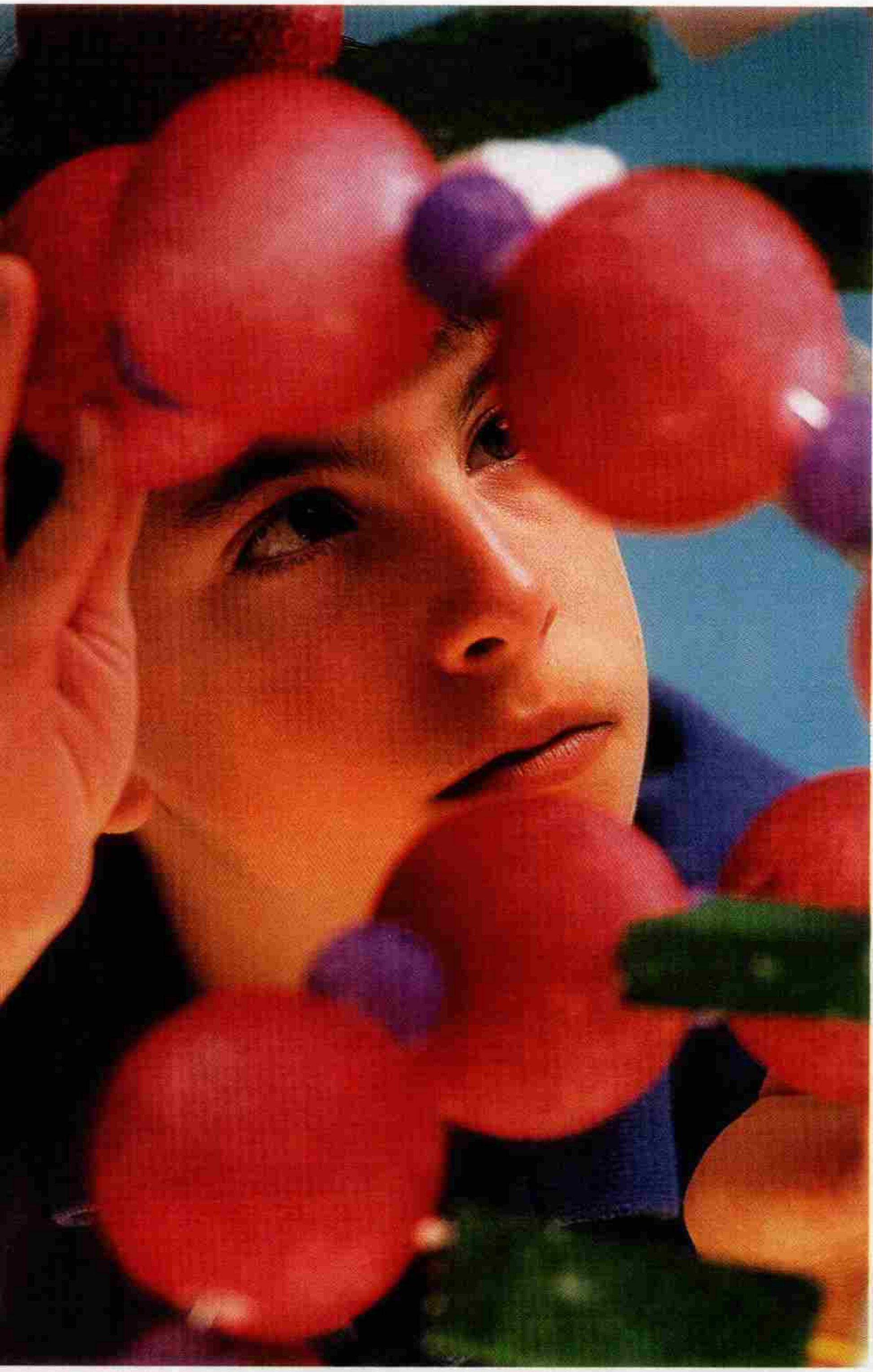
Learn

Students do not all learn in the same cookie-cutter fashion, and a dynamic analysis of learning and development provides powerful new tools for understanding their variations.



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skills that are developing in a domain, and the points of connection among the strands represent the integration of these skills. To read words, for example, the student needs to develop two different learning domains: visual-graphic skills, such as reading written letters and words; and sound analysis, such as rhyming and sounding out words. The idea of constructive webs explains how students can vary yet remain stable in development and leads to a recognition of patterns of variability that have eluded the classical models in the ladder framework.

Students continually construct multiple strands in their webs, such as sight and sound strands for reading words, with each skill contributing to the emergence of more complex skills along a strand. For example, identifying the letters of the alphabet helps students build the skills of reading and spelling individual words. A strand considered by itself is like a ladder of skills in a domain; however, it branches and connects with other strands—and there are many strands, not just one. In reading an alphabetic language such as English, the reader connects strands for visual-graphic and sound analysis to read effectively.

The development of a given skill involves diverse strands, branches, and connections, with one student showing a web like that in Figure 1 for reading and another student showing a different web. Unlike the rigid steps of a ladder, the sequence and order of the strands in a constructive web are not predetermined, nor is there one universal sequence.

At the same time, webs often demonstrate a great deal of order. Students commonly show similar strands, branches, and connections, as well as similar start and end points. These components are completely lost in the one-dimensional image of a ladder, which forces all students into one rigid model. Uncovering the orderly patterns through dynamic analysis of constructive webs creates powerful tools to help educators move beyond normative approaches and build effective individualized instruction. Two students in the same classroom may look similar in test performance, but their strengths and problems can be different because they are progressing through distinct developmental webs.

Early development of reading illustrates this type of ordered variability. In one study by our research group, the Dynamic Development Research Group at Harvard University (Knight & Fischer, 1992), 120 students in 1st, 2nd, and 3rd grades, ages 6–8, performed a series of six tasks with familiar words from their scholastic reading series in school. The six tasks all related to reading individual words: word definition, letter identification, rhyme recognition, rhyme production, reading recognition, and reading production. Examining these tasks allowed us to identify for each individual student the webs of skill development for learning to read single words (Fischer, Knight, & Van Parys, 1993). The webs from the study are far simpler than the one in Figure 1 because of the small number of tasks that we included in the study. With more tasks, the webs would show more strands and connections.

According to the standard theory of reading development, proficient reading comes from the integration of visual-graphic skills, such as letter identification, with sound-analysis skills, such as rhyme recognition (LaBerge & Samuels, 1974; Snow, Burns, & Griffin, 1998; Torgesen, Wagner, & Rashotte, 1994). The constructive web that illustrates this standard theory, shown as Pathway A in Figure 2, starts with word definition because students must know the word before they can use it appropriately. Initially, the sight and sound domains are independent and not integrated, forming separate branches for the early tasks: letter identification and rhyme recognition. Later, the two branches come together as students integrate sight and sound skills to read words and become proficient readers.

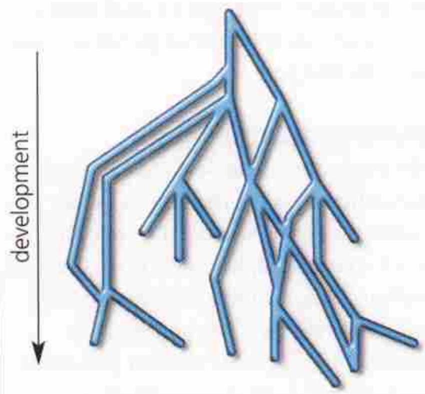
In our study, most normal readers, like Clara, demonstrated this developmental pathway and fit the standard theory. Clara's rhyming and reading tasks connected closely for each word that she read, so the sight and sound tasks in her constructive web integrated to form reading skills.

At the same time, a number of students performed the tasks differently and constructed two distinctive alternative webs that did not indicate integration (see fig. 3). Scott had difficulty with rhyming and sounding out words such as "black" and "waffle," even though he could read them. He was developing along one of the alternative webs, in which sight and sound tasks were not integrated. In Pathway B, the two strands remain separate and unintegrated. The web begins like the others, with word definition and then letter identification, but the remaining tasks develop along independent branches for reading and rhyming and do not achieve full integration. Rhyming tasks typically develop later than reading tasks, as with Scott.

The third web, Pathway C, shows even less integration, with three separate branches for letter identification, rhyming, and reading, as well as slow development of both reading and rhyming skills. The students who produced Pathway C all showed serious reading problems, and some of those developing along Pathway B had problems, too. These alternative webs illustrate the difficulty that poor readers have in integrating skills across strands.

FIGURE 1

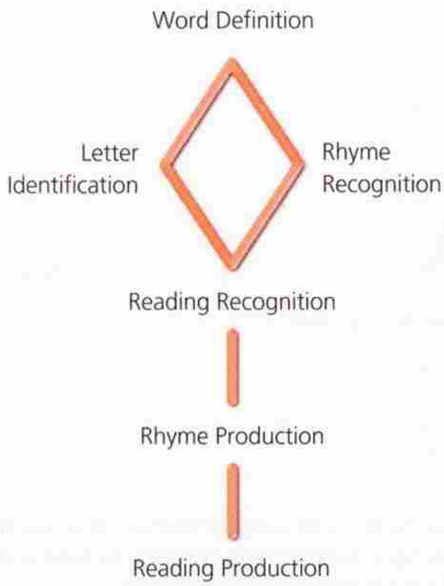
A Constructive Web of Development



The strands represent potential skills that are developing in a learning domain, and the points of connection among the strands represent the integration of these skills.

FIGURE 2

Pathway A: A Common Web for Reading Words



In this illustration of the constructive web for the standard theory of reading alphabetic languages, the sight (letter identification) and sound (rhyme recognition) domains are at first independent but then come together as students integrate sight and sound skills to read words.

Individual students perform and understand differently depending on context, especially whether they receive high or low support from their teachers or others.

Focusing only on deficits in the alternative webs is a mistake, however. The students producing these webs could read many of the words in the study, and some performed normally on standardized reading tests. They were developing along alternative pathways, learning to read without integrating the sights and sounds of words in the "normal" way. Learning to read is more difficult for most students following alternative pathways, but eventually many students with severe reading problems become skilled readers and writers by developing along distinctive pathways. In a study of highly successful adults who were dyslexic as students, Rosalie Fink (1995) found that they had become powerfully literate readers and writers, even though they still retained their difficulties with reading individual words, especially integrating the sights and sounds of novel words. These successful adults had found their own independent pathways to literacy.

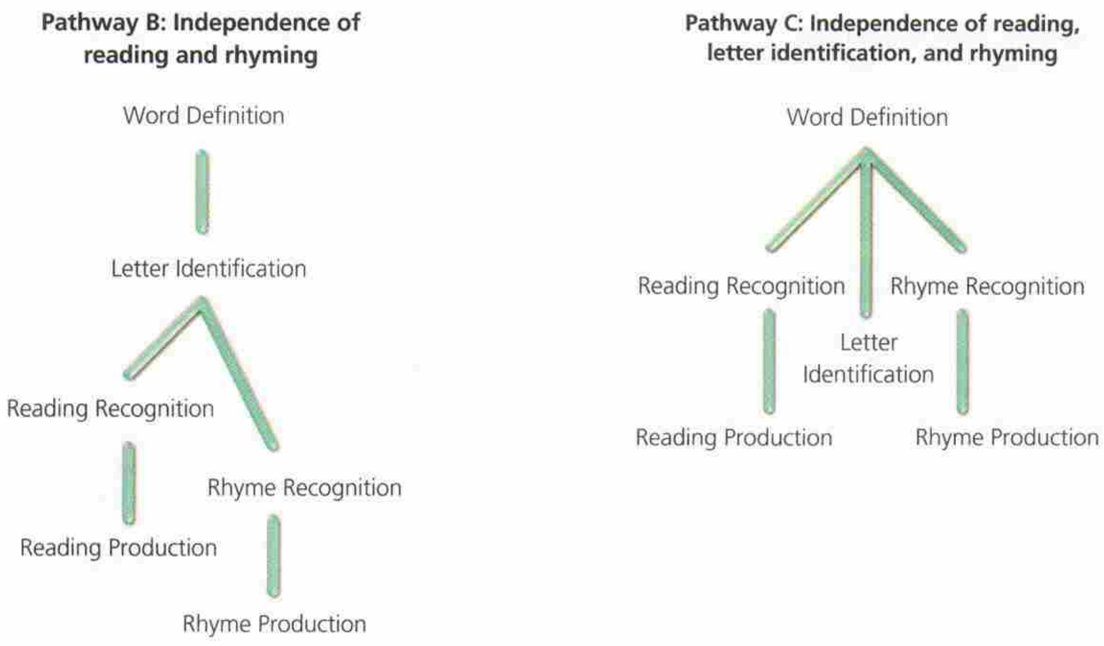
Developmental Range

Although a student develops along an individual web for reading, no individual acts consistently at a specific level on a strand; instead, he or she acts within a range of levels. Initially, Scott could not rhyme or sound out the words, but when his teacher provided support, he moved temporarily to a higher level, rhyming and sounding out successfully for several minutes. All students show similar variations in developmental range. They never remain fixed at one stage, even for a specific domain, such as reading words in the class curriculum, but instead vary across several stages or levels. Teachers know intuitively about this variation and are wary of claims that students operate at a fixed level of ability.

At first glance, this kind of variability may appear random or chaotic, especially when viewed through the lens of classic developmental theory. Like the differences in developmental pathways, however, there is order in what looks like chaos. An especially powerful influence on variation is contextual support for complex performance. Scott showed his ability to rhyme and sound out the harder words when his teacher provided support by prompting rhyming and sounding out, but this high-level ability disappeared in a few

FIGURE 3

Two Alternative Webs for Reading Words



All pathways of reading development begin with word definition skills (see figure 2), but these alternate pathways to reading show different skills developing independently. Learning to read is more difficult for most students following alternative pathways, but eventually many become skilled readers.

minutes after her support stopped.

The same variation occurs in all skills. A youth's competence at chess improves greatly in response to support from a mentor, and it varies with other factors: new situations, different challengers, and varying emotional states. Adults show this variation, too, especially when they are learning new material. For example, a member of our research group took a course about neural networks. In class, he demonstrated good use of network concepts with the support of the teacher's instruction, but when he went home and tried to explain neural networks to his wife, his level of understanding plummeted to much simpler, less sophisticated concepts.

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Extensive research has shown that each learner's range of development is defined by two upper limits of performance—the functional and optimal levels (Fischer & Bidell, 1998; Fischer, Knight, & Van Parys, 1993). Under low-support conditions, students function less skillfully, and their highest competence is their functional level, which is their best performance in most everyday functioning. When they receive high support, their highest competence is their optimal level, their best performance when a person or the context prompts the key components of the task for them. The optimal level develops in spurts during certain age periods, which are related to growth in neural networks in the brain (Fischer & Rose, 1998), but the functional level develops more slowly and continuously and varies greatly across domains.

Jill, 15, illustrates optimal and functional levels as she learns the mathematical relation between addition and multiplication for positive whole numbers. Addition and multiplication both involve combining numbers to get bigger numbers, with addition combining single numbers and multiplication combining groups of numbers (Fischer, Hand, & Russell, 1984). Explaining this conceptual relation between addition and multiplication eludes most adolescents, but when they turn 15 or 16, they can explain it with high contextual support. When Jill's teacher or friend prompts her with key ideas, Jill can explain this relation coherently for several specific arithmetic problems (such as 8 + 8 + 8 + 8 + 8 = 40 and 5 x 8 = 40) and exhibit competence at her optimal level. Within a few minutes after the prompting ends, however, her level of performance drops abruptly, and she cannot successfully explain the same relation that she dealt with cogently with support. Her level of performance on a test will depend similarly on whether the test question prompts the key components or not. In the classroom, students demonstrate this kind of fluctuation in understanding every day.

A primary goal of education is to improve the functional-level performance of students so that they can then produce the skill on their own.

The range between optimal and functional levels is large, as shown in the graph for skill growth in Figure 4. The graph shows only the levels that emerge during the school years; 13 developmental levels emerge between birth and age 30. Jill is in the midst of the spurt in optimal understanding that occurs at about age 15, but several years will pass before she can sustain the same understanding in ordinary performance and without high support. Variation of this kind occurs in almost all types of skills—not only reading, mathematics, and science, but also sports, social interaction, planning, and self-organization.

Dynamic Development

Students do not all learn in the same cookie-cutter fashion, and a dynamic analysis of learning and development provides powerful new tools for understanding their variations. The multiple webs of development capture the natural variability among students, and developmental range demonstrates how the variability occurs within each student.

Identifying common alternative webs provides a useful tool for educators because the webs illuminate the different ways that students learn important skills and show that students learn in multiple ways. Even individual students perform and understand differently depending on context, especially whether they receive high or low support. A primary goal of education is to improve the functional-level performance of students so that they can then produce the skill on their own. At the same time, an optimal-level skill is a target that students experience as realistic because they can achieve it if given high support.

When educational assessments distinguish alternative developmental webs for learning and note the differences between functional and optional levels of skill, educators can teach better, write more effective curricular materials, and improve the quality of their students' learning. ■

References

Fink, R. (1995). Successful dyslexics: A constructivist study of passionate-interest reading. *Journal of Adolescent and Adult Literacy, 39*, 268–280.

Fischer, K. W., & Bidell, T. R. (1998). Dynamic development of psychological structures in action and thought. In R. M. Lerner (Ed.), *Handbook of child psychology: Vol. 1. Theoretical models of human development* (5th ed., pp. 467–561). New York: Wiley.

Fischer, K. W., Hand, H. H., & Russell, S. L. (1984). The development of abstractions in adolescence and adulthood. In M. Commons, F. A. Richards, & C. Armon (Eds.), *Beyond formal operations* (pp. 43–73). New York: Praeger.

Fischer, K. W., Knight, C. C., & Van Parys, M. (1993). Analyzing diversity in developmental pathways: Methods and concepts. In R. Case & W. Edelstein (Eds.), *Contributions to human development: Vol. 23. The new structuralism in cognitive development: Theory and research on individual pathways* (pp. 33–56). Basel, Switzerland: Karger.

Fischer, K. W., & Rose, S. P. (1998). Growth cycles of brain and mind. *Educational Leadership, 56*(3), 56–60.

Knight, C. C., & Fischer, K. W. (1992). Learning to read words: Individual differences in developmental sequences. *Journal of Applied Developmental Psychology, 13*, 377–404.

LaBerge, D., & Samuels, S. J. (1974). Toward a theory of automatic information processing in reading. *Cognitive Psychology, 6*, 293–323.

Snow, C. E., Burns, M. S., & Griffin, P. (Eds.). (1998). *Preventing reading difficulties in young children*. Washington, DC: National Academy Press.

Torgesen, J., Wagner, R., & Rashotte, C. (1994). Longitudinal studies of phonological processes of reading. *Journal of Learning Disabilities, 27*, 276–286.

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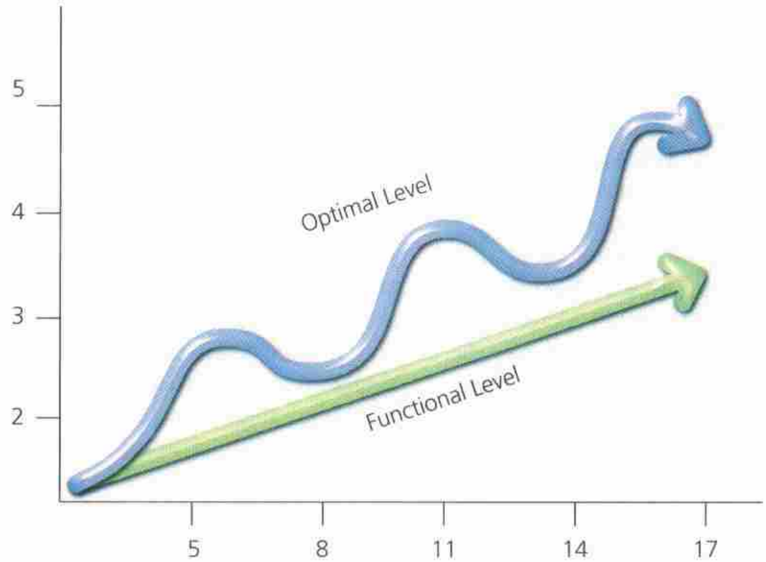
FIGURE 4

Developmental Range: Optimal and Functional Levels



The optimal level of skill is the level that a student can reach when he or she receives support. The functional level of skill is the level the student demonstrates independently, without help from context or teachers.