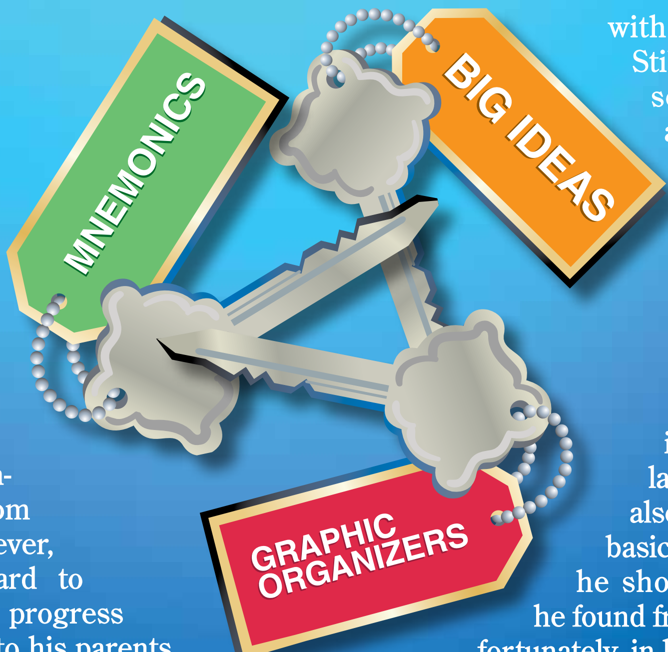
Three Keys to Success in Science for Students With Learning Disabilities

by Erica Kaldenberg, William Therrien, Sarah Watt, Jay Gorsh, and Jonte Taylor



Rudy is a 12-year-old boy with a learning disability (LD). This is his first year in middle school and, although he still has difficulty navigating the large school, he enjoys the increased freedom and responsibility. However, Rudy isn't looking forward to Friday because midterm progress reports will be sent home to his parents. Despite his best efforts, Rudy knows he is struggling in his life science class. In elementary school Rudy enjoyed science, particularly learning about insects. Unfortunately, as the vocabulary and concepts have become more difficult for him to understand, he has withdrawn from participating and actively learning in his science class. (Please note that Rudy is a fictional character.)

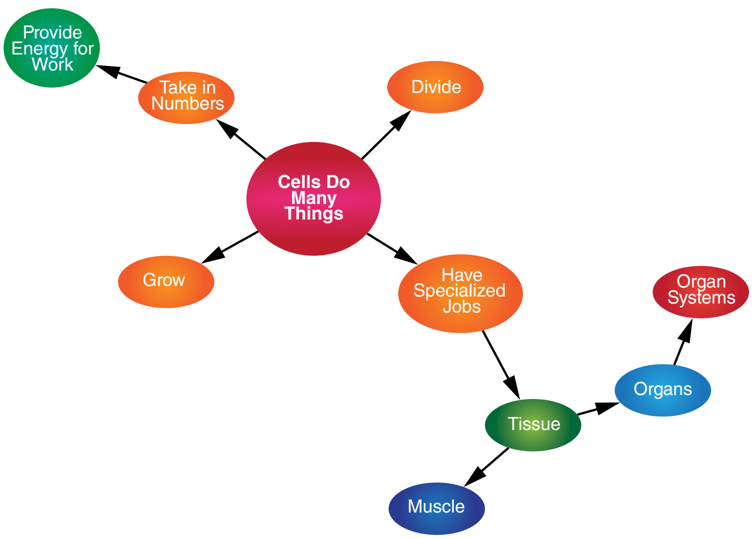
The middle school science curriculum used at Rudy's school is inquiry based, which is much different from the traditional textbook instruction that was used at his elementary school. Because Rudy is not reading at grade level, this inquiry approach has reduced some of his previous anxiety associated with reading the textbook. Still, Rudy struggles with some of the procedural aspects of the scientific investigations. His teachers have also noticed that he is having a hard time synthesizing the information from the hands-on activities into main ideas as well as determining the meaning of many of the vocabulary words. Sometimes he also struggles with making basic decisions, such as how he should display the results he found from an investigation. Unfortunately, in his inquiry science classroom, Rudy now spends most of his time in science as a spectator while others are actively engaged. As a result, he has not gained a strong understanding of the course content.

Students who struggle in science

On average, students with LDs score almost one standard deviation lower than students without disabilities on science achievement tests (Anderman 1998). Similarly, 4th-, 8th-, and 12th-grade students with disabilities scored significantly lower than their nondisabled peers on the National Assessment of Educational Progress science test (NCES 2011).

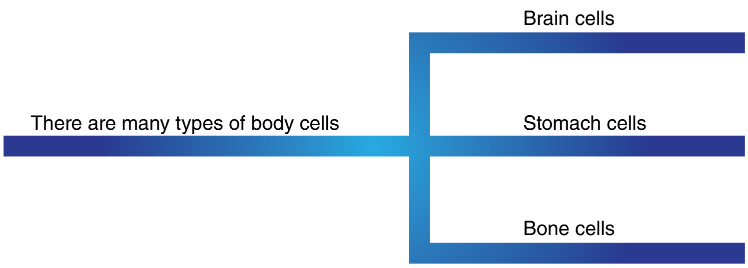
FIGURE 1 Examples of big ideas and graphic organizers

<table>
<tr><th>BIG IDEAS</th><th>GRAPHIC ORGANIZERS</th><th>EXPLAINATION</th></tr>
<tr><td rowspan="2">Cells do many things</td><td>Concept Map



</td><td>Concept maps help connect big ideas to numerous smaller concepts showing how things relate and interconnect. A concept map should be created by a teacher for planning purposes, but can also be created by students to assess understanding.

This concept map connects the big idea of "Cells do many things" with other smaller related concepts.</td></tr>
<tr><td>E-Chart/Pitch Fork



</td><td>E-charts are used to highlight main ideas or concepts to within a single idea.

This E-chart shows the relationship of three specific types of cells in the body.</td></tr>
</table>

Supports for students in inquiry classrooms

The National Science Education Standards call for teachers of science to plan "an inquiry-based science program for their students" (NRC 1996, p. 30). The hands-on investigations, decreased focus on rote memorization, and performance-based assessments found in inquiry classrooms benefit students with LDs (Scruggs and Mastropieri 2007). However, students with LDs often need additional supports and structure in these types of classrooms to be successful. Three simple ways teachers can enhance the achievement of students with LDs are by (1) focusing on big ideas, (2) using graphic organizers, and (3) providing mnemonic strategies to help students learn important facts. See Figure 1 for examples using big ideas and graphic organizers. Figure 2 illustrates an example of a mnemonic, and Figure 3 indicates the research from which the examples originate.

Big ideas

Students like Rudy often get overwhelmed trying to learn novel and complex science terminology. Hand et al. (2009) explain that "knowledge is stored in long-term memory as conceptual frameworks, not as separate content knowledge points" (p. 32). Consequently, when learning takes place, an individual's conceptual framework is rearranged and strengthened. Students with LDs in particular benefit from focusing on big ideas because this reduces the volume of information that needs to be memorized and provides an anchor (i.e., the big idea) to tie important concepts together.

Big ideas are concepts the teacher wants to ensure students internalize at the end of a science unit. In order to develop a big idea, a handful of key ideas for students to master should first be formed. State and national science standards can be used to guide the development of central concepts or big ideas (Hand et al. 2009). Oftentimes, however, state and national standards do not provide the exact objectives for the teacher to teach, so the teacher must develop the big idea based on content knowledge pertaining to the standard. For instance, in a life science content standard that states students should understand and apply knowledge "of the structure and function in living systems" (NRC 1996, p. 106), a variety of big ideas can be generated. After looking at this standard and examining the relationships between the ideas related to the standard, we generated the big idea "Cells do many things" (see Figure 1).

Through instruction, experimentation, and observation tied explicitly to the big idea, students gain an in-depth understanding of overall science concepts.

FIGURE 2 The keyword mnemonic strategy for *cell membrane*

Graphic organizers

Rudy's science teacher, Ms. Greene, occasionally uses graphic organizers. In the unit where she used a graphic organizer, Rudy obtained his highest score (i.e., 88% instead of his average 60%) on the summative test. The graphic organizer Rudy could have completed for the first unit is shown in Figure 1. Similar to all graphic organizers, this one visually displays the connection between ideas (Ellis and Howard 2007). This connection can express a hierarchical relationship, demonstrate cause and effect, compare and contrast two items, or symbolize a cyclical or a linear flow. Additionally, these images can act as a visual prompt for communication and understanding of complex relationships and important information.

Mnemonics

Rudy struggles with remembering key vocabulary words. Mnemonics may help him remember important terms or concepts. Mastropieri and Scruggs (1998) describe the use of mnemonics as a systematic way of enhancing memory input or encoding that makes information easier to access or retrieve. As identified by previous research, there are a number of specific mnemonic strategies that teachers and students can use. Some of the specific mnemonic strategies detailed by Mastropieri and Scruggs (1998) include the keyword method and the letter strategy (e.g., using letter prompts). The keyword mnemonic strategy pairs the keyword with an illustration, demonstrating how the keyword is related to the vocabulary word. The keyword and the illustration are used as a prompt for students to redevelop the correct definition of the represented vocabulary word (Atkinson 1975). Figure 2 demonstrates a possible keyword mnemonic Ms. Greene could have created to help Rudy remember the definition of the word *cell membrane*. In the example, the keyword *brain* is used for the vocabulary word *cell membrane*. The figure shows a brain walking through a door because the cell membrane acts as a door through which particles pass back and forth. If Rudy were to study using this mnemonic strategy, when he saw the vocabulary word *cell membrane* he would be prompted to remember the keyword *brain*. Then he would remember the illustration and recall that the cell membrane is like a door that allows things to move in and out of the cell.

FIGURE 3 Research supporting strategies presented in this article

Strategies	Articles
Big ideas	Archer and Hughes (2011) McCleery and Tindal (1999)
Mnemonics	King-Sears, Mercer, and Sindelar (1992) Mastropieri, Scruggs, and Levin (1985)
Graphic organizers	Dexter and Hughes (2011) Griffin, Simmons, and Kameenui (1991)

Conclusion

Struggling students with LD will benefit greatly from graphic organizers and the use of mnemonic devices to learn unfamiliar vocabulary. The identification and exploration of the big ideas in connection with a student's prior knowledge can also help create a strong environment of learning for a diverse population of students. Successfully implementing these strategies into science classrooms will prevent students like Rudy from becoming spectators in a content area filled with hands-on learning. ■

References

Anderman, E.M. 1998. The middle school experience: Effects on the math and science achievement of adolescents with LD. *Journal of Learning Disabilities* 31 (2): 128–38.

Archer, A.L., and C.A. Hughes. 2011. *Explicit instruction: Effective and efficient teaching*. New York: Guilford Press.

Atkinson, R.C. 1975. Mnemotechnics in second-language learning. *American Psychologist* 30 (8) 821–28.

Dexter, D.D., and C.A. Hughes. 2011. Graphic organizers and students with learning disabilities: A meta-analysis. *Learning Disability Quarterly* 34 (2): 51–72.

Ellis, E.S., and P.W. Howard. 2007. A focus on graphic organizers: Power tools for teaching students with learning disabilities. *www.teachingld.org/pdf/alert13.pdf.*

Griffin, C.C., D.C. Simmons, and E.J. Kameenui. 1991. Investigating the effectiveness of graphic organizer instruction on the comprehension and recall of science content by students with learning disabilities. *Reading, Writing, and Learning Disabilities* 7 (4): 355–76.

Hand, B., L. Norton-Meiri, J. Staker, and J. Bintz. 2009. *Negotiating science: The critical role of argument in student inquiry.* Portsmouth, NH: Heinemann.

King-Sears, M.E., C.D. Mercer, and P.T. Sindelar. 1992. Toward independence with keyword mnemonics: A strategy for science vocabulary instruction. *Remedial and Special Education* 13 (5) 22–33.

Mastropieri, M.A., and T.E. Scruggs. 1998. Enhancing school success with mnemonic strategies. *LD Online. www.ldonline.org/article/5912*.

Mastropieri, M.A., T.E. Scruggs, and J.R. Levin. 1985. Mnemonic strategy instruction with learning disabled adolescents. *Journal of Learning Disabilities* 18 (2): 94–100.

McCleery, J.A., and G.A. Tindal. 1999. Teaching the scientific method to at-risk students and students with learning disabilities through concept anchoring and explicit instruction. *Remedial and Special Education* 20 (1): 7–18.

National Center for Education Statistics (NCES). 2011. *The nation's report card: Science 2009*. Washington, DC: U.S. Department of Education. *http://nces.ed.gov/nationsreportcard/pdf/main2009/2011451.pdf.*

National Research Council (NRC). 1996. *National science education standards.* Washington, DC: National Academies Press.

Scruggs, T.E., and M.A. Mastropieri. 2007. Science learning in special education: The case for constructed versus instructed learning. *Exceptionality* 15 (2): 57–74.

Erica Kaldenberg (*erica-kaldenberg@uiowa.edu*) is a doctoral student in special education in the Department of Teaching and Learning, ***William Therrien*** is an associate professor, ***Sarah Watt*** and ***Jay Gorsh*** are doctoral students, and ***Jonte Taylor*** holds a postdoctoral position in the special education program, all at the University of Iowa in Iowa City, Iowa.