Research-Based Instructional Strategies in Science for Students With EBD

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As the three teachers sat in their professional development in-service training, each wondered just how well they would perform their task. Jefferson School District assigned Mr. Blair, Mrs. Michaels, and Mrs. Ritchie to be science support teachers for their students with emotional and behavioral disorders (EBD) in the elementary, middle, and high schools, respectively. While Mrs. Michaels was a bit less nervous having volunteered herself for the task due to her interest and experience in science teaching, Mr. Blair and Mrs. Ritchie felt quite apprehensive about having to provide science supports. Mr. Blair was doubly worried, having spoken to the elementary teachers that he was to support. He had a hard enough time convincing them that his students could excel in their classes. He now discovered that none of the general education teachers felt prepared or confident in their knowledge of science content or their abilities to teach it. Mrs. Ritchie's concerns were rooted whether she would be able to keep up with the science content teachers in biology and chemistry, the classes in which her students were enrolled. All three teachers wondered just how much time could be devoted to teaching science when they believed there was more pressing material to teach in math, language arts, and behavior skills.

Due to their importance in the global economy, the areas of science, technology, engineering, and mathematics (STEM) have garnered major attention. According to the U.S. Bureau of Labor Statistics (2014), the annual mean wages and projected employment growth between STEM and non-STEM careers have differences of almost $40,000 and 8%, respectively. Unfortunately, the population of students with disabilities is underrepresented in STEM careers (National Science Foundation [NSF], 2013). Only 2% of individuals with disabilities participate in the STEM workforce (NSF, 2006). For students with disabilities to improve their prospects, they will likely need to attain a bachelor's degree in a STEM related field (Vilorio, 2014). Unsurprisingly, students with disabilities are less likely to enroll in college and more likely to drop out of high school and/or college (NSF, 2013).

Although each of the disciplines that make up STEM contributes to improved quality of life, science, and more specifically, science education and literacy, which has received the most attention. The Next Generation Science Standards (NGSS) explains how science knowledge is important to the decision making process. Understanding science allows for informed choices when making educational, occupational, and daily living decisions (NGSS Lead States, 2013) (see *Figure 1*). Knowledge of science concepts and related science skills is believed to increase an individual's opportunity for self-sufficient living and independence (NGSS Lead States, 2013).

Accessing these opportunities to use science as a means of independence can be a struggle. Students with disabilities tend to score lower on curriculum-based and standardized science measures than their nondisabled peers (Therrien, Taylor, Watt, & Kaldenberg, 2014). Based on national standardized measures, students with disabilities have not fared well in science achievement. The National Assessment of Educational Progress (NAEP) science scores for 2011 are lower for students with disabilities than nondisabled peers. Sixty-six percent of eighth grade students with special needs scored below basic, and only 11% scored proficient or higher (National Center for Education Statistics, 2012).

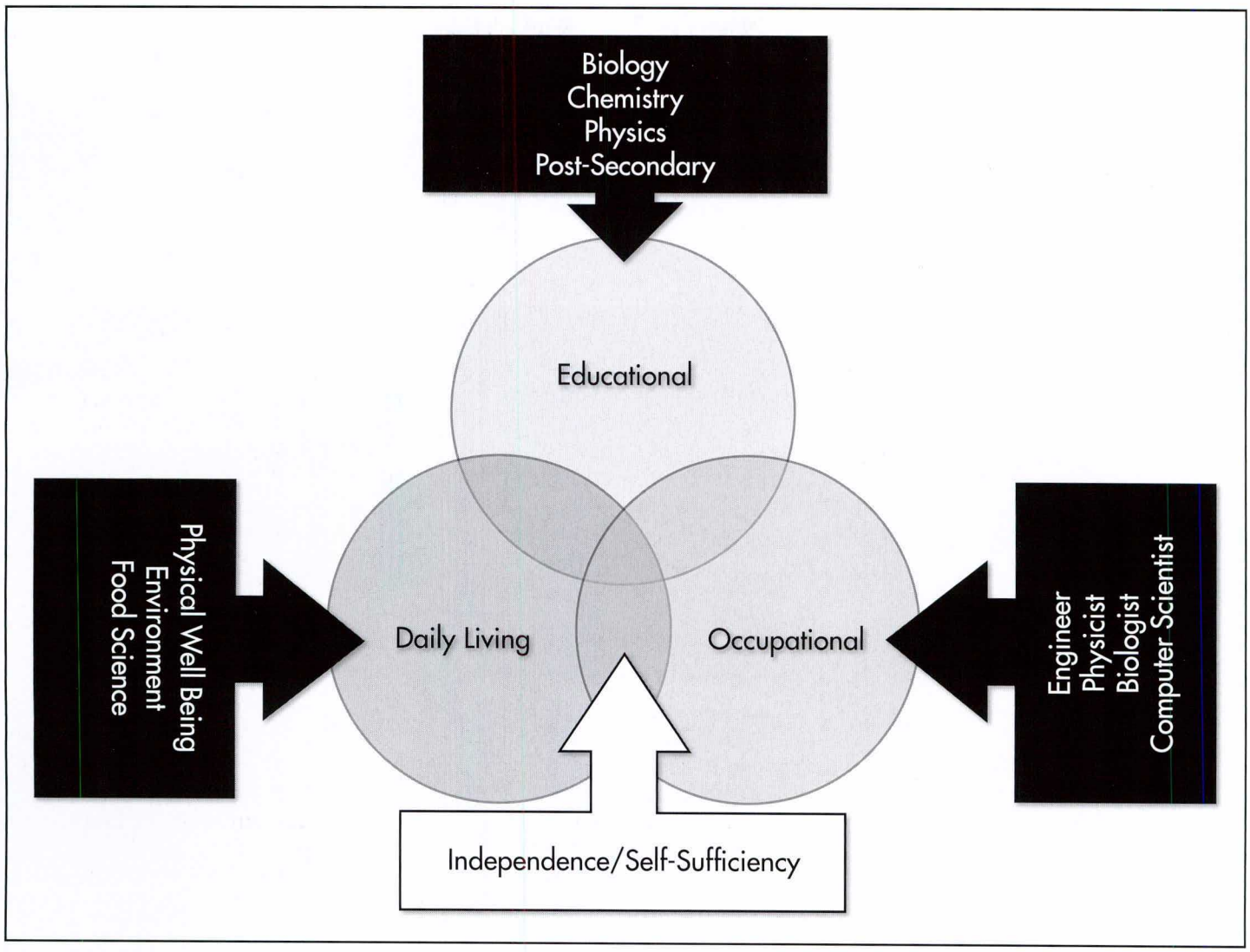
After their science in-service professional development, Mr. Blair, Mrs. Michaels, and Mrs. Ritchie decided to compare notes regarding their respective students and what possible problems they may encounter. All three agreed that they would likely encounter three big questions they would need to answer. First, how do I keep each student's attention to decrease potential behavioral problems? Second, how do I address academic problems that students may have including reading/vocabulary, math-related, and science content/background knowledge deficits? Lastly, what can I do to maximize each student's science achievement?

Barriers to Science Learning for Students With EBD

Most interventions for students with EBD have focused on improving behavior-related objectives (e.g. on/off task behavior; Vaughn, Levy, Coleman, & Bos, 2002). Along with behavior-related deficits, students with EBD have been found to display large gaps in achievement in core content areas (Lane, 2004), this includes the content areas of science. Those content area academic interventions for students with EBD have mainly focused on reading/literacy skills and mathematics. Although touted for years as an important content area, science instruction has received little attention (Therrien et al., 2014).

A number of factors contribute to poor science performance for students with EBD. Barriers to science achievement include student behavior, teacher training and confidence, and instructional format.

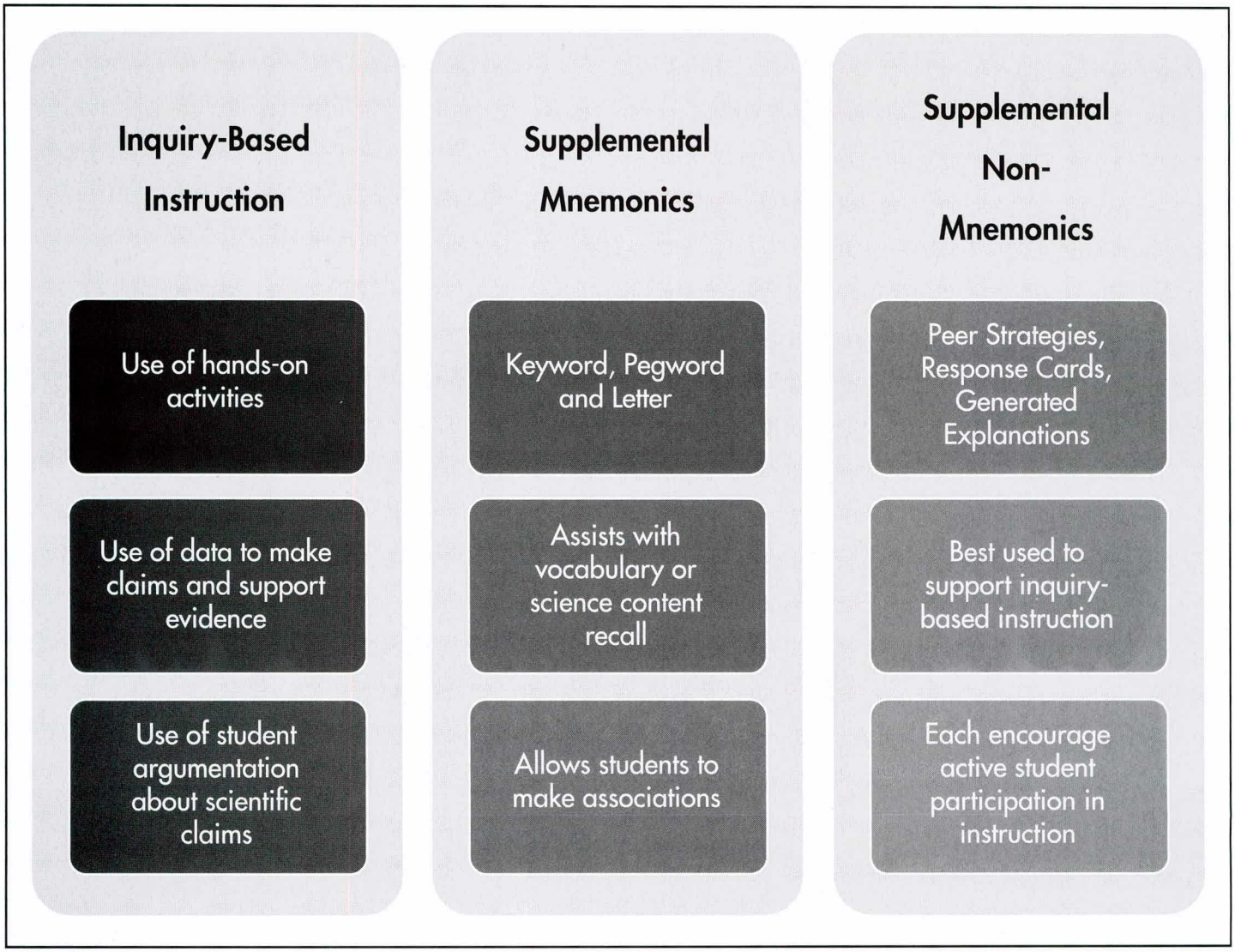
Figure 1 Intersectionality of Science Understanding in the Areas of Education, Occupation, and Daily Living for Students with EBD



Students with EBD exhibit problem behaviors consistent with the characteristics associated with their disability such as relating to peers and adults, following directions, and using critical thinking skills (Brigham, Scruggs, & Mastropieri, 2011). The extent to which teachers receive training to teach science content or students with disabilities contributes to how poorly students with EBD perform in science. Content area teachers in middle and high school report being underprepared to work with students with disabilities (Moon, Todd, Morton, & Ivey, 2012). Elementary and special education teachers have reported that they do not feel confident in teaching science content and curriculum. Teaching science using lecture-style presentation and textbook-based instruction is ineffective for students with EBD (Therrien et al., 2014) and for teaching science content (National Research Council [NRC], 2012). These traditional methods have heavy language and literacy demands (Parmar, Duluca, & Janczak, 1994) requiring content and prior knowledge in science (Scruggs & Mastropieri, 2000).

As they compared notes on how to teach science to their students with EBD, Mr. Blair, Mrs. Michaels, and Mrs. Ritchie each began thinking about what strategies could work for each of their students. Since Mr. Blair's students are in upper elementary inclusive science classrooms, he is planning to focus on learning more about inquiry-based instruction and using visual support based strategies. Mrs. Michaels is responsible for students in a self-contained classroom as well as students who receive pull-out science support at the middle school level. Her plans are to provide instruction using mnemonic strategies for her self-contained students, detailed explanations for the pull-out students, and peer strategies for both groups. Mrs. Ritchie's game plan for her high school students in inclusive biology and chemistry classes includes using visual support based strategies and response cards for teaching students science vocabulary.

Figure 2 Key Components of Science-Related Instructional Supports for Students With EBD



Research-Based Science Instructional Strategies for Students With EBD

Research studies that examine science instruction for students with EBD are limited (Therrien et al., 2014). Only 11 studies met the inclusion criteria for a review of science instruction and students with EBD, with three broad instructional categories (i.e., structured inquiry, supplemental mnemonic, and supplemental non-mnemonic) identified (see *Figure 2*). The supplemental non-mnemonic category was comprised of three subtypes (i.e., response cards, peer teaching strategies, and teacher/student generated explanations; see *Figure 3*).

Structured Inquiry-Based Instruction

For students with EBD, inquiry-based instruction with supports is successful in teaching science content and concepts (Therrien et al., 2014). While inquiry-based instruction is the recommended method of science instruction (NRC, 2012), there has been no consensus on how inquiry-based instruction should look in classrooms (Klahr & Li, 2005). Inquiry-based instruction is a continuum with one end of the spectrum being pure discovery learning (open inquiry) and increased amounts of explicit supports (structured inquiry; see *Figure 4*; Martin-Hansen, 2002; Rizzo & Taylor, 2016). While there is no consensus on the definition of inquiry-based instruction, across approaches there are similar characteristics.

The NRC (2012) and Therrien et al. (2014) suggested that inquiry-based approaches should incorporate students using hands-on activities and conducting experiments aligned with the content. Students can also learn how to recognize data sources and demonstrate the ability to collect and analyze different types of data (e.g., producing measurement variables and/or using text/online resources). Inquiry-based science instruction can also include students' use of debate, argumentation, and/or negotiation with peers to develop claims about science and use data as evidence to support their claims.

Figure 3 Online Resources for Science-Specific Instructional Strategies

Instructional Strategies	Online Resources
Inquiry-based Instruction	http://scholarworks.rit.edu/jsesd/ Search: inquiry or inquiry-based instruction
Mnemonic Instruction	http://www.ldonline.org/article/5912
Peer-related Strategies	http://www.education.com/reference/article/peer-tutoring/
Teacher/Student Generated Science Explanations	http://www.questia.com/library/journal/1G1-14965960/promoting-relational-thinking-elaborative-interrogation
Response Cards	http://ebi.missouri.edu/wp-content/uploads/2011/04/EBI-Brief_Response-cards_2010.pdf
Science Instruction (across all disabilities)	http://www.sesd.info

Many science-instruction programs apply the continuum of inquiry as the foundation for instruction that is often paired with other instructional strategies. Additional inquiry-specific instructional supports include student and teacher templates, graphic organizers, large and small group discussion, teacher modeling, guided practice, multimodal representations, and the use of manipulatives. Teachers are advised to use these supports, either as individual strategies or strategy packages, when engaging in inquiry-based instruction with students with EBD.

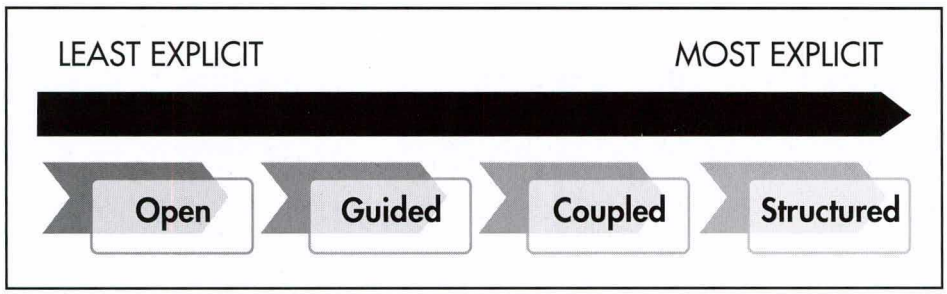
Supplemental Mnemonic Strategies

Using mnemonic devices to help students remember information, facts, or vocabulary is not new but only a few studies have examined their use for science instruction for students with EBD. Brigham and Brigham (2001) defined mnemonics as cues that are structured to provide explicit recall strategies connected to important information. Mastropieri and Scruggs (1998) described the use of keyword, pegword, and letter-based mnemonic strategies for students with disabilities in classroom settings. Mastropieri, Emerick, and Scruggs (1988) and King-Sears, Mercer, and Sindelar (1992) used keyword mnemonics to improve student retention of science factual knowledge and vocabulary terms and definitions.

Mnemonic strategies are a memory strategy for learning content area vocabulary. Science content is heavy with vocabulary and mnemonics can assist students with EBD in learning key terms. The use of keyword mnemonics allows students to use a word they are familiar with and sounds similar to a target word on a concept in an effort to provide memorable association. Pegword mnemonics are words in a concept or idea that can be associated with a corresponding rhyming number (e.g., eight and skate).

Pairing pegwords with visuals can strengthen associations. The use of letter mnemonics is generally associated with the use of acronyms (i.e., the first letter of key terms used to create another word to assist in remembering the key terms). For example, N.E.W.S. associates the four directional words of north, east, west, and south. Similar to an acronym, an acrostic uses the first letters of key terms

Figure 4 Inquiry-Based Instructional Continuum. Inquiry-Based Science Instruction Continuum



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as words. As an example, the sentence, "My very educated mother just sent us nine pizzas" (Mastropieri & Scruggs, 1998, p. 271) can represent the ordered names of planets from the sun (i.e., Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto).

Supplemental Non-Mnemonic Strategies

Other strategies and tools are effective with students with EBD. Therrien et al. (2014) identified use of response cards for learning science vocabulary, peer-assisted learning strategies, and student- or teacher-generated explanations as effective non-mnemonic strategies.

Cavanaugh, Heward, and Donelson (1996) used response cards successfully to review science vocabulary for students with EBD. Students can engage in active learning when practicing science vocabulary terms and definitions using response cards. This strategy was more effective than passive vocabulary reviews, with the teacher reading science definitions to students. In using response cards, teachers should provide students with cards containing vocabulary words while actively reciting vocabulary word definitions, allowing students to raise the card with the appropriate response.

Another effective non-mnemonic instructional strategy for learning scientific concepts is teacher- or student-generated explanations of science facts. In a study that compared the use of explanations about science phenomenon versus using only science facts, Scruggs, Mastropieri, and Sullivan (1994) found that students remembered more with explanations. Instead of giving students "just the facts," teachers should provide more explanation, telling student the "why" of a phenomenon that elaborates on the fact. For example, for the science fact that frogs' eggs sink to the bottom of a lake, a science explanation could suggest that frogs' eggs sink to lake bottoms so that they are hidden from predators.

Finally, the use of peer-related strategies were examined to measure their impact on science achievement and on-task behavior (Bowman-Perrott, Greenwood, & Tapia, 2007; Mastropieri et al., 2006). When using peer-related learning strategies, Mastropieri, Scruggs, and Berkeley (2007) suggested the following: (a) teaching students to be tutors, (b) making sure partnerships made sense, (c) carefully selecting instructional materials for peer tutoring, (d) supplying and reviewing procedures to tutors, (e) explaining procedures for role switching, and (f) monitoring tutor and tutee progress.

Conclusion

Science instruction plays an important role in the education of students with disabilities, including students with EBD (Rizzo & Taylor, 2016). Understanding science leads to a higher level of independence and improved quality of life for students with EBD demonstrating predictable deficits in academic and post-secondary life outcomes (Rizzo & Taylor, 2016; NSF, 2006, 2013). The growing need for all students, including those with EBD, to have science understanding is evident when examining occupational opportunities and job growth (Vilorio, 2014).

At the end of the school year, Mr. Blair, Mrs. Michaels, and Mrs. Ritchie reconvened to share their experiences with teaching science over the past year. All three discussed strengths, weaknesses, and surprises they encountered while teaching. Mr. Blair was surprised by how much students enjoyed doing science and how much easier instruction was by using science kits. He was also impressed by how well students were able to learn by supplementing the use of the science kits with both encouraging multimodal work (e.g., using alternative means to display information besides textual) and mnemonics. Mrs. Michaels agreed with Mr. Blair with the successful use of mnemonics. Her students did well in remembering facts when she paired mnemonics and student generated explanations. Mrs. Ritchie shared a number of successes for her students with EBD in high school chemistry and biology. While response cards worked well

for some students, her best results came from using mnemonic strategies for science vocabulary and multimodal strategies for science concepts. All three teachers felt positive about the school year for their students. Overall, the teachers agreed that, while at times challenging, teaching and supporting science instruction is important.

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