

Research-Based Practices for Creating Access to the General Curriculum in Science for Students  
with Significant Intellectual Disabilities

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## Research-Based Practices for Creating Access to the General Curriculum in Science for Students with Significant Intellectual Disabilities

The objective of this monograph is to increase teacher understanding of creating access to the general curriculum in science for students with significant intellectual disabilities through an exhaustive literature review pertaining to the teaching practices for science instruction for students with significant intellectual disabilities. This monograph will review the seven content areas of National Science Education Standards (NSES, National Research Council, 1996) and review the current research findings for students with significant intellectual disabilities, including students who may have physical and sensory impairments. These findings will be used to identify effective instructional practices for teaching science to students with significant intellectual disabilities and present the supporting evidence for the practice.

### Background on Access to the General Curriculum

Progress in the general education curriculum in content areas such as English Language Arts, mathematics and science is a federal requirement as part of IDEA (1997, 2004) and NCLB (2002). All students, including students with significant intellectual disabilities, are to demonstrate progress in the general curriculum and to be included in state- and/or district-wide assessments measuring such progress. Alternate assessments can be used to measure student progress for those who are unable to access the state- and/or district-wide assessment.

These mandates require teachers to find ways to teach grade-level material from the general curriculum to students with significant intellectual disabilities. Due to their unique learning demands these students need effective, research-based instruction in academic content areas to meet these federal mandates. Identifying evidence-based practices in teaching content areas of ELA, mathematics, and science can assist teachers in facing this challenge.

## National Science Education Standards

In order to provide students with significant intellectual disabilities with effective instruction in science, teachers need to know the science standards. In 1989, Project 2061, the American Association for the Advancement of Science (AAAS) published *Science for All Americans*, providing scientific literacy definitions for all high school graduates. Through science education reform momentum originating with Project 2061, the National Science Education Standards (NSES, National Research Council, 1996), were created. Eight content standards were designed to encompass the full scope of science. These standards were identified as: (a) Unifying concepts and processes; (b) Science as Inquiry; (c) Physical Science; (d) Life Science; (e) Earth and Space Science; (f) Science and Technology; (g) Science in Personal and Social Perspectives; and (h) History and Nature of Science.

Within the eight science standards of NSES, five specific standards (Unifying concepts and processes, Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives, History and Nature of Science) are designed to deepen students understanding of the journey through the field of science; past, present and future. Beginning with Unifying concepts and processes, the ability to associate concepts from one year to the next throughout a student's school years is an imperative piece of the puzzle in science depth of knowledge. Unifying concepts and processes transcend the domains in science, and have application in other disciplines, such as mathematics. This standard presented in K-12, and is to be taught throughout a student's entire educational career. For example, Systems, Order, and Organization is a unifying concept which can be introduced in elementary grades with the water cycle, in middle school with the earth's rotation, and in high school within human biology. Often in early grades,

students are introduced to the unifying concepts and processes, in later grades connections are made within the content standards to strengthen scientific content knowledge.

The vision of Science as Inquiry is to promote the processes of science. Science should be taught in a way that asks students to combine the processes and understandings of science using reasoning and critical thinking to develop deeper understanding. Through inquiry learning, students begin to understand the concepts, appreciate “how we know” science, the nature of science, skills needed to become independent inquirers, and the functionalities associated with science (NSES, 1996). For students with significant intellectual disabilities, the process of inquiry can be taught using task-analytic instruction. For example, students can ask specific questions related to the experiment (e.g., What is it?; What do I want to know about it?; How can I find out?; What did I learn?). Using models, experiments and technology to discover the world creates a strong basis for inquiry learning and promotes self-determination. Science as Inquiry is the “what”, “how,” and “where” of science instruction.

As a complement to Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives, and History and Nature of Science provide the details. In Science and Technology, students discover the link between technology used in science and how science contributes to the evolution of the technology itself. For example, students with significant intellectual disabilities can learn how to use a telescope and its need when viewing a star during an Earth and Space unit of the constellations. An important aspect of science education for all students is its ability to provide them with the capability to understand and act on social and personal issues. Science in Personal and Social Perspectives is designed to develop student’s concept knowledge and link it to their own personal world, surrounding topics such as personal health, population growth, natural hazards and resources. For example, identification of the daily

“ozone code” in relation to planning outside activities could play a very important role in personal health linked to the environmental quality. Finally, the History and Nature of Science provides students a look into the past endeavors of science that have brought us to what we as a society know now, and more importantly what science can do for us in the future. Science as a human endeavor can be introduced to students with significant intellectual disabilities multiple ways, for example the internet (e.g., NASA for students website, Sci4kids website), newspapers (e.g., News-2-You), television (e.g., documentary of ocean explorer, Jacques Cousteau). For students with significant intellectual disabilities, the five overarching standards set forth by NSES provide the functional link to science education. Science means more than discrete content knowledge; the application of this information in their daily lives is what makes science personally relevant.

The NSES standards for physical science, life science, and earth and space science explain the subject matter of science. Important facts, principles, theories, models, and concepts are addressed within each standard. In physical science, students with intellectual disabilities may learn that the sun produces heat, identify the heat, and how heat is used. The family unit is investigated within life science, as well as heredity and reproduction. Students with significant intellectual disabilities can ask questions such as “Why is my hair brown and my friend’s hair blonde?” Earth and space science introduces the concepts of weather and land formations. Students may gain knowledge of local landforms (e.g., mountain, volcano), what they are, how they were created, and what to do to stay safe around the local landforms.

Using the parameters set forth by the NSES, Courtade, Spooner, and Browder (2007) conducted a comprehensive literature review of studies linked with science for this population, finding limited research on teaching science to students with moderate and severe disabilities.

They identified 11 studies that taught science skills linked to the NSES to students with significant intellectual disabilities. Although the science studies conducted with students with significant disabilities produced successful results, the extent of the skills was limited. The instructional skills taught in eight of the 11 studies fell under Content Standard F (Science in Personal and Social Perspectives). Two studies conducted research that included describing relative position (Taber, Alberto, Hughes, & Seltzer, 2002; Taber, Alberto, Seltzer, & Hughes, 2003) which fell under Content Standard B (Physical Science). One study (Browder & Shear, 1996) conducted research about teaching weather related sight words which fell under Content Standard D (Earth and Space Science). Skills that fall under other content standards (i.e., science as inquiry, life science, science and technology, history and nature of science) have not been addressed. They found that science has been taught only in the context of functional skills such as personal health (e.g., first aid) and weather (e.g., planets). Furthermore, no research was found on teaching students with significant intellectual disabilities more complex science concepts, such as chemistry, water cycle, microbiology.

There appears to be a lack of science research supporting students with significant intellectual disabilities (i.e., students with moderate or severe disabilities that may have other disabilities such as autism or physical and sensory impairments). While this research produces a platform for science instruction with students with significant intellectual disabilities, it does not provide the guidance needed to meet the goals set forth by federal policy. Evidence of instructional strategies in science is needed under all standards of science set forth by NSES.

## Method

### *Literature Search Procedures*

This literature review attempted to find the most up to date research (i.e., quantitative, qualitative, correlational) from peer-reviewed journals in special education, psychology, and research in which a skill in science was taught to at least one individual with significant intellectual disabilities. A total list of 27 search terms describing both the student population (e.g., moderate mental retardation, severe disabilities, autism), was used in combination with terms related to teaching science (e.g., weather, horticulture, health, technology). For example, the term severe disability was used in combination with each of the science instruction terms. Both an electronic and a hand search were conducted to determine articles for review. Electronic databases searched included InfoTrac, Masterfile Premier, ERIC, PsychInfo, and Academic Search Elite. In addition, authors hand searched articles pertaining to the field of special education from 2003 until April 2009 in the following peer reviewed journals: *Education and Training in Mental Retardation and Developmental Disabilities*, *The Journal of Special Education*, *Focus on Autism and Other Developmental Disabilities*, *Research and Practice for Persons with Severe Disabilities*, and *Journal of Applied Behavior Analysis*.

### *Inclusion and Exclusion Criteria*

In order for a study to be included in this literature review it needed to meet the following criteria: (a) inclusion of an intervention which focused on teaching an academic science skill even if not the focus of the study; (b) inclusion of at least one individual who could be classified as having a significant intellectual disability (defined as having an IQ of 55 or less and/or a description of the student as having moderate, severe or profound disabilities); and (c) inclusion in a peer reviewed journal published between 2003 and April 2009. In order to provide a

comprehensive review of all recent research literature pertaining to science instruction for students with significant intellectual disabilities the following criteria for research design was used: (a) for both single subject and group studies, the design needed to be either experimental or quasi experimental, (b) for correlational studies, the relationship between a science skill/ability and other variables needed to be examined, and (c) for qualitative studies, academic outcomes for students in the area of science needed to be addressed within the research question, or an emergent theme derived from data analysis. Reviews of the literature, dissertations, and certain studies were not included in the review. For example Taber, Alberto, Seltzer, and Hughes (2003) investigating student acquisition of use of a cell phone to indicate when lost, this study was not included because the target skill was not found to be linked to a science content standard. Two additional studies (Carter, Cushing, Clark, and Kennedy, 2005; Carter, Sisco, Melekoglu, & Kurkowski, 2007) were found but not included in this review, they both measured student academic attention in a general curriculum science setting; however, the skills taught were not science (i.e., taking notes, attending to lecture, etc.).

### *Coding*

Once an individual study met the criteria for inclusion in the review, authors used a researcher-developed, literature review coding form to record the characteristics for analysis. These characteristics included (a) science academic component, (b) targeted science skill, (c) level of alignment with general curriculum (Flowers, Wakeman, Browder, & Karvonen, 2009), (d) research study design type, (e) participants, (f) level of cognitive engagement (Bloom, 1956), (g) assistive technology, (h) format of instruction (e.g., type of prompting and prompt fading), and (i) other outcome measures (i.e., generalization, maintenance, and social validity). Inter-rater reliability was used to check for agreement on the coding forms for one-third of the coding forms

using a point-by-point method. Number of agreements were divided by total number (agreements plus disagreements) of coded items, and then multiplied by 100 to convert it to a percent.

After studies were coded, individual studies were entered into a statistical database program (SPSS, 2004). For descriptive analysis of the studies, frequencies and types of each of the following were calculated (a) academic component of science skill (which of the eight content standards in science were taught), (b) targeted science skill, (c) instructional format (i.e., one to one), (d) instructional procedure, (e) prompting strategy, (f) error correction, (g) reinforcement, (h) setting, and (h) the individual teaching. Each dependent and independent variable was entered separately when studies used either multiple dependent or independent variables. For example, McDonnell, Johnson, Polychronis, Riesen, and Kercher (2006) used an alternating treatment design to compare one to one embedded instruction in a general education setting to a small group format in special education setting. The embedded instruction used constant time delay, differential reinforcement, and error correction while the small group instruction employed an intrasequential format with spaced trials (e.g., using a round robin style). In this example, each independent variable would be coded (constant time delay, differential reinforcement, and error correction). Further, for studies in which the dependent and/or independent variable was related to training of peers, parents, or teachers, only the variables directly affecting student outcomes in science were considered. Finally, for studies in which the independent variable was used across content areas, only the effects on the dependent variables related to science were used. For example, in a study conducted by Jameson, McDonnell, Johnson, Riesen, and Polychronis (2007), a comparison of one-to-one embedded instruction in the general education classroom and one-to-one massed trial in a special education classroom on instructional targets from the general education curriculum was examined using

four students. Only one of the four students' instructional target sets was from the general education science class (i.e., states of matter); another was from the general education Foods class, and two others were from the general education Teen Living class. In this example, the instructional target for science (i.e., states of matter) was the only dependent variable coded on the review form.

## Results

### *Inter-rater Reliability*

Two researchers came to consensus for the inclusion of the articles and no disagreements occurred. Inter-rater reliability was conducted on 3 of the 6 articles (50%). Overall, inter-rater reliability for coding the article components was 96.4% with a range of 94.1% to 100%.

### *Description of the Included Studies*

Overall, eight articles were located and reviewed to decide the extent in which each met the science inclusion criteria. Two articles were excluded from this review because the targeted learning objective could not be classified as relating to science. During the preliminary search, these two articles were originally selected because they taught academic skills within the science classroom, after a closer review the learning objectives could not be identified as science. For consensus a science content expert was consulted and he agreed that the learning objectives were not science related. The remaining six articles located in four different publications met the inclusion criteria in order to be included in the analysis. Five of the six studies were conducted using a single subject research design, specifically one used a multiple baseline design, one used a multiple probe design and three used an alternating treatment design. A qualitative research design was used in one of the studies. No studies were found using group experimental or correlational research designs.

### *Quantitative Studies*

A total of 18 individuals with disabilities participated in these studies; however only nine of the participants were identified as students with significant intellectual disabilities. Only the information pertaining to the students with significant intellectual disabilities was coded and analyzed. Of those nine students, six were male and three were female. Participant ages ranged from 9 to 15 years old. One study was conducted at the elementary grade-level (Collins, Evans, Creech-Galloway, Karl, & Miller, 2007), three studies were conducted at the middle grade-level (Agran, Cavin, Wehmeyer, & Palmer 2006; Jameson, McDonnell, Johnson, Riesen, & Polyshronis, 2007; McDonnell et al., 2006) and two studies were conducted at the high school grade-level (Jameson et al., 2008; McDonnell et al., 2006). One study was conducted at both middle and high school grade-levels (McDonnell et al., 2006). Participants of these studies included five students with moderate disabilities, three students with severe/profound disabilities, one student with autism, and one student with multiple disabilities. Students with physical disabilities or sensory impairments were not included in any of the studies. Two studies reported participant ethnicity; reporting two Caucasian students, one African-American student, and one Hispanic student participated. Five of the studies were conducted with students who used a symbolic level of communication; however, one study was found with students at an early symbolic level. No studies were found with students at a presymbolic level of communication. One study (Agran et al., 2006) was conducted with students at multiple levels of communication.

This research represents six of the eight standards of science outlined by NSES. There were no studies found demonstrating target skills in Science and Technology or History and Nature of Science. Three studies were conducted on skills that fall in the strand of Physical Science, three in Life Science, one in Earth and Space science, one in Unifying Concepts and

Processes, one in Science as Inquiry, and one in Personal and Social Perspectives. Four of the five studies included target science skills that fell within more than one stand of science. The level of alignment with the general curriculum found all skills to be academic, referenced to the student's grade level, focused on achievement that maintained fidelity with the content to the original grade level materials, using age appropriate materials, scoring rubrics to be based on independence with minimal assistance, and potential barriers to be minimized when appropriate. Levels of cognitive engagement (Bloom, 1956) were examined finding all five articles targeting skills that fell within the "remembering" level and only two within the "understanding" level. No studies were located that included target skills in the levels of "applying", "analyzing", "evaluating", or "creating".

Assistive technology was used in one of the studies; Agran et al. (2006) used a goal setting card to assist one of the students. No studies were found using assistive technology for communication purposes. All five studies were conducted using systematic instruction, including one that used milieu teaching, four that used with practice with feedback, one that used total task chaining, two that used massed trials, five that used distributed trials, and four that used embedded trials. There were no studies that used stimulus prompting (e.g., stimulus shaping, stimulus fading). Response prompting was used for all studies. Specifically, two used verbal directions, one used a verbal model, and one used a picture cue. All studies used response fading prompts. Specifically, one used simultaneous prompting and two used a constant time delay procedure. Error correction procedures were conducted using strategies such as ignoring errors, stating "no", and demonstration of the correct response. Only two studies reported the use of reinforcers, specifically the use of praise.

Four studies were conducted in both the general education setting and special education setting. Only one study was conducted solely in the general education classroom (Jameson et al., 2008). In two of the studies a paraprofessional taught the target skill (Jameson et al., 2007; McDonnell et al., 2006). Other science instruction was provided the researcher in one study, self-directed instruction in one study (Agran et al., 2006), peer instruction in one study (Jameson et al., 2008), and co-teaching by the special and general education teachers in one study (Collins et al., 2007).

Finally, three of the five studies conducted generalization measures on targeted skills, one across settings, one across people, and three across materials. One study conducted generalization across all three measures (Collins et al., 2007). Maintenance data was collected for three studies (Agran et al., 2006; Collins et al., 2007; Jameson et al., 2008). Social validity was collected for three of the five studies.

PND values can give a rudimentary description of student growth resulting from the instruction. The PND values of the studies included in this review ranged from 28% to 100% with a mean of 87.52% and a median of 97.92%. The PND provides a magnitude of the improvement in student responding due to the instruction. A PND of 100% means that all of the student responses during the treatment exceed their highest response rate in the baseline phase before the instructional intervention began. A PND of 28% means that almost all of the responses during the intervention were below baseline performance. Even though this is an increase in correct responding it is considered very small.

## Description of Teaching Practices

Eight important teaching practices were identified from the current review on teaching science to students with significant disabilities. For each of the eight identified teaching practices a description of the practice and evidence from the literature supporting the practice is provided.

### **Science Practice 1: Use Inquiry across Strands in Science**

According to Grossen, Carnine, Romance, & Vitale (2007), science inquiry, or the process of seeking the truth, is fundamental to an understanding of science. Students should have the opportunity to engage in scientific inquiry across the eight content areas of science identified by National Research Council (1996).

#### *Description of the Practice*

Requiring more from students than simply the correct answer to a question, inquiry promotes critical thinking through investigation, exploration, discovery, and evaluation (Kuhlthau, Maniotes, & Caspari, 2007). Although the literature defines science inquiry differently depending on the source, the essential features of science inquiry typically include: (a) scientifically oriented questions, (b) scientific evidence is used to respond to questions, (c) explanations are formed from the evidence, (d) explanations are connected to scientific knowledge, and (e) explanation are communicated and justified (NRC, 2002). Inquiry-based science instruction is an interactive process which involves the integration of hands-on activities, self-directed learning (posing questions), and collaboration (sharing in discoveries) of the natural world. Students with significant intellectual disabilities, including those with sensory or physical impairments “should have the opportunity to gain wonder and understanding of the natural world and their place in it” (Jimenez, Spooner, Browder, DiBiase, & Knight, 2008, p. 6). The goal of

wonder and understanding promotes quality of life. For example, inquiry may spark a students' interest in collecting rocks and gems, leading to a career in Mineralogy (Jimenez, et al., 2008).

### *Evidence*

Only 1 of the 6 studies used an inquiry approach to science (Agran et al., 2006). On the other hand, research has demonstrated that inquiry when presented in a structured format improves performance of individuals with high incidence disabilities (e.g., Scruggs, Mastropieri, & Okolo, 2008). Courtade (2006) found that teachers of students with severe disabilities could learn an inquiry approach to science. Finding inquiry to be beneficial for students with severe disabilities, Courtade used the inquiry method across content areas (e.g., physical, life science).

### **Science Practice 2: Use Systematic Instructional Procedures across Content Areas**

Despite the focus on inquiry as a recommended science teaching practice, there is no single approach to teaching science (NSES, 1996). In addition to inquiry, grade aligned content may be taught using systematic instruction for students with significant intellectual disabilities. Snell (1983) defines systematic instruction as a “. . . replicable process which reflects currently accepted “best” practices, uses performance data (both probe and instructional) to make modifications, and proceeds from acquisition to proficiency, maintenance, and finally generalization learning” (p. 113).

### *Description of the Practice*

In a literature review on science instruction for students with significant intellectual disabilities conducted by Courtade, Spooner, and Browder (2007), authors found systematic response prompting methods, including time delay, was commonly used to teach students with significant intellectual disabilities science skills. Although the number of studies in this review was only 11 studies, the findings are supported by other literature reviews for teaching

academics to this population recommending systematic instruction (Browder, Spooner, Ahlgrim-Delzell, Harris, & Wakeman, 2008; Browder, Wakeman, Spooner, Ahlgrim-Delzell, & Algozzine, 2006). Further, it would seem logical that the effective teaching procedures for mathematics and ELA would also be valuable in science. Systematic instruction may at first seem to contradict the way that inquiry is taught, as systematic instruction is traditionally teacher directed, while inquiry is more student directed. On the other hand, preliminary research for students with mild disabilities shows these students benefit from highly structured inquiry (Scruggs, Mastropieri, & Okolo, 2008). Although the research in the area science inquiry for students with significant intellectual disabilities is lacking, it would seem as though a guided inquiry approach would be beneficial for this population as well (Courtade, 2006).

### *Evidence*

In this review, most of the studies were conducted in multiple content areas (e.g., math, language arts), including science. The systematic procedures worked for all content areas. In each study, the same procedures were used in science as in the other content areas. We may glean that instructional strategies used in other content areas (math and reading) are useful for students with disabilities in science.

### **Science Practice 3: Consider Universal Design for Learning (UDL) to Design the Science Curriculum**

UDL is a new approach to teaching which advocates for the creation of flexible goals, methods, materials, and assessments to accommodate the widest range of learners. If the curriculum is designed from the beginning to reach a diverse student body, the need for individualization through accommodations and modifications is reduced (CAST, 2008). To

consider an UDL framework of science, educators determine multiple means of representation, expression, and engagement in science for their diverse classroom.

### *Description of the Practice*

Three principals are inherent to UDL: (a) multiple means of representation (various ways of presenting information to facilitate student knowledge and understanding); (b) multiple means of expression (various methods for students to show what they know); and (c) multiple means of engagement (various ways to tap student interest, to challenge students, and to motivate students; CAST, 2008). Within an inquiry lesson, teachers might provide students with multiple means of representation of the content or materials (e.g., using picture symbols, objects, and words of the concept of “precipitation”). Students can express their learning of the content and processes in science through multiple means; for example, students may eye gaze, use assistive technology, sign/gesture to the correct answer, or point to indicate the next step in the activity. Finally, teachers can engage and challenge students multiple ways; some students may respond to verbal praise during the science lesson, some students may be motivated to work with peers during an experiment, and some students may want to self-monitor their progress during an inquiry-based science lesson.

As Scruggs (2004) has suggested, many tools intended to support students with disabilities can assist many students’ understanding of science concepts. Some of these tools specific to science include “accessible lab furniture, microscope cameras, tactile graphics, talking calculators, liquid level indicators, Braille thermometers, light sensors, and a variety of 3-dimensional interactive models” (Scruggs, 2004 p. 1).

### *Evidence*

Even though the concept of UDL is young, evidence from this literature review did find some evidence to support the use of UDL when planning science instruction for students with significant intellectual disabilities. All six studies were conducted within a general education classroom with non disabled peers, focusing on learning objectives aligned to the grade level objectives currently being taught in the general curriculum. Specific examples of UDL were not given with the methods for research; however, evidence of student achievement within the science classroom on science standards supports UDL friendly strategies such as embedded instruction, and peer supports. With strong evidence (all six studies) found in support of embedded instruction within the general education science classroom, it is suggested that this instructional approach be used when planning universally designed science lessons for students with significant intellectual disabilities.

### **Science Practice 4: Peers and Embedded Instruction can Promote Inclusive Science Classes**

Each classroom has naturally existing supports within it. The overuse of adult-delivered supports may not be allowing for the social and academic benefits educational teams planned for students with significant disabilities in inclusive settings (Carter & Kennedy, 2006). Science instruction may provide a unique opportunity to provide instruction to students with disabilities in inclusive settings, with the use of the natural supports within all science classrooms (i.e., peers, inquiry). Due to the hands-on learning approach of inquiry based science, natural peer interaction can provide an opportunity for academic learning as well as social interaction.

### *Description of the Practice*

Peer mediated instruction refers to the practice of using one or more classmate without a disability providing academic or social support to a student with a disability. With peer mediated

approaches (e.g., peer supports) classmates directly deliver the intervention package. One strategy for peers to provide instruction to students with disabilities within the general curriculum is through the use of embedded instruction. Embedded instruction refers to the use of explicit, systematic instruction designed to distribute instructional trials within the on-going routine of the classroom. The procedures of embedded instruction are designed based on the specific needs of the student, skill being taught, and context of instruction (McDonnell, Johnson, & McQuivey, 2008).

### *Evidence*

In this review one study was found that used peer mediated instruction. Jameson et al. (2008) used peer mediated instruction in an inclusive science classroom. Peers were taught to embed instructional trials in an inclusive science classroom. Evidence from this review also located four studies that used embedded instruction to teach science academic target behaviors within an inclusive setting.

The use of peer-mediated strategies has been used to teach students with significant disabilities academic (Dugan et al., 1995), functional (Werts, Caldwell, & Wolery, 1996), and social skills (Carter, Cushing, Clark, & Kennedy, 2005). Peer supports are emerging as a recommended alternative practice to the over use of paraprofessionals and other adult-delivered supports within the inclusive classroom (Downing, 2006; Giangreco, Halvorsen, Doyle, & Broer, 2004). One suggested approach for peer mediated instruction is the use of embedded trials within the naturally occurring classroom routine (Jameson et al., 2008). Research has been conducted using embedded instruction over the past several decades, to teach functional, social and academic objectives. More recently, the emphasis of research conducted using embedded instruction has been within the general education classroom to teach a wide range of academic

skills (Collins, Branson, Hall, & Rankin, 2001; Polychronis, McDonnell, Johnson, Riesen, & Jameson, 2004; Riesen, McDonnell, Johnson, Ploychronis, & Jameson, 2003). Research to date, including those located in our review of the science literature, suggest embedded instruction to be a strong instructional strategy when teaching science to students with significant disabilities within the general curriculum context. While only one study was located in which peers were taught to embed instructional trials within the science classroom, evidence from both the peer mediated instruction literature and that of the embedded instruction literature suggest the use of both strategies could provide the natural context in which both peer supports and embedded instruction thrive.

### **Science Practice 5: Include Science Vocabulary, Processes, and Concepts**

As a result of federal mandates, such as NCLB and IDEA, students must demonstrate progress in general education science content. Teachers must challenge themselves to teach grade aligned science content to students with disabilities, moving beyond fact-based learning (i.e., vocabulary words relative to the lesson), to include more difficult procedural and conceptual learning.

#### *Description of the Practice*

Although factual, or vocabulary based knowledge, is essential to the basic understanding of science, in order to understand and apply science, students need to be taught the “...fundamental concepts, principals, facts, laws, and theories which exemplify scientific literacy by providing a foundation for understanding and applying science.” (Grossen, Carnine, Romance, & Vitale, 2007, p. 172).

Concepts can be defined as categories of events, names, actions, which share commonalities that define them as an example of the group, or class. This differentiates concepts from facts,

because facts only have one correct exemplar (Kame'enui & Simmons, 1990; McCleery & Tindal, 1999). For example, a fact is the answer to *what is one plus one*, because there is only one correct answer. Concepts can be defined as "...the recognition of an object, event, action, or situation as part of a class of objects, events, actions, or situations that are the same based on a feature or a set of features that are the same" (Kame'enui & Simmons, p. 148). Concepts are "...sweeping in range of meaning and examples tied to their use and reflect multiple meanings and characteristics" (p. 148). For example, *A gas is which disperses in any container* is a concept. In this case, gas is a concept because there are multiple examples of gases which define them as a group; there are various chemicals that can be classified as gases (e.g., hydrogen, oxygen). Procedural understanding "...refers to the knowledge of how to perform a task or the processes used to carry out a task" (Scruggs, et al., 2008, p. 10). Based on literature for mild disabilities, teaching methods to support conceptual and procedural understanding may include the use of graphic organizers, teaching vocabulary words in context, organizing information around the big ideas in science, and personalizing the lesson for the learner (Scruggs, et al., 2008).

### *Evidence*

Only two examples (i.e., Collins et al., 2007; Jameson et al., 2007) of the standard Unifying Concepts and Processes were located in this review. One example was a study conducted by Jameson et al. (2007) where a student was taught to identify six vocabulary terms from a unit on "states of matter." While this is an example of teaching vocabulary and concepts, a deeper conceptual use of the standard should be employed. For students to truly grasp the understanding of science content such as weather patterns, land formations, chemical reactions, or the life cycle, it is important to remember not to teach science as a "foreign language." The

vocabulary words do not mean much to a student unless paired with the meaning. The meaning is formed through the conceptual understanding. Students with significant disabilities need to make connects to how things work together to understand and use knowledge proficiently. For example, knowing that the white fluffy object in the sky is a cloud is useless, unless connections are made with the cloud and rain, shade, or temperature. For some students with significant intellectual disabilities, identification of the cloud may be a learning objective at the current moment. This objective is sufficient with the promise of building upon that knowledge and creating learning links in future lessons, units, or school years. Making connections within science are necessary in creating learners that can use this knowledge within their personal lives.

### **Science Practice 6: Address Multiple Science Standards in One Lesson**

The NSES are written to promote learning in science for all students across the wide scope of scientific understanding. Science instruction is unique in that its primary function is a focus on concept acquisition rather than discrete skills. Science should be presented to all students within the eight learning standards presented by NSES. When science is presented as a solitary skill, students are not able to gather information to formulate conceptual understanding of the world around them. Understanding of the world around us is what guides scientific learning, hence development of “science” may possibly be one of the most personally relevant academic skills we can offer students with disabilities.

#### *Description of the Practice*

Courtade et al. (2007) states “students with disabilities need instruction that promotes generalization across science content and to general education contexts.” Specifically, the eight science standards outlined by NSES are not intended to be taught separately, rather to be intertwined to develop scientific knowledge. While this review found an over abundance of

studies conducted within the standard of personal and social perspectives, it is imperative that students with disabilities learn to use technology and inquiry to develop concepts within the core content standards of Life Science, Physical science, and Earth and Space Science. These core content standards provide the specific concepts to be obtained, inquiry provides a mode to learn those concepts, and the other four standards (e.g., Science and Technology) provide the detail and support students need to gain true scientific understanding. With a well-rounded science curriculum, rich in development (i.e., all eight standards present), all students can begin to build upon their own scientific knowledge, beginning at their own present level of performance.

### *Evidence*

From this review, four of the six research studies targeted learning skills that incorporated multiple science standards. The Unifying Concepts standard was incorporated within two studies (Collins et al., 2007; Jameson et al., 2007); Inquiry was used in one study (Agran et al., 2006); and Personal and Social Perspectives was used in one study (Collins et al., 2007). Life Science, Physical Science, and Earth and Space Science were standards found in unison with other more universal standards, such as Inquiry, Unifying Concepts or Personal and Social Perspectives. The Science and Technology; History and Nature of Science standards were not found in any of the reviewed studies.

This review provides some guidance on incorporating multiple standards to teach science skills to students with significant disabilities. Previous literature on teaching science to this population has primarily focused on teaching skills that fall within the science standard of Personal and Social Perspectives. Caution should be used while reviewing the literature in science education for this population of students. While no studies were found teaching students with significant intellectual disabilities Science and Technology or History and Nature of

Science it is important to note that based on this review and the previous one conducted by Courtade et al. (2007), the evidence base on teaching science to this population is continuing to grow and span across multiple science standards. More research is needed on teaching specific science content to students with significant disabilities; however, at this time based on the current literature and the suggestions of NSES science instruction should include all eight standards to build students understanding of the world around them.

### **Science Practice 7: Consult with a Science Expert**

There is a documented need for special educators to understand general education science content, including how the content is taught, as well as what the science standards are (Courtade, et al., 2007). One way to accomplish this is to consult with a science general education expert.

#### *Description of the Practice*

Collaboration in general education science can lead to successful inclusion of students with significant intellectual disabilities, including students with sensory and physical impairments (Siegel-Causey et al., 1998). Since teaching science is a relatively new endeavor for teachers of students with significant intellectual disabilities, special education teachers may not be familiar with the content standards in science. Further, special education teachers will want to maintain fidelity to the science content for students with significant intellectual disabilities (i.e., is the skill I am teaching really “science?”); a challenging task when many special education teachers have never had preparation in the area of science. By teaming up with a general education science expert to ensure alignment to the curriculum, special educators can determine ways to adapt and modify the science concepts to facilitate student understanding, and the general education teacher can delineate the most important vocabulary, skills, and concepts for the science lesson. Collaborating to make a lesson successful, teachers can consider the

following alignment criteria as suggested by Flowers, et al (2009): (a) content is academic and includes the major domains/strands of the content area, (b) content is referenced to the students' assigned grade level, (c) focus of achievement maintains fidelity with content of the original grade level standards, (d) materials are age appropriate, (e) scoring rubrics focus on student performance with minimal assistance, and (f) potential barriers to demonstrating what students know and can do are minimized.

### *Evidence*

While it is not certain that collaboration with general education content experts were consulted in the research studies reviewed, it can be assumed that some resource for science was reviewed (e.g., NSES standards, school-based science curriculum, state standards). All of the studies reviewed met the alignment criteria set forth by Flowers et al., (2009). Recent literature in the area academic instruction for students with significant cognitive disabilities has focused on the alignment of instruction to grade level standards, and building upon that knowledge over the course of a student's academic career (Browder, Flowers, & Wakeman, 2008; Browder, Wakeman, Flowers, Rickelman, Pugalee, & Karvonen, 2007). Spooner, Ahlgrim-DeLzell, Kohprasert, Baker, & Courtade, (2009), examined the number of states that included science-related performance indicators (PIs) in their alternate assessments and the PIs linked to the eight NSES. A majority of the state PIs fell into the areas of Earth and Space Science and Science (weather) in Personal and Social Perspectives. This suggests that special educators need additional examples of science skills that fall into the other six areas. General education science teachers can help generate these examples.

### **Science Practice 8: Considerations for Students with Sensory and Physical Impairments**

Considerations for students with sensory and physical impairments can be made by considering a UDL framework. Goals, methods, and materials can be developed in a flexible

manner so that all students can access science content. Science is perhaps one of the easiest content areas for students with sensory and physical impairments to be included in, as the nature of science is manipulative and hands-on.

### *Description of the Practice*

A quote by Scruggs et al. (2008) illustrates the need for all students to engage in science education, including students with sensory and physical challenges; “Science has a special and fundamental role in the education of students with disabilities, in that science has always encouraged us to advance beyond the sensory and physical barriers that affect and challenge us all, to develop our thinking and our imaginations, and to probe for rational and logical explanations for the observed universe. “Science education promotes learning for those who learn best by doing” (p. 1).

### *Evidence*

Research to date on science instruction for students with significant intellectual disabilities has not focused on the instruction of students with physical and sensory impairments. No studies were located in which students with these challenges were identified; however, the need for this database is great. One possibility is that students with sensory or physical disabilities have participated in such research, but their needs had not created a barrier due to the learning objectives being taught. For example, a student with a physical disability would be able to identify science sight words within a classroom verbally without any special accommodations or modifications. While the evidence has not yet been provided supporting models for science instruction with students with physical and sensory disabilities, it is best to assume that the strategies and techniques implemented within other content areas (e.g., assistive technology,

picture symbols, text-to-speech software, Braille, tactile models) would provide students the greatest access to science instruction and understanding.

### Summary

Although the research in the area of science instruction for students with significant intellectual disabilities is just beginning to emerge, teachers can benefit from applying scientifically-based practices from the areas of reading and math to the area of science. Further, research-based instructional practices for teaching science to students with high incidence disabilities can serve as a framework for how to teach vocabulary, concepts, and processes to low incidence populations.

Until additional research is conducted in the area of science, teachers can use the following guidelines for science instruction for students with significant intellectual disabilities: (a) science inquiry can be used as one way to teach across the domains in science; (b) systematic instructional practices used in math and ELA can be useful in science; (c) UDL can be considered as a framework for designing accessible science curriculum for all learners; (d) teacher or peer-delivered embedded instruction can promote inclusion, (e) science instruction should encompass vocabulary, conceptual, and procedural knowledge, (f) multiple science standards can be addressed in one lesson; (g) special and general education teachers can work together to align instruction to grade levels in all strands of science; and (h) the manipulative nature of science instruction may lend itself well as an area for inclusion for students with sensory and physical impairments.

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Table 1: Summary of the fourteen studies that meet the inclusion criteria

Reference	Independent Variable/ instructional Strategy; response prompt fading	Participants *	Science strand	Dependent variable/ targeted skill	Setting/ who taught	Results
Agran et al. (2006)	Systematic instruction, total task chaining, embedded instruction, SDLMI	1 male, 1 female; ages 13, 15; AU IQ= none given	Inquiry, Life Science	Scientific inquiry skills Match body system with function	General Education, Special Education/ student (self taught), researcher	PND = 96.7%
Collins et al. (2007)	Systematic instruction, milieu teaching, massed trials, distributed instruction, embedded instruction; simultaneous prompting	1 male; age 9 yrs IQ= 50	Unifying concept, Physical, Earth & Space, Personal and Social Perspectives	Core words (vibration, electricity, precipitation) vs Functional words (combine, refrigerate, measure)	General Education, Special Education/ Regular education and Special Education teachers	PND = 47% (functional words) PND = 27% (core content words )
Dymond et al. (2006)	Qualitative study using a constant comparative method for exploring the process of creating a universally designed science course and to promote access to the general curriculum.	1 general education teacher 1 special education teacher 1 special education case manager for students with severe disabilities	None directly stated	Data related to the redesign process such as roles and responsibilities, changes to lesson plans, effectiveness of UDL strategies, student outcomes	Inclusive Science class; general education teacher taught, collaboration with special education teacher and case manager	Students made progress on IEP goals and addressing the main concepts of the science curriculum, relationships with peers improved. Little detail about students learning, they told the teacher what they learned each day
Jameson et al. (2007)	Systematic instruction, embedded instruction; Constant time delay	1 male; age 15 yrs IQ= 46	Unifying concept, Physical Science	Define science words (e.g., boil, melt, freeze)	General Education, Special Education/ paraprofessional	PND = 86% (embedded trial instruction) PND = 100% ( massed trial instruction)
Jameson et al. (2008)	Systematic instruction, embedded trials, constant time delay	1 female; age 15 IQ= 46	Life Science	Describe effects of smoking on specific body parts/organs	General Education/ peer	PND = 80% (trained set) PND = 83 % (generalized set) PND = 81.65% (overall)
McDonnell et al. (2006)	Systematic Instruction, embedded instruction; Constant time delay; intrasequential format with spaced trials	2 2 males; ages 13-15; SP, MU IQ= none given	Physical Science, Life Science	Define science words (e.g., biosphere, food web, metabolism, element, atom)	General Education, Special Education/ paraprofessional	PND = 94% (overall embed instruction) PND = 91% (overall small group instruction )

## Annotated Bibliography

**Agran, M., Cavin, M., Wehmeyer, M., & Palmer, S. (2006). Participation of students with moderate to severe disabilities in the general curriculum: The effects of the self-determined learning model of instruction. *Research & Practice for Person with Severe Disabilities, 31*, 230-241.**

The national science standards addressed in this study were Inquiry and Life sciences. The target skill for the intervention were determined by the grade level standards and the students' IEP; for one student the target skill was scientific inquiry, and for another student the target skill was matching of a body system to the body function. Instructional strategies included systematic instruction, total task chaining, embedded instruction, and the Self Determined Learning Model of Instruction (SDLMI). Participants who received the intervention were 1 female and 1 male aged 13 and 15. One student had ASD and one had an intellectual disability. Delivery of instruction was by the student themselves (self monitoring), and the location of instruction was in a resource room to explain the intervention, and in a general education setting during the self monitoring.

**Collins, B. C., Evans, A., Creech-Galloway, C., Karl, J., & Miller, A. (2007). Comparison of the acquisition and maintenance of the teaching functional and core content sight words in special and general education settings. *Focus on Autism and Other Developmental Disabilities, 22*, 220-233.**

The national science standards addressed in this study were Unifying concepts and processes, Physical, earth and Space science, and Personal and Social Perspectives. The target skill for the intervention was determined by the grade level standards (i.e., core content words) and the students' IEP (i.e., functional words); for example, one student's functional words included combine, refrigerate, and measure; the student's core words included vibration, electricity, and precipitation. Instructional strategies included systematic instruction, milieu teaching, massed trials, distributed trials, embedded trial instruction, and simultaneous prompting. The participant who received the intervention was a male aged 9, who had an IQ of 50, and classified as having moderate to severe disabilities. Delivery of instruction was a comparison of massed trial instruction in a special education classroom with a special education teacher, and distributed and embedded trial instruction in the general education classroom by the general education teacher.

**Dymond, Renzaglia, Rosenstein, Chun, Banks, Niswander, et al. (2006). Using a participatory action research approach to create a universally designed inclusive high school course: A case study. *Research & Practice for Persons with Severe Disabilities, 31*, 293-308.**

There was no specific mention of the particular national science standards addressed in this study; although the study evaluated changes to an entire science course. There was no specific mention of a target skill, since this was a qualitative study; however, categories from the redesign process were developed and included: roles and responsibilities, changes to lesson plans, effectiveness of UDL strategies, student outcomes, and factors related to redesign process (e.g., most helpful aspects). Specific instructional strategies were not mentioned, but the focus of the study was on UDL and access to the general education curriculum for students with significant cognitive disabilities. Participants included 1 general education teacher, 1 special education teacher, and 1 special education case manager for students with significant cognitive

disabilities. No mention of the number or characteristics of the students who received the intervention was mentioned. Delivery of instruction was by the general education teacher with support from the special education teacher and case manager, and instruction took place in a general education inclusion science classroom.

**Jameson, J. M., McDonnell, J., Johnson, J. W., Riesen, T., & Polychronis, S. (2007). A comparison of one to one embedded instruction in the general education classroom and one to one massed practice instruction in the special education classroom. *Education and Treatment of Children, 30, 23-44.***

The national science standards addressed in this study were Unifying concepts and processes, and Physical science. The target skill for the intervention was to define science words (e.g., boil, melt, and freeze). Instructional strategies included systematic instruction, embedded instruction, and constant time delay. The participant who received the intervention was a male aged 15, who had an IQ of 46 and was classified as having Down syndrome. The study compared a one to one massed trial format in the special education classroom with a special education teacher to a group, embedded trial format in a general education classroom with a paraprofessional.

**Jameson, J. M., McDonnell, J., Polychronis, S., & Riesen, T. (2008). Embedded, constant time delay instruction by peers without disabilities in general education classrooms. *Intellectual and Developmental Disabilities, 46, 346-363.***

The national science standard addressed in this study was Life Science. The target skill for the intervention was determined by the grade level standards and the students' IEP ; for example, one student's target skill was to describe the effects of smoking tobacco on specific body parts/organs. Instructional strategies included systematic instruction, embedded trial instruction, and constant time delay. The participant who received the intervention was a female aged 15 who had an IQ of 46, and was classified as having a severe intellectual disability. Delivery of instruction was in a general education setting, and provided by a peer.

**McDonnell, J., Johnson, J., Polychronis, S., Riesen, T., and Kercher, K. (2006). Comparison of one-to-one embedded instruction in general education classes with small group instruction in special education classes. *Education and Training in Developmental Disabilities, 41, 125-138.***

The national science standards addressed in this study were Physical science and Life science. The target skill for the intervention was to define words from the general education curriculum; for example, one student's target skill was to define such words as biosphere, food web, and metabolism. Instructional strategies included systematic instruction, embedded trial instruction, constant time delay, and intrasequential format. The participants who received the intervention were 2 males aged 13-15. One student was classified as having multiple disabilities and using a wheelchair and the other student did not have a disability classification. Delivery of instruction was a comparison of a one to one, embedded instructional format in a general education classroom delivered by a peer to a small group format in a special education classroom delivered by a special education teacher.