Students with special needs in the United States are included more in general education classrooms and have more exposure to the general education curriculum today than ever before (U.S. Department of Education, 2006). This is partly explained by the fact that federal special education law requires students with disabilities to have access to the general education curriculum and to be educated alongside general education peers as much as possible (Individuals With Disabilities Education Act, 2006). In addition, educational reform (i.e., No Child Left Behind of 2001, 2006) emphasizes the use of evidence-based instructional methods and strategies resulting in a deeper understanding of how the brain works and how students learn, providing teachers more methods and strategies for teaching students with varying abilities (Goswami, 2006).

Further, with the expanding research base of best practices for teaching students with special needs, educational researchers have come to learn that best practices for instructing students with special needs are also very effective with general education students. Conversely, best practices for general education students are effective with students with special needs (Fuchs & Fuchs, 2001). The knowledge that ALL students can benefit from the same tool chest of instructional methods and strategies should provide a great deal of relief to general and special education teachers concerned about meeting the needs of diverse learners in science classes. However, this knowledge leads to a very essential question: What are best practices for educating ALL students in science?

**DIS²ECT**

A Framework for Effective Inclusive Science Instruction

Lucinda S. Spaulding and Jenny Sue Flannagan

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**Our Experience**

As a general education science teacher and a special education teacher of students with learning disabilities, we began to grapple with this important question as we sought to meet the needs of diverse learners. With the explosion of educational research in special education and science over the last few decades, we had no problem finding evidenced-based strategies and
What are best practices for educating ALL students in science?

activities? Perhaps our biggest concern was how do we co-plan and co-teach to ensure that the needs of all children are met?

When we began working together to ensure that all students were achieving to their greatest potential in our science class, we felt we needed something to help us structure and focus our planning, instruction, and assessment. Our research and collaboration led us to DIS_2ECT. DIS_2ECT is an acronym for a framework that helps us systematically ensure we are meeting the needs of all our students, so all can develop as scientists and explore and understand their world.

**DIS_2ECT**

DIS_2ECT stands for Design (Backwards), Individualization, Scaffold and Strategies, Experiential Learning, Cooperative Learning, and Teamwork. In the following example, we illustrate how we use DIS_2ECT when we plan science units and lessons. A lesson plan developed using the DIS_2ECT framework can be found in Figure 1.

**Design**

We designed our instructional plan by following the Backward Design model (see Childre, Sands, & Pope, 2009; Wiggins & McTighe, 2005), which suggests the following planning sequence: Step 1: Identify learners; Step 2: Identify curricular priorities; Step 3: Design assessment framework; and others self-created), we compile this information and use it when developing groups and designing lessons.

With our learners’ interests and abilities in mind, we turn to designing the unit plan (Step 2). Using the big ideas of science and essential questions, we use our state standards and curriculum resources to identify what students need to know (knowledge) and be able to do (skills) at the end of a unit. We then align these to the big ideas in science. Next, we design essential questions that will frame our lesson and help us create assessments, which will provide us with information on how our students are doing (Step 3). Assessments may include quizzes, tests, performance tasks, or projects. Last, we develop the daily lesson plans (Step 4), leading us to think about our next step in the DIS_2ECT process—individualization.

**Individualization**

Individualization is the centerpiece of special education (IDEA, 2004), and it is essential for educators in inclusive environments to focus on meeting the individual needs of their learners. To address these needs when planning lessons, teachers need to be aware of the difficulties students with learning challenges typically face. First, they tend to have difficulty with inductive and deductive thinking skills, skills that are associated with scientific reasoning (Mastropieri, Scruggs, Boon, & Carter, 2001). Second, their independent reading levels are often below grade level, meaning they will likely have a difficult time comprehending their grade-level science textbook (Cawley, Parmar, Foley, Salmon, & Roy, 2001). Further, students with learning challenges often have limited independent study strategies and need to be explicitly taught how to study and review for tests and quizzes. Finally, they need significant practice, repetition, feedback, and reinforcement in order to retain information and generalize skills and concepts (Mastropieri et al., 2001). Along with information garnered through interest inventories and formal and informal assessments of present levels of performance, it is very important for teachers to keep these characteristics of students with learning challenges in mind when planning daily lessons. The needs of individual students can be met through the next step—scaffolding and strategy instruction.

**Scaffolding**

Scaffolds can be viewed as bridges. Each student comes to class with a certain level of knowledge and understanding on a topic, and each may have certain obstacles to overcome in order to learn new concepts. This is where scaffolding comes into play. By providing just the right level of support, students can move from their current understanding to higher levels of understanding (e.g., Vygotsky, 1978). For example, the state standard may require fourth-grade students to design their own science experiment. Students with learning challenges may struggle to complete this higher order thinking problem on their own, but by working with a peer or small group, they can be successful. From this successful experience students gain confidence along with conceptual understanding and, with sufficient repetition and reinforcement, can begin to demonstrate the skill independently.

Although difficult to teach, inductive and deductive reasoning skills can be developed through teacher prompting.
Big Ideas of Science: Change Can Be Irreversible

Topic: Matter

Grade: 8th Grade

Learner Characteristics: 12 general education students; 4 students with LD; 1 student with ADHD; 2 students with ED; 1 student with a visual impairment

National Standard: N.S. 5–8.2 Physical Science: As a result of their activities in Grades 5–8, all students should develop an understanding of:
- Properties and changes of properties in Matter

Objectives:
The students will know:
- Matter can be described by its physical properties, which include shape, density, solubility, odor, melting point, boiling point, and color. Some physical properties, such as density, boiling point, and solubility, are characteristic of a specific substance and do not depend on the size of the sample. Characteristic properties can be used to identify unknown substances.
- Equal volumes of different substances usually have different masses.
- Matter can also be described by its chemical properties, which include acidity, basicity, combustibility, and reactivity. A chemical property indicates whether a substance can undergo a chemical change.

Students will be able to:
- Determine the identity of an unknown substance by comparing its properties to those of known substances.
- Distinguish between physical properties (i.e., shape, density, solubility, odor, melting point, boiling point, and color) and chemical properties (i.e., acidity, basicity, combustibility, and reactivity) and identify if a physical change or chemical change has occurred.

Materials:
16 oz. empty plastic soda bottle (preferably with a narrow neck such as those made by Coca-Cola); 1/2 cup 20-volume hydrogen peroxide (20-volume is 6% solution, purchased from a beauty supply store); squirt of Dawn dish detergent; 3–4 drops of food coloring; 1 teaspoon yeast dissolved in 2 tablespoons very warm water; funnel; foil cake pan with 2-inch sides; lab goggles; lab smock

Cooperative Learning:
- Team Investigation
- One Stray (Kagan, 1994)
- Small Group and Class Discussion

Scaffolding for Students:
- Building on prior knowledge
- Experience: students need a concrete experience that does not involve a color change—this is often mistaken for “chemical change.”
- Cooperative learning strategies
- Graphic organizers

continues
Figure 1. Continued

**Engage**

Ask students what they know about hydrogen peroxide. “Have you ever put hydrogen peroxide on a cut? What happens when it comes in contact with the cut?” (it bubbles)

Tell students that they are going to do an activity today that uses hydrogen peroxide and will be looking to see how things change.

**Explore**

**Team Project:** Assign lab roles: **Principal Investigator** who directs others to follow procedures; **Materials Manager** who does experiment; **Reporter** who records data; **Timekeeper/Clean Up Captain** who keeps time and helps clean up. Distribute lab reports and materials.

1. At each student’s place: cake pan, plastic bottle, Dawn in small cup, food coloring, funnel, goggles, 1/2 cup peroxide, yeast.
2. Have students make observations of each material they have—in other words, have them generate words that a scientist would use in order to describe the objects.
   - Dawn soap
   - Food coloring
   - Peroxide
   - Yeast
3. Inform students they are going to observe changes that occur when two materials are mixed together.
   Have students follow these procedures:
   - a. Stand up bottle in the center of the cake pan.
   - b. Put funnel in opening. Add 3–4 drops of food coloring to the peroxide and pour the peroxide through the funnel into the bottle.
   - c. Add the Dawn detergent to the peroxide in the bottle.
   - d. Pour the yeast mixture into the bottle and quickly remove the funnel.
   - e. Make observations once they mix the materials together. Allow them to touch the bottle to feel any changes that take place.
   - f. Have the recorders for each group post the observations they collected. Ask students to develop an explanation for what happened.

**Explain**

Use the cooperative learning strategy **One Stray** to have recorders go to at least 3 different groups to share what their group observed and learn what other groups observed. Have students share as a class their findings.

Introduce the term chemical change through reading. Use the strategy Frayer’s Model of Vocabulary to define the term chemical change. Be sure to point out the differences between chemical and physical changes.

Once students have defined the term, give them some simple examples of changes that can happen in the world and have them identify if they think they are physical or chemical changes. For those students who might struggle, give them the hint cards to help them.
Extend

Each team has a bag filled with a mystery powder. Their job is to try to identify how many powders have mixed together in the bag. Here are the responsibilities for group work:

1. **Materials Managers** should get a bag of mystery powders for each team.

2. **Recorders**: Instruct your team to observe your powders carefully.
   - **Observing**: How many different powders do you think are in the bag?
   - **Describing**: Describe the physical properties of each powder.

Once teams have made their observations, have recorders report out to the class their group’s findings. Inform the students that next they are going to learn a little more about their mystery powders. In this next activity, they are going to see what happens when they mix their powder with a liquid (vinegar).

Direct students to do the following:

1. Empty the bag of powders into a dry beaker.
2. Fill the graduated cylinder to the 20-ml line with vinegar.
3. Pour the vinegar into the beaker and make observations. You should record your observations.
   - **Observing**: What happened? Give a description of the change and the result.
   - **Making inferences**: What experiences can you draw upon that might help you explain what you just observed? Do you think this is a physical or chemical change and what is your evidence?

In teams, design a method to identify your mystery powder:

- Now that you have observed your mystery powder, your team now must identify the mystery powder.
- Using the following materials only, design a methodology to identify your powder.
- Before you begin, share your plans and get approval from one of your teachers.
- For each new combination you try, write down the name, observation of what the powder looks like, and predict what you think will happen when added to the vinegar. This data will help you identify your mystery powder!

### Materials:

<table>
<thead>
<tr>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baking soda</td>
</tr>
<tr>
<td>Alum</td>
</tr>
<tr>
<td>Plain gelatin</td>
</tr>
<tr>
<td>White vinegar</td>
</tr>
<tr>
<td>Beaker</td>
</tr>
<tr>
<td>Hand lens</td>
</tr>
</tbody>
</table>

Evaluate

Students will define the difference between chemical and physical change.

- **Students with special needs**: Students will be given six pictures of concrete examples of physical and chemical changes. Students will explain orally and use their graphic organizers to assist them in explaining with evidence the type of change that has occurred.
- **Gifted**: Students will be presented with more abstract examples of chemical and physical changes. For example, for chemical change, students will be given a physical metal object that has rust on it and a description of how rust forms. Students will have to justify with evidence what type of change it falls under.

continues
### Hint Card

Ask yourselves these questions to help determine if you have a chemical change:

<table>
<thead>
<tr>
<th>Question</th>
<th>What You Might Have Observed</th>
<th>What Is Going On</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did you see the production of a gas?</td>
<td>Bubbles from mixing</td>
<td>The gas is a product formed from the two substances reacting.</td>
</tr>
<tr>
<td>Did you feel or collect a temperature change?</td>
<td>The container got warm or if a temperature probe was used there was a change in reading.</td>
<td>Chemical energy is being released (in the form of heat) or being removed (cold)</td>
</tr>
<tr>
<td>Did you see a precipitate form?</td>
<td>Clear liquid would become cloudy. In the case of two liquids, a solid suddenly formed.</td>
<td>Two things come together to make something that is not able to be dissolved in the liquid.</td>
</tr>
<tr>
<td>Did you see a color change?</td>
<td>Color appears when two colorless liquids were mixed or colored materials become colorless or one color changes to another.</td>
<td>Materials are combining in such a way that it affects how much energy it takes to move electrons around.</td>
</tr>
</tbody>
</table>

### Chemical Change

**Definition**

[Blank]

**Characteristics**

[Blank]

**Examples**

[Blank]

**Nonexamples**

[Blank]
and questioning, also referred to as coached elaborations and guided inquiry (Scruggs, Mastropieri, & Okolo, 2008). For example, young children often have the misconception that the moon "glows" and transmits light just like the sun does. However, after a simple scientific inquiry using a flashlight, a globe, and a tennis ball, teachers can guide students to accurate understanding through a series of simple questions.

To address varying levels of reading proficiency, finding alternative texts and leveled nonfiction books provides opportunities for students to read independently while still learning the necessary concepts. If we design a standards-based lesson (e.g., chemical and physical changes in matter) around student interest, and we know that after providing guided practice with peers we want students to research a topic independently, we then realize that we have to provide books at various reading levels. We would love it if our students could all read on the same level, but our experience is that our students read at various levels, some above, some on, others below, and some far below. We work with the librarian and reading specialist to ensure we can provide an assortment of nonfiction texts, all addressing content, but at students’ independent or instructional reading levels rather than at their frustration level (e.g., Gickling & Havertape, 1981).

In science, it is very important for students to develop understandings of interrelationships between concepts (e.g., organisms and their habitats) as well as to develop conceptual understandings of scientific laws and principles (e.g., force and motion). Graphic organizers, text organizers, and semantic maps help students acquire, organize, and recall information, as well as understand relationships between facts and concepts (Dexter, Park, & Hughes, 2011). When we plan together, we keep in mind that not all students need the same map or graphic organizer. In fact, some students can create their own, rather than be given one. With elementary students who are reading well below grade level, we might create a version of the same graphic organizer but with picture cues in place of or alongside words. This creates a simpler design, making the content accessible to all students. If the standard is for all students to know characteristics of various organisms and be able to classify them, then students with learning challenges may do this by modifying and individualizing the organizer.

**Strategies**

Similar to scaffolding, strategy instruction involves teaching students approaches for solving problems and organizing information. Strategy instruction is well supported by research (e.g., Fuchs et al., 2003; Santangelo, Harris, & Graham, 2008) and can involve teaching students self-monitoring and self-regulation (e.g., self-scoring problems, charting daily scores, setting goals and monitoring progress), self-questioning (asking “Does this make sense?”), main idea and summarization strategies, and repeated reading. Students can learn study strategies by making a simple board game with review questions, or covering up sections of an outlined note page to recall covered material. Mnemonics are highly effective devices for helping students recall difficult-to-remember facts through relating them to pictures, acronyms, pegwords, and keywords (Fontana, Scruggs, & Mastropieri, 2007; Therrien, Taylor, Hosp, Kaldenberg, & Gorsh, 2011). Mnemonics can be differentiated, in that some students can be given a mnemonic, some co-create them with the teacher, and others can be challenged to create their own. Even in science, reading strategies should be taught and reinforced, such as predicting, sequencing, summarizing, questioning, and identifying the main idea and supporting details. Although all of these strategies are effective and applicable for students with and without learning challenges, students who may need more intense instruction can work in smaller groups and receive additional instructional time (Foorman & Torgesen, 2001).

**Experiential Learning**

The way to ensure that all students are successful in science is to focus on designing structured lessons based on experiential learning principles (Therrien et al., 2011). Therefore, design the lessons to first engage students, providing opportunities for discovery and exploration. In other words, content is seldom discussed first. Students must have an opportunity to experience something in order to make sense of it (Scruggs et al., 2008). For example, in one of our lessons students examine how matter can change chemically and how scientists recognize a chemical change. Instead of reading the text or
even giving students a definition or vocabulary words, present students with the task of observing what occurs when two materials—peroxide and yeast—are mixed together in a soda bottle. Students observe changes with their senses. Students are excited when they see a light foam begin to rise out of the bottle. Even with their excitement, remind them to write down what they see with their eyes and what they feel with their hands. Groups document their findings and then use the cooperative learning structure One Stray (Kagan, 1994) to have the reporter for each group go to another group and share what they found and record any new information from the group they “strayed” to visit. When we asked each group if they felt a change occurred, the answer was always “yes.” When asked to elaborate on what evidence they used to say “yes,” students often said, “We saw bubbles, we saw a difference substance.” It is only after students have had an experience with the concepts of chemical change that they then open their science texts, and we introduce the content and begin defining factors chemists use to identify chemical changes.

This structured yet inquiry-based approach to science instruction is well supported by research (Therrien et al., 2011). Scruggs and Mastropieri (2007) reported, “Advantages to the constructivist approach include an emphasis on concrete, meaningful experiences; an emphasis on depth of learning; less emphasis on rote verbal learning; and use of performance assessment rather than paper-and-pencil tests” (p. 59). Childre et al. (2009) affirmed these observations, noting that “learning should be driven by student efforts to answer essential questions and problems posed through unit activities and assessments” (p. 10). In addition, this approach to learning “moves students out of passive roles into active learning roles more supportive of learning for students with disabilities, because learning is hands-on and meaningful” (p. 10). Perhaps the most significant research finding related to inquiry-based, constructivist science classrooms is that “many students with high-incidence disabilities will perform similarly to typically achieving students on a constructivist science task, even though they are far behind in reading and math achievement” (Mastropieri et al., 2001, p. 135). As the research suggests, when provided experiential learning opportunities, students with learning challenges can be contributing members of a group and can even help their normally achieving peers make sense of new information, which is the next step in the DIS2ECT process—cooperative learning.

Cooperative Learning

During the chemical change lesson described earlier, a variety of cooperative learning strategies were used. Cooperative learning is a great tool to ensure all students are active, engaged, and communicating about the content. Cooperative learning has academic as well as social benefits (Vaughn, Gersten, & Chard, 2000). Social benefits include increased self-confidence, improved self-esteem, and improved attitudes about school and high levels of self-responsibility (Scruggs & Rich- ter, 1985). Cooperative learning arrangements can involve students working with one partner or several group members. Depending on the content, homogenous (e.g., grouping students according to similar reading levels) or heterogeneous (mixed ability) groups can be created. Again, this is why it is crucial to know the students’ skills and abilities. It is important to note that some social skills training and regular monitoring are important elements of cooperative learning, and that measures need to be in place to hold each member of the group accountable for contributing (e.g., team roles such as materials manager, recorder, etc.). Although it is the last letter in our acronym, teamwork is truly the foundation of our work together.

Teamwork

Effective teamwork and co-teaching between general education science teachers and special education teachers is critical. The definition of co-teaching is quite simply, “two or more people working toward a common goal” (Snell & Janney, 2000, p. 3). Collaboration is grounded in the common goal of ensuring all students learn science. Mastropieri, Scruggs, and Graetz (2005) identified effective science co-teaching partners as those who (a) work well together, (b) are excited about teaching science, (c) set time aside for co-planning, (d) use appropriate curriculum materials, (e) are skilled instructors, and (f) adapt instruction to meet the needs of individual students.

There are several different teaming strategies; the most common are team teaching, parallel teaching, alternative teaching, and station teaching (Snell & Janney, 2000). Team teaching is when both teachers deliver the instruction content together. Parallel teaching is when the class is divided into two sections and both teach the same content at the same time, just to smaller groups. Alternative teaching is when one teacher leads an activity or investi-
nity to explore and understand the natural world around them. However, as we conclude, there are two significant points we need to make.

First, simply placing students with special needs in a general education setting does not equate to inclusion. Inclusion is educating students with special needs alongside their general education peers. Sadly, research suggests that oftentimes the inclusion classroom is “a setting essentially devoid of special education,” (Kavale & Forness, 2000, p. 283) and that placement (inclusion vs. self-contained) has only a modest influence on academic achievement (Murawski & Swanson, 2001). Effective inclusion involves intentional planning to meet the varied and individualized needs of each student in the classroom.

The second point we want to emphasize is that administrative support for inclusion is integral (Scruggs & Mastropieri, 2004). Lack of common planning time and administrative support are two of the greatest challenges to co-teaching reported by teachers (Carter, Prater, Jackson, & Marchant, 2009). It is important for administrators to understand that schedules need to be coordinated to ensure common planning times, and it is essential for general and special education teachers to have time to plan, reflect, and analyze assessment data together (Carter et al., 2009). Our experience shows us that the number one way to ensure administrative support for inclusion is to demonstrate that ALL students are learning, and we have found that DISINSERT is an effective framework for reaching this important goal.

References
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