Inquiry for everyone: Authentic science experiences for students with special needs

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Abstract

The National Research Council (1996), the American Association for the Advancement of Science (1993) and the National Science Teachers Association (2004) all posit that quality science instruction for all students is imperative in promoting scientific literacy that extends into adulthood. Hands-on, inquiry based experiences are effective means of instruction for all students, but such experiences are critical in creating meaningful experiences in science for students with special learning needs. This article addresses common challenges to implementing quality science experiences within the special education classroom, together with methods for overcoming these challenges.

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Introduction

The National Science Education Standards clearly state that all students should experience quality science instruction rooted in authentic, inquiry-based experiences, specifically that "equity... should pervade all aspects of science education" (National Research Council, 1996). With the current curricular emphasis on academic basics such as reading, writing and mathematics, science is an oft-neglected. This is particularly so within the special education classroom setting where there exists a multitude of individualized curriculum goals and a large diversity of issues to address. For special educators who try and make science an integral part of the curriculum, a lack of materials, adopted curricula, and background knowledge can provide even the best-intentioned educator with seemingly insurmountable obstacles. The National Science Teachers Association recognizes these challenges in their position statement on science for students with disabilities but go on to assert that NSTA "is strongly committed to developing strategies to overcome these barriers to ensure that all students have the benefit of a good science education and can achieve scientific literacy" (2004).

The alternative of not finding a way to include quality science experiences for students with special needs simply perpetuates the long held myth of science as an elitist subject reserved for only the "best" students, a myth in direct opposition of the most central values of special education and its ultimate goal of inclusion. This article seeks to address some of the challenges associated with creating inquiry-based science experiences within the special education classroom and to provide concrete strategies for overcoming these challenges. While this article is written with an emphasis on the special education classroom, the ideas addressed are simply good science instruction that would benefit any student and thus are as readily applicable to a general education classroom.

Why Science?

Inquiry based science experiences are exceptionally well suited for the diversity of learners within a special education setting. Science taps into a different way of thinking and exploring- an excellent way for students who may struggle with other academic subjects to experience success. The tactile nature of science is often a good fit for students who may struggle when presented with traditional paper and pencil activities. What is perhaps most helpful is that hands-on science is not simply a "modification" of the traditional curriculum but rather the most authentic way for any student to experience science. In hand with this, active scientific inquiry is best measured through authentic assessment such as projects, illustrations or student performance of a task or skill. This is a natural fit for the individualized assessment that is already in place within the special education classroom. For many of these suggested activities that follow, students use scientific illustration to communicate their discoveries, a method used within the scientific community for years (Ben-Ari, 1999) and one that allows students an alternative pathway from written tests yet still rooted in a real-world application.

When authentic, inquiry based science experiences are incorporated into the special education classroom, these experiences build skills that support all other academic areas. For example, inquiry-based science explorations might require students to observe, take measurements or describe what they see, and communicate their findings through the written word or oral discussion (see Appendix A). Most importantly, inquiry-based science relies on critical thinking which supports academic learning and the development of basic life-skills.

Perhaps most importantly, one needs to consider what is known about motivation and its effect on learning. We know that a motivated student is more likely to apply himself/herself to the task at hand (Covington 1997), which in turn can lead to greater learning gains. Inquiry-based science experiences can be highly engaging and go a long way to keeping students on task and cognitively engaged. For students who need extra motivation to tackle subjects they find intimidating, integrating them with exciting science activities provides additional encouragement. For example, a student who may normally balk at writing a descriptive sentence might tackle the same task with relish when it involves handling a live insect, dissecting a plant, or creating a chemical reaction.

Context and Relevance is Critical

Mastropieri and Scruggs (1995) and Patton (1995) remind us those hands-on/minds-on activities, and personally relevant topics, are critical for engaging learners with special needs in topics of science. Concrete experiences with personally relevant science topics, from petunias to pet, are critical for students who have difficulty with abstract concepts. When working with urban students who may have limited life experiences in addition to learning disabilities, this becomes even more critical. For example, when learning about the circulatory system, teaching a student how to take their own pulse before and after exercise is significantly more relevant than learning the same concept through reading a chapter or reviewing charts and diagrams.

Making it Happen

“I don’t have time- language arts alone can take up the full day!”
“We don’t have any science supplies and I can’t afford those expensive kits”
“I don’t know much about science- how am I supposed to teach it?”
”Some of my students really struggle- I think science is too difficult for them to understand”
“Where do I even begin?!?!”

While not direct quotes, I have had many teachers share these and many other concerns just like them. There are very real challenges to teaching science to any student. Working with students with special needs brings these challenges and additional ones as well. Challenges are not road blocks, however, and with some simple tips they can be mediated and even overcome.

The Time Factor

It’s an established fact that there is never enough time in the day to teach students all they need to know. And while certainly an hour of science would be a wonderful, a large block of time is not essential in providing quality science experiences. It’s not how much time you spend on science but rather what the time is spent doing. Having students observe birds in the playground for 5 minutes is more desirable than coloring a picture of ocean animals for 30 minutes. The key is to tap into process skills associated with scientific inquiry (See “What is Inquiry?” below) and think of ways for students to use these skills. Some examples of ten-minute-science are:

1. Walk around the playground and look for blooming plants
2. Observe playground birds- pigeons count!
3. Record the daily temperature every week throughout the school year- what changes do students notice?
4. Put a rock, shell, seed, vegetable, or fruit on each students' desk and have them describe it to a partner
5. Place an ice cube on hot cement. What happens?

What is Inquiry?

Inquiry-based science does not involve routinely answering questions at the end of a book chapter, completing animal-themed coloring pages, or creating a clay model of the solar system. While these activities have their appropriate place within the curriculum, they are not scientific inquiry.

Inquiry-based science requires students to be active investigators, not passive learners. These are a sampling of elements of inquiry-based science as defined by the National Science Education Standards (1996, p. 23). It's important to remember that one activity need not encompass all these skills to be inquiry-based- even one is a step towards quality science instruction.

- Making Observations
- Posing questions
- Examining books and other information sources
- Planning investigations
- Using tools to gather and analyze data
- Proposing explanations
- Communicating results

Materials...Materials...Materials...

The majority of educators struggle with acquiring quality materials for use in the classroom environment and the reality is that within many districts, quality science materials are not a high priority. The most important factor to remember is that materials need not be expensive or exotic in order to capture the attention of students. Further, the more a student can handle an object and guide his or her own experience, the better. A sturdy, less exotic item, like a pinecone, that students can actively handle and explore will have more impact than a rare or expensive item that must remain high on a shelf or behind glass. Here are some suggestions of easy-to-acquire items and associated activity suggestions.

Shells

Shells are easy to find- either at a local craft store or even a nearby coastline- and relatively inexpensive. They are sturdy and can withstand significant handling by students. Students can practice observation skills by sorting the shells in various ways, or communicating discoveries by drawing their favorite shell with careful attention to detail. They may practice making hypotheses by drawing or explaining what they thought might have lived inside the shell.

Backyard Critters

Arthropod is a catchall term for insects, spiders, and other leggy animals you might find in your backyard (see *"A Glimpse into the Classroom"* - below). Bringing arthropods (and their relatives snails and slugs) into the classroom will generate excitement and provide students with authentic life-science experiences. Most animals such as pill bugs, snails, or mealworms are hardy, can usually survive a class session of handling, and then simply be set free after the exploration. Students can again practice their observation skills by watching methods of movement or body structures or create simple (humane) investigations such as counting legs or identifying favorite foods.

A Glimpse Into the Classroom

"Mine can walk upside down!"

"Mine too! Mine too!"

"I don't have a stick for mine to walk on..."

"Look- you can use your pencil like I am."

"I did it! I did it! I think he can walk upside because he has so many legs to hold on with."

This was the second day of a series of inquiry experiences with a K-2 Special Day Class. Students were working in pairs to practice cooperative learning skills yet each had their own pill bug to investigate. Each student is completely engrossed in what their particular pill bug was doing but yet was quick to check in with their neighbors to compare size, shape, or even how well their pill bug was able to "walk upside down". By limiting direct instruction and creating a constructivist learning environment, each student was able to explore and discover at their own pace and in line with authentic inquiry.

"What's that?" Amy asked me pointing at a small slug inside the larger container where I kept all the insects and other critters.

"It's a slug," I answered leaving out the part that it had snuck its way into the container and wasn't a planned part of the investigation.

"When do we get to hold that one?"

Quick to grab an unplanned, teachable moment I quickly answered, "Right now," and plunked it into her outstretched, first grade hand. For the next 10 minutes Amy watched it stretch and slide over her hand, showed the other students how the "eyes" would extend and contract if the animal was startled and with enough coaxing allowed her peers to briefly take a turn holding it as they compared its movement with that of the pill bugs with all those legs.

As the students remained engrossed in their world of backyard critters, their teacher pulled me aside to explain that she was absolutely shocked by Amy's behavior. Not only had Amy expressed some grave reservations about my visit the day before, not confident she would like to handle the animals, she had a significant difficulty with touching certain textures. "You don't understand," she chattered, "she won't even touch STRING CHEESE and now she's passing a slug around." She concluded with "We need more science like this!" I had to agree.

Flowers and Plants

Flowers and plants are excellent for encouraging careful observation and the use of authentic tools (magnifying glasses) to see detail. Cut flowers and leaves can easily be gathered free of charge from the schoolyard, a nearby park, or a teacher's own backyard. Sometimes flower shops may be willing to provide slightly wilted flowers free or at reduced cost to educators. For just a few dollars, "six packs" of flowers such as marigolds or petunias can be purchased from a local nursery. Start by reinforcing observation skills by having students draw and color a picture of their flower/plant (see *"Looking Closely"* below). Plants and flowers have different shapes and textures as well, elements that can only be discovered when students are provided tactile experiences in exploring these specimens.

Looking Closely

"Look a little closer, is your flower purple?"

"I like purple. It's my favorite color," Shana answered impetuously stroking the marigold in front of her and peering carefully at it through her magnifying glass.

"I like purple too," her teacher countered, "but we are working like scientists today so we want to draw exactly what we see. What colors would you need if you wanted to color this flower like a scientist?"

Shana furrowed her brow and carefully selected from the bag of crayons at her desk. She tentatively drew out an orange crayon, a green crayon, a yellow crayon and then paused. With a quick look back at the flower, she reached back into the bag and drew out a red crayon. Beaming at her teacher, she flipped over her paper and began to draw again.

Building your own Knowledge Base

In science, not having definitive answers has led to the some of our greatest discoveries. Even expert scientists find themselves looking things up and mumbling, "I don't know". The most important thing to know about science is *where* to find the answers. When starting a new science unit, sometimes a simple children's book on a topic will provide you with all the content you need to teach the unit successfully. The Eyewitness series of nonfiction children's books is an excellent place to begin. See *"Literature Connection"* on the following page for additional resources.

Literature Connection

There are a number of quality science books to support your classroom instruction. Try one from the list or visit one of the following websites for additional suggestions!

For Students:
What is a Scientist? by Barbara Lehn
A simple introduction to scientific process skills with limited text and colorful photographs of primary students engaged in active inquiry.

Snailology / Rolypolyology by Michael Elsohn Ross
Provides background information on our most common backyard buddies and ideas for simple (humane) experiments for students to try.

One Small Square: Backyard by Donald M. Silver
Learn about the amazing animal and plant diversity in your own backyard through gorgeous illustrations and carefully worded content

Urban Roosts: Where Birds Nest in the City by Barbara Bash
Discover just how many different birds call the city home in this carefully illustrated children's book.

Mealworms by Adrienne Mason
A great resource on the common mealworm- simple writing, detailed illustrations, and experiments for students to try.

Discover more titles by using one of the following databases of quality science literature for children:

California Department of Education: Literature for Science and Mathematics Database
http://www.cde.ca.gov/ci/sc/ll/ap/searchlist.asp

National Science Teachers Association: NSTA Recommends
http://www2.nsta.org/recommends/
For Teachers:
Teaching Science with Everyday Things
by Victor E. Schmidt & Verne N. Rockcastle
Over a hundred hands-on activities and investigations using simple and inexpensive materials

"Science and Children"
National Science Teachers Association Journal - Become a member of NSTA and receive a monthly journal filled with ideas for hands-on science activities, information on assessment techniques, current happenings in science, and reviews of children's' literature. To join, visit www.nsta.org.

Capitalizing on Student Strengths

Some time ago the urban myth that science was only for our brightest members of society began and science educators have been trying to debunk it ever since. Standards advocate that in addition to teaching students science content, it's important they understand the very nature of science. This includes, among many other qualities, the idea that scientific study is engaging, a valuable human endeavor, and perhaps most of all creative in nature (National Research Council 1996). The National Science Teachers Association (2000) posits that "Creativity is a vital, yet personal, ingredient in the production of scientific knowledge". Thinking outside the box is expected in authentic science exploration. And though many famous scientists have been ridiculed at one point in their life for doing things a little differently than their peers, it is this creativity and thinking outside the box that led to the fantastic discoveries that eventually brought them recognition. Stephen Hawking, Thomas Edison, Albert Einstein, and Louis Pasteur are just a few successful scientists with disabilities.

Getting Started

Even with enough background knowledge, a block of time, and the right materials it can be difficult to know where to begin with science instruction. Using the 5-E Model as a guide for developing inquiry-based science lessons is one way to organize your ideas into a cohesive, organized science lesson. The 5-E Model is comprised of five phases: Engagement, Exploration, Explanation, Elaboration, and Evaluation all of which call for active student participation (Weld 2004). The sample inquiry lesson on the following page uses this model.

Final Thoughts

Motivation for building scientific literacy among our students goes beyond simply preparing them for a potential career in the sciences or academic success in subsequent grades. Rather, creating scientifically literate students is the first step toward creating scientifically literate adults, capable of actively participating in the scientific phenomena that surrounds them everyday so that they may live a richer life. From learning how to select a ripe peach, caring for a pet, or stargazing at night, to understanding medical choices, science is a part of everyone's life. To build a truly scientific literate society, quality science instruction for all students, including those within a special education classroom, is critical. Active inquiry is the best way to take this step without leaving any students behind. Perhaps most importantly, we know active investigations are what are best for all learners. Thus, it becomes less about creating unique experiences for select students, and instead about creating quality science experiences that meet the needs of all learners.

Sample Lesson Plan: Using the 5-E Model is one way to organize an inquiry-based science lesson. A simplified version of a 5-E lesson follows.

<u>Objective:</u> Students can identify major structures of a flowering plant

<u>Engagement:</u> Assess prior knowledge
Begin class by putting one large plant in a location where all students can see it. Provide students with 10 minutes to talk about the plant with a partner. Finish with a group discussion where students can share what they know about plants. (Inquiry Skill: Observation)

<u>Exploration:</u> Provide students with opportunity to build a common knowledge base
Give students their own plant to investigate. Guide investigations by providing the names of three to four structures students should look for. Have students carefully illustrate their plant and label these parts with the help of a "word bank" on the board as a form of scientific communication. (Inquiry Skills: Observation, Using Tools to Collect Data, Communicating Results)

<u>Explanation:</u> Provide clear explanations of content to support scientific understanding
Share published illustrations of plants with appropriately labeled parts. Encourage students to share their illustrations with the class. Answer students' questions regarding plant structures and encourage students to share what they have discovered. (Inquiry Skill: Communicating Results)

<u>Elaboration:</u> Apply new knowledge to a related experience
Take students for a walk around the school yard and ask them to look at the many different types of plants you encounter. Ask students to apply what they learned from the plant dissection and identify similarities and differences between these plants and the ones they explored in the classroom. Encourage them to touch and smell the plants they encounter in addition to observing carefully. Back in the classroom, provide students with resources to answer the questions they posed. (Inquiry Skills: Observation, Posing Questions, Examining Information Sources)

<u>Evaluation:</u> Assessment Stage
Meet with students individually and have them share their illustration with you. Ask them to evaluate their illustration as compared to a scientific illustration from a botany book. Did they capture the main parts? Give them the option to amend their illustrations but focus on the elements that are correct. (Inquiry Skills: Examining Information Sources, Drawing Conclusions)

Definitions adapted from Weld (2004).

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