Using An Activities-Based Approach To Teach Science
To Students With Disabilities

By Spencer J. Salend

Reports have called upon our nation's schools to make science literacy a reality for all students, including those with disabilities. Although educators, parents, and administrators have recognized the importance of science education for students with disabilities, recent research has indicated that many of them receive very little instruction in science—or none. When teachers employ instructional adaptations based on effective practices, students with disabilities can learn and master science content in the general education curriculum. This article provides educators with guidelines for enhancing their science instruction for students with disabilities by adapting, implementing, and assessing the effectiveness of an activities-based approach.

Science is one of the major content areas of the general education curriculum on which the educational reform movement has focused. In such nationwide reports as Science for All Americans (American Association for the Advancement of Science, 1989), our nation's schools have been exhorted to make science literacy a reality for all students, including those with disabilities. In 1993, the National Committee on Science Education Standards and Assessment noted that "the commitment to Science for All implies inclusion not only of those who traditionally have received encouragement and opportunity to pursue science, but of women and girls, all racial and ethnic groups, the physically and educationally challenged, and those with limited English proficiency" (p. 5).

Science can be related to the lives of all students, and it is essential to preparing students for the transition to adulthood and for membership in an increasingly technological workforce (Fradd & Lee, 1995; Gurganus, Janas, & Schmitt, 1995; Patton, 1995). Science education can help students learn about the physical environments in which they live and develop a multicultural worldview of scientific phenomena. For many students, particularly those who are learning English, science activities can serve as a vehicle for developing language skills and social behaviors (Fathman, Quinn, & Kessler, 1992).

Although the growing importance of science education for students with disabilities has been recognized, research by Patton, Polloway, and Cronin (cited in Cawley, 1994) indicated that many students with disabilities receive very little or no science instruction. Further, because many special and general educators have not been adequately prepared to teach science to students with disabilities (Gurganus et al., 1995), they often use a content-oriented approach that focuses on learning vocabulary and factual text-based information through textbooks and teacher-directed presentations such as lectures and demonstrations (Mastropieri & Scruggs, 1994; Weiss, 1993). Because such an approach requires that students have certain levels of reading, writing, and memory skills, many students with disabilities do not benefit from it (Scruggs & Mastropieri, 1993). They
therefore often receive low grades and perform significantly below their general education peers (Holahan, McFarland, & Piccillo, 1994; Parmar & Cawley, 1993). However, students with disabilities can learn and master content in the general education curriculum when teachers employ instructional adaptations based on certain kinds of effective practices (Grossen & Carnine, 1996; Scruggs & Mastropieri, 1993).

This article provides guidelines for enhancing science instruction through adapting, implementing, and assessing the effectiveness of an activities-based approach. These guidelines can also be used to facilitate the performance of students without disabilities.

**An Activities-oriented Approach**

Many students with disabilities benefit from learning science through an activities-oriented approach that reduces the reliance on textbooks, lectures, knowledge of vocabulary, and pencil-and-paper tests (Mastropieri & Scruggs, 1994). This kind of approach seeks to promote learning by providing students with experiences that allow them to discover and experiment with science. Through discovery and inquiry, teachers involve students in creating and expanding their knowledge and understanding about the content area being studied (Mastropieri & Scruggs, 1995).

**A Structured Learning Cycle**

When employing an activities-oriented approach, teachers offer students a variety of active educational experiences structured according to a learning cycle. This cycle consists of an instructional sequence that includes engagement, exploration, development, and extension (Guillaume, Yopp, & Yopp, 1996; Gurganus et al., 1995). The learning cycle begins with the engagement phase, whereby teachers use real-life activities, problems, and questions to motivate students to learn about the topic and to assess their prior knowledge. Students explore the content and phenomena by manipulating materials and start to address the presented questions. For example, as part of a unit on simple machines, teachers can ask students to identify simple machines that they use and have students take apart broken household appliances. During the exploration phase, students formulate new ideas and questions to be developed in the subsequent phases. For example, teachers can have students explore how the household appliances work, identify their components, and formulate hypotheses about how to fix them. In the development phase, students add to their understanding by gathering more information and making conclusions about the concepts, phenomena, and questions previously generated. For example, students can use the Internet to learn more about the appliances and to draw conclusions about how they work. In the final stage, extension, students extend their learning by applying it to new and different situations as well as to their own experiences. For example, students can hypothesize about how other machines and household appliances that they use work. Educators help students move through the learning cycle by asking them to think about questions, helping them find solutions, providing additional activities that further students' learning, and aiding them in summarizing and evaluating their learning.
An integral part of an activities-oriented approach is providing hands-on, multisensory experiences and materials. Hands-on learning gives students concrete experiences that establish a foundation for learning more abstract concepts. These kinds of activities also help students actively explore and discover content, and they lessen the language and literacy demands that may interfere with learning for students who have learning difficulties and/or are second-language learners (Fradd & Lee, 1995). For example, students can learn about electricity by building electric circuits or about earth science by creating models out of papier-mâché.

Special Concerns

Because students with physical, sensory, and fine-motor disabilities may experience some difficulties using manipulatives and scientific materials and equipment, educators may need to offer adapted equipment (Mastropieri & Scruggs, 1995). Students with visual disabilities, for example, may need Braille-marked and talking materials and equipment such as a Braille labeler, ruler, and meter stick; talking thermometer and balance; enlarged three-dimensional models; and large-screen video and microprojectors to enhance visual images.

In an activities-based science instruction approach, students often work in labs solving problems and conducting experiments. Educators can maximize this type of learning experience by showcasing and demonstrating essential aspects of problems and experiments, letting students with disabilities team up with nondisabled peers, disseminating a checklist of steps students can consider when working on a task, checking their progress, and asking them to maintain lab journals.

Teachers also can ensure that all students are able to work safely and successfully in laboratories and with materials (Kucera, 1993). For example, teachers can begin each experiment by posting, discussing, and reviewing the rules, safety factors, and evacuation procedures and assessing students' knowledge of them. They can use print and tactile substances to label important areas, materials, and substances; have all students wear safety equipment (e.g., splash-proof goggles, rubber aprons, and gloves); and assign lab partners.

Teachers must know whether some students need adapted workstations and specialized equipment (Kucera, 1993). Students with physical disabilities may need a workstation with a work surface 30 inches from the floor, accessible equipment controls, and appropriate clearance and leg space, as well as good aisle widths. These students also may benefit from adjustable-height storage units; pull-out or drop-leaf shelves and countertops; single-action lever controls and blade-type handles; flexible connections to water, electrical, and gas lines; and lightweight fire extinguishers. Similarly, the performance and safety of students with sensory disabilities may be enhanced through the use of adaptive equipment such as electric machines and alarm systems that have visual and auditory cues to indicate their on/off status, spoons with sliding covers, and glassware with raised letters and numbers.


**Relate Science to Students' Lives**

Relating science instruction to students' personal experiences and to general societal problems is an essential component of an activities-oriented approach. Relating science to practical, civic, professional, recreational, and cultural events that are familiar and relevant to students' backgrounds and experiences can promote science literacy, motivate students, and help them learn to value science. To aid students in seeing the relevance of science to their lives, teachers can present them with information, issues, and problems that relate to real-life situations and discuss with them the relevance of these problems to their lives and the situations in which this content can be applied. For example, students can investigate socially significant problems such as water supply, weather, pollution, nutrition, and solar energy.

Teachers can make connections between science and students' cultural backgrounds by using learning activities and instructional materials that

- explore the different cultural origins of science,
- discuss scientific solutions and practices developed and used in all parts of the world,
- highlight the achievements of culturally and linguistically diverse scientists, and
- present a range of culturally diverse practical applications.

Connections to students' lives and cultures also can be established by having students

- conduct problem-solving activities that address community-based problems,
- use artifacts, buildings, geographical sites, museums, and other resources in their community, and
- interview community members.

These experiences will help illustrate and reinforce concepts, issues, phenomena, and events (Fradd & Lee, 1995; Taylor, Gutierrez, Whittaker, & Salend, 1995).

**Take Students on Field Trips**

Class field trips that are directly related to the curriculum can make learning more meaningful and real for students. They can also serve as the basis for developing instructional units. Trips to community and regional science museums and ecological sites can offer direct experiences and authentic tasks related to what students are learning. In addition, many field trips provide hands-on experiences that promote the learning not just of factual information, but also of processes. "Virtual field trips" to various museums and scientific sites can be done via the Internet (see the sidebar).

To help teachers and students benefit from field trips, many museums provide teacher training programs, model curricula and teaching strategies, special tours, exhibits, and materials for school groups and traveling exhibits that prepare students for and build upon experiences at the museum. Prior to taking their classes on trips, many teachers
make pre-visits to familiarize themselves with various aspects of the facility (e.g., available exhibits and activities, admission costs, facility and restroom accessibility, rules on photography, whether there are lunchrooms and coatrooms, etc.). Teachers may also meet with the facility's staff concerning the size and unique needs of their classes and the availability and scope of guided tours. Field trips also can be enhanced by giving students a variety of pre-trip learning experiences to prepare them, explaining expectations regarding their behavior on the trip, giving them notepads on which to take notes and make sketches, eliciting and answering questions on the ride to the site, and discussing positive and negative aspects of the trip with them on the ride back to school (Roberts & Kellough, 1996). Teachers can also prepare trip chaperones by giving them information about the facility and their responsibilities.

The educational benefit of field trips can be enhanced by videotaping them. These videos can subsequently be viewed and discussed in class and can serve as a basis for lessons to help students understand important information presented on the trip. Students can show the video and discuss it with other classes or students who were not able to make the field trip.

Organize Instruction Around "Big Ideas" and Interdisciplinary Themes

In activities-oriented approaches, teachers focus on breadth of understanding rather than a broad coverage of science. Carnine (1995) proposed that educators structure instruction in science according to "big ideas," which he defined as important concepts or principles that help students organize, connect, and apply material so that they see a meaningful relationship between the material to be learned and their own lives. Carnine also suggested that teachers sequence instruction by employing big ideas to help students develop a mechanism for learning "smaller ideas" such as facts that relate to the broader concepts and big ideas being presented.

The science performance of students with disabilities will be enhanced when teachers organize instruction around broad-based, common, and interdisciplinary theme concepts (Kataoka & Lock, 1995; Rutherford & Ahlgren, 1990). Interdisciplinary themes can link the various science disciplines (e.g., biology, chemistry, earth science, physics) as well as relate science themes to other subject areas (e.g., English, mathematics, social studies, foreign languages, art, music). For example, for an interdisciplinary thematic unit on weather, students would study the scientific principles undergirding various weather patterns as part of science class and the history of weather and its effects on lifestyles and cultural traditions in social studies class. As part of their mathematics classes, students would be asked to solve various mathematical problems related to weather and, for language arts classes, to read literature and poetry related to weather. In art class, students would see how weather changes the appearance of various landscapes and then produce art forms to reflect these landscapes.

When selecting common and interdisciplinary themes around which to organize instruction, teachers should consider several factors, including whether the themes (a) are feasible for students and teachers in terms of motivation, relevance to the curriculum and
students' lives, length of time, availability of materials and resources; (b) provide sufficient opportunities to teach basic- and higher-level content, information, and skills; and (c) relate to meaningful and worthwhile contextualized content (Savage & Armstrong, 1996). Once themes are selected, teachers formulate objectives and develop, select, and organize the content and instructional resources; implement with students a diverse set of theme-connected direct and hands-on learning activities that integrate science, social studies, language arts, music, art, and other content areas; and devise appropriate assessment procedures to be employed throughout the instructional unit (Roberts & Kellough, 1996). Interdisciplinary thematic units usually conclude with students completing a culminating activity that allows them to summarize and present what they have learned.

Have Students Work in Cooperative Learning Groups

In an activities-based approach, teachers often structure learning so that students work in cooperative learning groups (Gurganus et al., 1995). The use of such groups can encourage the establishment of scientific classroom communities where students work in groups to communicate about and experiment with solutions to scientific problems. Cooperatively structured learning lets students formulate and pose questions, share ideas, clarify thoughts, experiment, brainstorm, and present solutions with their classmates. Students can see multiple perspectives and solutions to scientific problems. For example, in a unit about flowers, students can be assigned to work in cooperative groups to design a flower garden for their school. The group can plan their garden by posing questions (What flowers grow best in the available soil and lighting conditions? What flowers and colors go together? What materials will be needed to maintain the garden?) and gathering data to address these questions. The group also can share a drawing of their proposed garden and the reasons that guided their design with the whole class.

Use Instructional Technology and Multimedia

Instructional technology and interactive multimedia provide students with access to learning environments that link text, sound, animation, video, and graphics to present content in a nonlinear and instantaneous fashion that can foster critical thinking skills and social interactions (The Cognition and Technology Group at Vanderbilt Learning Technology Center, 1993). These technologies also can be incorporated throughout the curriculum to adapt instruction to students' learning styles and provide them with experiences that allow them to control their learning.

Instructional technology and interactive multimedia such as computer software, hypertext/hypermedia, computer simulations, videocassettes, videodiscs, captioned television, liquid crystal display (LCD) computer projection panels, CD-ROM, virtual reality, and the Internet can be used to introduce, review, and apply science concepts and have students experience events, places, and phenomena (Trowbridge & Bybee, 1996). For example, through virtual reality systems, students can experience Newton's law of gravity firsthand or through multimedia applications, they can perform complicated scientific experiments such as studying chemical reactions. In addition to providing
students with an opportunity to obtain information about and interact with unique aspects of science, these instructional delivery systems can motivate them and stimulate their curiosity.

The Internet holds great promise as an instructional tool because it provides educators and students with access to the information superhighway and a variety of exploratory-and discovery-based learning and communication experiences (Peha, 1995). The Internet also can offer students greater control over the curriculum because it provides them with many choices related to what and how they learn. Specifically, students can learn science by having access to information, educational resources, pictorials, databases, problem-solving experiences, and communications with other students and professionals from throughout the world. For example, the National Geographic Society and the Technical Education Research Center sponsor the Kids Network, an international telecommunications-based curriculum to teach science and geography to elementary and middle school students (Bradsher & Hagan, 1995). Students work in small groups to pose questions concerning socially significant problems, conduct experiments, and collect and analyze data related to their questions. Through the network, students exchange information and share their findings with peers worldwide. Listings and descriptions of computer networking resources for educators and students are available and can be obtained by contacting professional organizations, state education departments, and computer-based companies.

Support Instruction Through Specially Designed Programs and Curricula

Specially designed science programs and curricula can be incorporated into an activities-based instructional program. An example would be the Full Option Science System (FOSS; Encyclopedia Britannica Co., 1992), which offers teachers a hands-on, laboratory-based K-6 curriculum structured around four themes: scientific reasoning, physical science, earth science, and life science. FOSS also uses discovery learning, cooperative learning groups, interdisciplinary activities, and other types of activities to teach science language and the use of scientific equipment. It also includes Science Activities for the Visually Impaired (SAVI) and Science Enrichment Learning for Learners with Physical Handicaps (SELPH), activities-based science programs for students with disabilities.

Two hands-on laboratory-based curriculum models are

- Science for All Children (SAC; Cawley, Miller, Sentman, & Bennett, 1993), which addresses four interrelated themes and thinking processes: systems, change, structure, and relationship, has been designed as a multiple-option curriculum for elementary-level students and allows teachers to adapt the activities to the cognitive, cultural, language, and social-personal needs of their students.
- Applications in Biology/Chemistry (ABC; Prescott, Rinard, Cockerill, & Baker, 1996), which seeks to promote the science literacy skills of secondary students in the middle 50% range by linking science concepts to personal and societal contexts and the world of work. Through the use of real-world activities, job
profiles, cooperative learning, learning-style adaptations, laboratory exercises, and hands-on activities, the ABC curriculum provides teachers with a framework for teaching science in context.

Science curricula and programs designed to address the needs of students from culturally and linguistically diverse backgrounds also are available:

- Finding Out/Descubrimiento (De Avila, 1988) is a collaborative learning, hands-on, problem-solving math and science program for second-language learners that includes materials in English and Spanish and pictorial directions.
- Beginning Science Equitably (Educational Equity Concepts, n.d.) is an early childhood science program designed to provide teachers with developmentally appropriate lessons that help students, regardless of gender, race, disability, or socioeconomic status, to develop the visual-spatial, problem-solving, and decision-making skills that promote positive attitudes toward and future success in science. The program also includes a hands-on curriculum that introduces a variety of science concepts using the scientific method and a series of science activities that families can do to help their children learn about science.

**Evaluate Student Performance**

Rather than using paper-and-pencil tests to assess student performance, educators using an activities-oriented approach often employ authentic performance and student-centered assessments. Performance and student-centered assessments seek to connect assessment and instruction and involve students in examining the process and products of learning. In performance assessment, students reveal their skills, problem-solving abilities, and knowledge and understanding of science by creating and making things, developing projects, solving problems, producing written products, responding to simulations, giving presentations, conducting investigations, and designing and performing experiments. For example, as part of a unit on water pollution, students can perform a variety of activities and experiments using local water samples. These activities can then be assessed by having students present their findings to a local community group and/or by creating a Web page summarizing their results.

Students can be involved in the assessment process through use of such student-centered assessment strategies as portfolios (Rueda & Garcia, 1997; Salend, 1998), journals and learning logs (Davison & Pearce, 1992), think-alouds (Andrews & Mason, 1991), and self-evaluation questionnaires and interviews (Pike & Salend, 1995). These assessment strategies provide students with opportunities to monitor their progress, evaluate their understanding, and gain insights into the ways they approach and think about science. Portfolios are archival in nature and consist of student products selected by both students and teachers over a period of time. Portfolios are continuously examined by students, educators, and families to reflect upon and document the students' growth, effort, attitudes, and the processes they use to learn science.
Journals and learning logs offer students opportunities to react to and reflect upon their learning and to develop their skill at communicating scientifically (Davison & Pearce, 1992). During or after a learning activity, students write entries in their journals/logs that address

1. What they learned,
2. How they learned it,
3. What they do not understand,
4. Why they do not understand it, and
5. What assistance they would like to receive.

Think-aloud techniques involve teachers prompting students to verbalize the processes they are using and their thoughts while working on a science activity by asking students to respond to a variety of questions (e.g., As you work on that activity, what are you thinking about? How did you arrive at that solution?). Similarly, self-evaluation interviews and questionnaires are designed so that students respond to a variety of questions that reveal their approach to various learning activities, their perceptions of their educational needs, and their progress in understanding science. Information collected from these student-centered assessment strategies can be used to devise instructional strategies that help students become better learners.

Summary

Our nation's schools are being challenged to make science literacy a reality for all students. Although the benefits of science literacy for students with disabilities have been recognized, many of these students perform poorly in science because of a variety of pedagogical and training factors. This article was designed to help educators meet the challenge of enhancing science literacy of all students by offering guidelines for adapting, implementing, and assessing the effectiveness of an activities-based approach to teaching science to students with disabilities.

References


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Spencer J. Salend, EdD, is a professor of special education in the Department of Educational Studies at the State University of New York at New Paltz. His research interests relate to educating students with disabilities in general education classrooms and meeting the educational needs of students from culturally and linguistically diverse backgrounds, including migrant students with disabilities. Address: Spencer J. Salend, Department of Educational Studies, SUNY at New Paltz, 75 South Manheim Blvd., New Paltz, NY 12561.

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