Teaching Science to the Visually Impaired

Practical strategies for engaging visually impaired students in science-related activities

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Research indicates that students with exceptionalities such as visual impairments are more academically successful when they are included in the regular classroom setting and have opportunities to engage in active learning (Ferguson and Asch 1989; Baker, Wang, and Walberg 1994; Rea 1999; Rea, Millican, and Watson 2000; Wasserman 1992). Therefore, science educators must address their needs by motivating visually impaired students in science and making accommodations in the laboratory and science classroom.

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Defining visual impairment

Educators often refer to the following educational definition of "visually impaired": "1) A student who is totally blind receives no useful information through the sense of vision and must use tactile and auditory senses for all learning. 2) A child who is functionally blind has so little vision that she learns primarily through the auditory and tactile senses; however, she may be able to use her limited vision to supplement the information received from the other senses and to assist with certain tasks (e.g., moving about the classroom). 3) A child with low vision uses vision as a primary means of learning but may supplement visual information with tactile and auditory input" (Heward 2003, 405).

Most students who have a visual impairment have IQs that fall within the normal range. These students generally learn to read and write, which enhances their ability to participate in the education curriculum (Miller 2002). Children with visual impairments constitute a very small percentage of the school-age population—fewer than two children in one thousand (Heward 2003). Still, it is likely that over the course of a teaching career most science educators will teach one or more visually impaired students. Some students with a visual impairment also have other disabilities and are therefore included in additional disability categories within the public school setting.

Rethinking instruction

The current focus of special education is to integrate schools (Bina 1993). Visually impaired students are placed in inclusive classrooms in public schools at even higher rates than students with other disabilities (Heward 2003).

Research shows students learn best when the subject matter is interesting to them and is structured for active engagement in the learning process (Rea 1999; Rea, Millican, and Watson 2000; Wasserman 1992). We offer the following strategies for teaching science to visually impaired students. Many of the instructional strategies discussed are applicable to all students, regardless of visual ability, in the promotion of active engagement in the learning process and safe laboratory practices.

Alterations made in instructional procedures for visually impaired students should be minimal (Lewis and Doorlag 2003). According to Blankenship and Lilly, curricular goals should be identical for both typical and visually impaired students (1981). This is understandable because students with visual impairments do not differ in their cognitive ability from other students (Kumar, Ramasamy, and Stefanich 2001). Because typical schooling is primarily visually oriented, students with visual impairments often experience academic difficulties (Kumar, Ramasamy, and Stefanich 2001). Therefore, it is crucial that science education explore alternative means of science learning experiences for the visually impaired science student (Figure 1, p. 33).

Science classroom adaptations

According to Trowbridge, Bybee, and Powell, "students with visual impairments learn through sensory channels other than vision, primarily hearing" (2004, 277). Therefore, visually impaired students should be seated closest to the sound source. Likewise, visually impaired students should sit in an area of the classroom with the best lighting. "Positioning a student's desk so that the light comes over the shoulder's nondominant hand helps reduce glare" (Miller 2002, 119). Unfortunately, the best area for optimal sound may not be well lit and vice versa. So, it may be necessary to allow the visually impaired student to move from one location to another depending on what activity is taking place in the classroom.

The physical arrangement of the classroom should also be considered when making allowances for visually impaired students. Unnecessary obstacles in the room should be eliminated and visually impaired students should be informed if the room arrangement has been altered or if a temporary obstacle has been placed in the room such as a demonstration table or movie screen (Lewis and Doorlag 2003).

Unobstructed pathways are a must, as well as placing the desk of a visually impaired student away from any kind of potential danger (Miller 2002). Furthermore, if possible, desks and tables should be arranged so that ample room exists for visually impaired students to maneuver with canes or guide dogs. If the classroom arrangement changes in any way, the visually impaired student should be given the opportunity to practice moving about in the revised environment. Often these accommodations are detailed in the students' Individualized Education Plans (IEP). Lewis and Doorlag also stress the necessity of keeping classroom doors either fully opened or fully closed to prevent visually impaired students from accidentally running into them (2003). This also holds true for objects in the science laboratory including doors to safety goggle cleaning cabinets and chemical storage rooms.

Orientation and mobility training for students with sensory disabilities is also important. "Orientation is knowing where you are, where you are going, and how to get there by interpreting information from the environment. Mobility involves moving safely and efficiently from one point to another" (Heward 2003, 420). According to the Individuals with Disabilities Education Act of 1997, orientation and mobility instruction is considered a related service (Heward 2003). Visually impaired students must know and be able to move about their environment with ease. Students with a visual impairment must become familiar with the school environment to ensure safety as well as a good learning situation.

Lab safety issues

Issues of safety are often first-priority concerns for teachers of visually impaired science students. Because the science laboratory can be a hazardous environment for all occupants, laboratory safety should be the first topic discussed in all science classes. Particular precautions should be in place in laboratories in which visually impaired students are working. We suggest that science teachers arrange a time for visually impaired students to "tour" the science laboratory. Ideally, this would be during the teacher's planning period or before or after school, when the lab is vacant and the teacher has the students' undivided attention. These students need to become familiar with the science lab environment so that they can move about the room with ease and locate necessary equipment and materials such as emergency showers, fire extinguishers, eye wash stations, and first aid kits (Kumar, Ramasamy, and Stefanich 2001).

Non–visually impaired students should also be prepared for the presence of a visually challenged student in the science laboratory. Establishing a rule that visually impaired students always have the right-of-way when they are moving about the class is recommended as well as cautioning students to keep aisles as barrier-free as possible. Students should also be warned about moving desks and other classroom furniture and materials from their regular placements without first warning visually impaired students. Non–visually impaired students should also be briefed about the function of guide dogs and cautioned against treating them as pets. The teacher should ask the class for volunteers to work as a lab partner with the visually impaired student. This will prevent the assigning of a lab partner who may be unwilling or uncomfortable working with a visually impaired student.

As with all students, during the course of a laboratory lesson, especially when working with chemicals, visually impaired students should wear rubber gloves, an apron, and goggles (Kucera 1993). When applicable, plastic measuring devices and containers should be substituted for glassware and rubber mats should be used for stabilizing glassware, especially when liquids are being transferred. Hotplates are also suggested as a substitution for Bunsen burners, if possible. Figure 1 offers a metric lesson modified for visually impaired students.

Lab equipment accommodations

Increasingly more attention is being paid to the development and modification of laboratory materials for visually impaired students. Braille label makers are available for those students who read via the Braille system. Science teachers may use these label makers in a variety of different ways in the science laboratory. For example, labels could be applied to chemical and reagent containers, glassware, and other laboratory equipment. The first laboratory activity high school science students engage in each fall should be one that requires them to become familiar with the laboratory equipment they will be using throughout the year. Each piece of equipment can be placed on the lab tables along with a numbered index card with the name of the item in print for students with normal vision and with a Braille label attached for the visually impaired. The teacher can then describe the function of each item while handing it to the visually impaired student. Finally, students can rotate around the lab and those with normal vision can draw pictures of the item while the visually impaired student explores the equipment tactilely and records descriptions in Braille.

Visually impaired students can use common laboratory measuring devices with little or no modifications. For example, tactile markings may be added to graduated cylinders, beakers, and flasks at the measurement required for a specific experiment. The use of puff paint can be used for tactile markings. Other paint products are available that have been designed specifically for tactile usage by the visually impaired. Alternatively, premarked tactile rulers, metersticks, and other devices are available from the American Printing House for the Blind. Stapling markings on metersticks for tactile measurements can be helpful. Other possibilities for modifications include punching holes in plastic beakers and other measuring devices to mark certain measurements. Students fill the containers with the desired liquid (noncaustic only) and the excess will drain out of the holes. Furthermore, students who have moderately impaired vision may be able to see the meniscus of a graduated cylinder if it is placed against a contrasting background.

Visually impaired students may also determine the mass of an object by using a triple beam balance if the weights are marked with tactile markings. Digital balances may suffice for those with reduced vision. For measuring temperature in the science laboratory setting, tactile and talking thermometers are available commercially. Likewise, tactile timers, Braille timers, and timers with extra-large displays are also easily obtained from companies such as Maxi-Aids. For physical science students, Braille compasses and toned light probes are available.

For science teachers who do not have labs, Science Activities for the Visually Impaired (SAVI) are complete modules that address topics ranging from scientific reasoning to environmental energy to mixtures and solutions. These modules can be obtained from the Lawrence Hall of Science at the University of California at Berkeley (Chiapetta and Koballa 1994).

Some students with visual impairments can successfully use a microscope with the help of a micro projector.

FIGURE 1

A metric measurement lesson modified for visually impaired (V.I.) students.

Metric Measurement

Name:____

Materials:

- Metric ruler (premarked tactile for V.I. students)
- Meterstick (premarked tactile for V.I. students)
- Graduated cylinder (premarked tactile for V.I. students) or liquid measuring spoons (for V.I. students)
- Triple beam balance (premarked with tactile markings for V.I. students or talking scale)
- Wooden block
- Balloon
- Thermometer (talking, premarked tactile, large display, or colored alcohol for V.I. students)
- Three different sized containers (e.g., beakers, food jars, film canisters)
- Water (colored water for moderately V.I. students)

Procedure:

1. Use a metric ruler to measure lines A, B, C, and D on this page (these lines will need to be painted over with puff paint for V.I. students). Write the length of each line (in mm) on that line.
2. Use a meterstick to measure the length and width of your classroom. Be sure area is clear of obstructions for the V.I. students. Write these measurements (in cm) in Table 1 (an enlarged version of the table can be made with puff paint for the V.I. students).
3. Use a graduated cylinder to measure the liquid volume of three different containers (liquid measuring spoons may be used by the V.I. students: 1 tsp = 5 mL, 1 tbsp = 15mL, 1 c = 240 mL OR colored water may suffice for the moderately V.I. students OR a science partner may have to aid a completely blind student by placing their finger on the marking corresponding to the water level in the graduated cylinder). In Table 1, record the type of containers and their volume (in mL).
4. Use a triple beam balance to measure the mass of the wooden block, and any two other objects (e.g., jewelry, pens, books, pencils, calculators, and eyeglasses). Also, determine the mass of an empty balloon and an inflated balloon. In Table 1, record the names of the objects and their masses (in g).
5. Use a thermometer to measure the temperature (in °C) of tap water. Enter this information in Table 1.

Line A: _______________ Line B: _______________ Line C:_______________ Line D:_______________

TABLE 1

	Length (cm)	Volume (mL)	Mass (g)	Temperature (°C)
Length of room		X	X	X
Width of room		X	X	X
Container 1:	X		X	X
Container 2:	X		X	X
Container 3:	X		X	X
Wooden block	X	X		X
Balloon (empty)	X	X		X
Balloon (inflated)	X	X		X
Object:	X	X		X
Object:	X	X		X
Temperature of tap water	X	X	X	

Questions:

1. What instrument is used to measure liquid volume?
2. What instrument is used to measure mass?
3. Name a metric unit of length:

Note:

For moderately V.I. students, instructions and tables could be enlarged. For completely V.I. students, these instructions could be provided in Braille.

A compilation of advice for teaching visually impaired students (provided by Kumar 2001; Trowbridge, Bybee, and Powell 2004; and Weigerber 1993).

- Allow the audio taping of lectures;
- Provide large-print copies of textual materials;
- Provide for the translation of textual materials into Braille and adaptive electronic media;
- Assign a typical student to describe in detail visual representations such as videos, slides, and overhead transparencies to the visually impaired student;
- Supply tactile representations of diagrams and graphs;
- Allow extra time for reading and viewing;
- Use the student's name when addressing him or her;
- Provide numerous laboratory science experiences; and
- Allow students to manipulate relevant scientific objects, models, and other materials when possible.

Videos or microscopic material are also available commercially that can be projected onto a larger screen for easier viewing (Chiapetta and Koballa 1994).

Technology accessibility

Educational software presents challenges for students with disabilities. For example, if students are using an interactive simulation to learn a biology lesson, the student with low vision may be sitting to one side listening to classmates as they describe the activity steps. Chances are, the sighted students will leave out some details and the visually impaired student will miss important information. The lack of accessibility can stigmatize visually impaired students by preventing them from using the same materials as their peers, which can actually limit their educational opportunities (Heward 2003).

Students may receive electronic versions of textbooks, with moving pictures and links to information not contained in the primary source book. Similarly, textbooks often go hand-in-hand with many types of tactile, kinesthetic modifications a teacher can provide for the visually impaired student.

Students who are blind often make use of multimedia presentations, but access the information through verbal descriptions as often as any specific piece of technology (Corn and Wall 2002). If a teacher presents simulated frog dissections whereby students use their computer mouse to perform directed tasks, the student who is visually impaired is not able to obtain a similar experience without planning, resources, and professionals devoted to preparing the task (Corn and Wall 2002).

However, Corn and Wall also found that teachers of visually impaired students felt more comfortable with general technology than with technology designed specifically for students with a visual impairment (2002). This could be due to the additional training required in the area of assistive technology. Therefore, one barrier to the use of multimedia presentations for visually impaired students is that teachers need to develop their multimedia skills further (Corn and Wall 2002). The need for universal design is imperative in all subject areas for students with a visual impairment.

Models and manipulatives

A wide variety of commercially produced three-dimensional models and manipulatives are available for science students, whether the students are visually impaired or not. Elaborate and intricate models of plant and animal cells, internal structures of worms and frogs, steps of mitosis and meiosis, types of bacteria, and cross sections of trees, for example, can be purchased from biological supply companies (but often at expensive prices). If models are to be used by blind students, care should be taken that the components are represented three-dimensionally rather than through color codes.

Although the process can be time consuming, it is more economically feasible to create models. Once again we suggest the use of puff paint and common household materials to create various models. Students can even benefit by constructing their own models. For extra credit, biology students could create a three-dimensional tactile cell, complete with organelles. "The Incredible Touchable Cell" contest can result in the most amazing creations to represent a cell and all of its components. Cells made of shoeboxes or modeling clay with embedded objects like marbles, rubber bands, pipe cleaners, and small rubber balls used to represent organelles, are examples of tactile cells created by students. Visually impaired students often create some of the most unusual cells; through this process, these students can successfully learn the different organelles found in cells.

Modifying demonstrations

Demonstrations are an integral component of science instruction, but often must be modified for visually impaired students. The teacher should place more emphasis on oral descriptions of scientific processes rather than textual representations of the demonstration so that visually impaired students might gain a mental picture of what is taking place (Ratliff 1997). For example, if the demonstration involves the chemical reaction of two elements, the teacher should fully describe—or have other students describe—the physical appearance of the individual elements and their separate chemical properties followed by a vivid depiction of the reaction process and its product(s). Having normally sighted students accurately describe the demonstration will help these students develop the skills of careful observation and effective communication. The teacher should also pass around physical objects related to the demonstration as it takes place (Ratliff 1997).

Student involvement in demonstrations is also an excellent instructional strategy for the visually impaired. For example, when introducing volume, a bucket can be filled with water to the brim and placed inside a cake pan. The visually impaired student can then be asked to form a fist with his or her hand and insert it into the water up to the wrist. The overflow is then caught in the cake pan. The student can then pour the water from the cake pan into a large graduated cylinder whereupon a measurement of the volume of water (equal to the volume of the fist) can be measured by tactilely feeling the raised gradations on the side of the cylinder.

Practical assessment

Modifications in testing procedures are necessary for many visually impaired students. Whenever possible, teachers should use a practical form of assessment rather than a written assessment. For example, when assessing knowledge of an animal cell's structure, a visually impaired student can feel the different organelles on a three-dimensional model and verbally identify them.

Alternatively, textual examinations may be translated into Braille for those who read with Braille and may otherwise be modified for those who do not. For example, Friend and Bursuck suggest that wider line spacing, spacing between words and margins, and larger fonts be used in test construction (1999). They also suggest the use of taped responses to essay questions on examinations. Visually impaired students may also benefit from a reader reading the test information to them. Students who have Braille note takers may respond to test questions as they are read to them by typing answers.

Visually impaired students are just as cognitively capable as other students in science and should be provided ample opportunities to engage in science-related activities. Our hope is that the suggestions provided in this article will help teachers develop ways to enhance scientific learning for visually impaired students. With encouragement and motivation, these students may not only succeed in the classroom but also someday choose to pursue science-related careers. ■

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