SEEING SCIENCE

Visually impaired students can conduct independent science investigations.

Rhea Miles and Alana Zambone

Students who are blind or visually impaired (BVI), like all students, need to conduct scientific investigations that involve measurements and reading experimental procedures. Best instructional practices for BVI students include touch and hearing experiences (Sahin and Yorek 2009). Related strategies and tools include electronic textbooks, assistive technologies such as screen magnifiers and readers, voice commands on cell phones, enlarged fonts and spacing, tactile models, and Braille transcription of print (Kumar, Ramasamy, and Stefanich 2001; Ostrowski 2016).

In this article, a student with BVI uses assisted technologies and modified devices to independently participate in the Science Education Against Drug Abuse Partnership (SEADAP), through which students conduct drug addiction research on planarians (flatworms) (see “On the web”). The project, titled "Planarians and the pharmacology of addiction: An in vivo model for K–12 education," is funded by the National Institute on Drug Abuse, National Institutes of Health (NIH). Typically, students enrolled in advanced placement (AP) statistics, biology, AP biology, or honors chemistry conduct independent research after school for two hours once a week for 14 weeks at a nearby university.

Background and research

Inclusive instruction applies the principles of "universal design," a framework used to develop flexible learning environments that optimize teaching and learning for all people at all levels of education (Ostrowski 2016). Examples of inclusive instruction for BVI students might include optimizing lighting and positioning; providing a choice of Braille, audio, or adapted print materials; or offering alternative assignments. Science laboratories typically have limited access for BVI students. Additionally, reliance on a lab partner to complete work impedes the student's acquisition of skills and diminishes his or her confidence (Carver 1967).

Research at the university level has shown that BVI students can succeed in science with appropriate accommodations. As Parry, Brazier, and Fischbach (1997) reported, accommodations for a college physics student with BVI included a note-taker during lectures, a lab assistant, a reader for exams, and Braille transcription of some assignments. Cole and Slavin (2013) provided a camera that permitted a physics student with BVI to use his hands while viewing the monitor and independently complete laboratory activities. Carver (1967) reported on a blind college student who independently completed a physics laboratory investigation involving a pendulum and oscilloscope by using a photodetector that converted light levels to audible tones.

Information about the SEADAP participant

Thomas, a legally blind ninth-grade honor roll student, was one of six SEADAP students in the eastern United States. His vision is 20/200 in both eyes with extremely limited peripheral sight. To access classroom print information, Thomas receives school services from a teacher of the visually impaired, an orientation and mobility specialist, and a teacher assistant. He also is served by a vocational rehabilitation counselor through the Division of Services for the Blind.

Thomas worked alone in the afterschool SEADAP program. Although Braille transcription was available through the participating university's resource librarian, Thomas chose not to read information in Braille, saying that he only used Braille for English and social studies classes.

For hands-on science activities, Thomas usually worked in groups, helping group members answer questions about the activity while they completed the hands-on parts. In science classes, Thomas used a MacBook laptop with ZoomText screen-reading software and a video magnifier. He conducted science-related activities in school predominantly on the computer.

Thomas's experiment

Thomas's SEADAP-related investigation sought to determine whether a combination of nicotine and sucrose caused planarians to change their preference from dark environments to light environments by using place-preference conditioning. He also determined whether the motility (movement or locomotion of the organism) and stereotypy (C-shaped or repetitive movements) of the planarians increased or decreased when exposed to nicotine and sucrose and compared those results to those of planarians exposed to just spring water.

Modifications and assistive technologies

Modifications and assistive technologies can help BVI students conduct SEADAP experiments. Students who are completely blind can hear information being read aloud using the software ZoomText and pour liquids and perform liquid measurements using gloves and a liquid indicator. When transferring planaria from the home jar (the container in which the planaria are shipped) to a petri dish, Thomas used a video magnifier and a modified pipette to measure specific amounts of liquids.

ZoomText

ZoomText enhances color, reads words aloud, and enlarges text and the pointer on the computer screen. With ZoomText, Thomas read research literature related to SEADAP, discussion notes he took during SEADAP sessions, and data he recorded for analysis.

Gloves and liquid indicator

All SEADAP investigations require students to fill a petri dish with a liquid. Typically, people with BVI place a finger onto the rim of a container to determine when to stop pouring a liquid before it spills. There are some safety and contamination concerns with this this strategy, however. Thus, Thomas was asked to wear gloves to pour and measure concentrations of sucrose and nicotine solutions that were very low and of low risk to humans (0.5 millimolar [mM] and 1 mM).

Thomas had difficulty putting on laboratory gloves and tried fingernail disposable latex instead, but he could not feel through the latex to determine when to stop pouring a liquid into the petri dish. He found success with an audible liquid level indicator, which played music when the liquid touched the prongs of the device.

Pipette and video magnifier

In all of the SEADAP experiments, planaria must be removed from the home jar. Thomas used a video magnifier to see the petri dish and planaria, and he transferred the planaria (about 1 cm in length) from the home jar into liquid in a petri dish with a pipette. The goal was for Thomas to use the pipette independently. Eventually, the pipette was marked with a black pen, so that Thomas could see planaria being drawn into the pipette. He then successfully placed planaria into the petri dish on his own.

FIGURE 1

Cost of materials for SEADAP investigation and assisted devices.

Item	Cost
One jar of planaria	$10
Pack of 20 petri dishes	$6
Disposable pipettes	$10
Video Magnifier	$2,000 (Seek out assistance of services for disabled or blind to purchase, rent, or borrow this device.)
Audible liquid indicator	$25
Nicotine	$25
Sucrose	$5
ZoomText	$400 (Free 30-day trial available)
Finger gloves	$9

Classroom management

The teacher should prepare solutions, gather all materials the day before the experiment, and make sure the planaria arrive in the mail in time. Figure 1 lists the materials (with costs) for SEADAP experiments and modified and assisted devices for BVI students. The time needed to conduct any experiment will depend on a student's experience with the modifications and technologies. Thomas was able to independently complete a SEADAP-related investigation in about 90 minutes.

Safety

Neither the nicotine solutions nor the planaria should be disposed of down the drain. Planaria should be placed in a sealed container, then in a freezer for 48 hours. Subsequently, the container containing the planaria should be disposed of in a trash receptacle. The teacher needs to make sure students are not allergic to latex before finger gloves are used for any experiment. Disposal of the nicotine used in the experiments must follow the Environmental Protection Agency (EPA) and state and local/school district guidelines for disposal of chemical waste.

Conclusion

A question on a survey administered to all the students conducting the experiments asked: "What is the most positive result of your participation in SEADAP this year?" Thomas replied: "It [was] easier for me to do the experiments with the help of the devices I was given." He reported that he had never before used a liquid indicator or a pipette, which could assist him with making scientific measurements in the future.

Thomas plans to use his video magnifier, a modified pipette, and liquid indicator to conduct science investigations and will participate in SEADAP again. The devices that Thomas used enabled him to conduct science independently and improved his confidence. Notably, Thomas completed the laboratory experiments of his own design and presented his SEADAP research investigation, which addressed the *Next Generation Science Standards* (see box, p. 46), at a local and a regional science fair, where he placed third.

Further, Thomas increased his knowledge about the science of drug addiction and learned how animal models inform medical research. BVI students often miss opportunities to conduct science investigations, though many have a deep interest. As a result, the workforce loses potentially great contributors to scientific fields. Science teachers can provide highly motivated students like Thomas opportunities to meaningfully learn and participate in science, giving them the chance to reach their potential despite their vision problems. ■

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On the web

SEADAP investigation: *http://bit.ly/2jHmR2v*

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Connecting to the *Next Generation Science Standards* (NGSS Lead States 2013).

Standard **HS-LS1 From Molecules to Organisms: Structures and Processes**		
Performance Expectations The chart below makes one set of connections between the instruction outlined in this article and the *NGSS*. Other valid connections are likely; however, space restrictions prevent us from listing all possibilities. The activities outlined in this article are just one step toward reaching the performance expectations listed below. **HS-LS1-2.** Develop and use a model to illustrate the hierarchical organizations of interacting systems that provide specific functions within multicellular organisms. **HS-LS1-3.** Conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence.		
Dimension	**Name and *NGSS* code/citation**	**Specific connections to classroom activity**
Science and Engineering Practices	**Analyzing and Interpreting Data** • Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. **Planning and Carrying Out Investigations** • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-LS1-3)	Student used data to design models using different concentrations of drugs on live planarians. Student used a darkened pipette to capture and transfer worms into petri dishes; this pipette accompanied with the ZoomText (ZT) technology allowed him to more clearly observe the planarian's behavior for the experiment. Student worked independently to plan and conduct trials to record the planarian preference for light in sucrose, nicotine, and sucrose-nicotine mixture for his science fair investigation. Student used liquid indicator to measure spring water, sucrose, nicotine, and sucrose-nicotine mixture in separate petri dishes; student measured motility and stereotypy of planarian groups in these petri dishes to test a hypothesis.
Disciplinary Core Idea	**LS1.A: Structure and Function** • Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.	Student worked independently to conduct trials to record the planarian place of preference for light or dark environments in water, sucrose, nicotine, and sucrose-nicotine mixture for science fair investigation.
Crosscutting Concept	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	Student used statistical data to represent a relationship between the addiction rates and the environments (spring water, nicotine, sucrose, and sucrose-nicotine) that the planarians were introduced to. Using data tables, the student was able to make a claim on the causes and effects of these environments on planarians.