Practice Report

Use of a Video Assistive Device in a University Course in Laboratory Science: A Case Study

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Many countries, including Canada (Government of Ontario, 2005) and the United States (U.S. Government, 2004) have legislated the provision of assistive devices for persons with disabilities during their education and subsequent employment to enable them to contribute more fully to society. The complex visual requirements of the laboratory component of many university science courses require a collaboration between a student with low vision and a particular university science department to determine which devices are appropriate for each student. A number of articles have addressed this issue for physics students who are totally blind and use special hardware (see, for example, Carver, 1967; Parry, Brazier, & Fischbach, 1997; University of Nottingham, 2009; Windelborn, 1999) or software (such as Thompson, 2005). The assistive devices described in those articles allow limited access to certain kinds of experiments, usually in mechanics, but are not applicable in general. In contrast, this article addresses the use of modern video technology to allow a student with low vision to participate almost fully in a standard university science program that includes laboratory experiments.

Case study

A student with low vision (the first author) registered in the introductory physics course at Trent University in the fall of 2009. His Snellen visual acuity fluctuates significantly, with an average acuity of about 20/400. This low acuity presented obvious difficulties for him with the laboratory component of the course, for which he relied on his lab partner for the setup of the apparatus and the collection of data, although he was a full participant in the data analysis. The student then decided to major in Trent's program in chemical physics. Because the required physics labs have visual components, these components needed to be evaluated for accessibility. The available options were to (1) continue relying on sighted classmates as in his first-year course, (2) create a different "theoretical physics" degree program that did not require a laboratory component, or (3) work with the student to find assistive technology that would allow him to participate in a meaningful way in setting up equipment and recording data. The student and the department agreed that familiarity with laboratory equipment and the skill in recording data properly were desirable benefits ensuing from the laboratory component and that would be expected by an employer of a physics or chemistry graduate, so the third option were the best one if it was possible. Even if the student continued into theoretical areas, laboratory experience would assist him in relating theory to an experiment.

Selection of the assistive device

Without an assistive device, the student could see the outline of a power supply or a signal generator but could not tell them apart visually or see the gradations on the dials. He could not select the voltage, current, or resistance on a digital multimeter or its banana-plug holes in which to insert patch cords. He also could not see his hands well enough to insert the patch cords even if he could have seen the holes. Thus, he could not assemble equipment, view physical results, or read meters to take data. For example, in the classic

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e/m (electron charge-to-mass ratio) experiment, he could not see the circular path of an electron beam in a magnetic field as evidenced by the faint glow from the excited mercury vapor or the pins that fluoresce, when struck by the beam, that determine the radius of the beam. To participate fully in an undergraduate experiment, he was required to see well enough to do all of these tasks while having his hands free to manipulate the equipment. The assistive device described here satisfied all these requirements.

The student chose the Acrobat Panel and Long Arm (Enhanced Vision Systems, United States) for assessment. The weight is 3.5 pounds (1.6 kilograms) for the camera, long arm, and clamp, and 8 ounces (0.2 kilogram) for the USB bridge, including the battery. The monitor weighs 17 pounds (7.7 kilograms), but the student did not carry it with him, as is discussed later. All this equipment was purchased using a Bursary for Students with Disabilities provided by the Ontario government. The student has used it for 2.5 academic years of study. Similar electronic magnifiers are available from other suppliers.

The Acrobat Panel is a 19-inch LCD monitor, and the Long Arm is an articulated arm that carries an autofocus video camera at its end. The arm allows the camera to be positioned anywhere in a 60-centimeter (about 24-inch) radius, and the camera can enlarge up to 72 times using a remote control. It can focus on objects from a few centimeters to about 50 meters (about 55 yards) away. The controller also provides 7 viewing modes to optimize contrast and brightness.

Operation of the device

Once in position, the camera could be locked and would maintain its position, focus, and magnification. Therefore, it allowed the student to perform tasks with his hands while viewing the monitor. The enlarged image was displayed on the LCD monitor; however, any display with a standard yellow video input, such as most televisions have, could be used. The camera contains three built-in "views"—the distance view, reading mode, and self-view—which are selected automatically by the position of the camera.

The distance view is used for objects at a distance of more than 50 centimeters (about 20 inches). The camera is automatically set to the distance view when it is pointed within an angle of roughly 45 degrees above or below a plane parallel to the surface on which it is attached (hereafter referred to as the "horizontal"). In this setting, the camera can be used to zoom in and focus on any object within its line of sight. It has been used to read material on a chalkboard at a distance of a few meters, as well as computer monitors, dials, and measurement displays at closer distances. A good example was during a freezing-point depression lab in which the assistive device was used to read a nondigital thermometer roughly 1 meter (39 inches) away so as to record the temperature of a substance at one-minute intervals with an accuracy of $\pm$ 0.05 degrees Celsius. A magnifying lens was provided to other students who were performing the experiment to read the thermometer more clearly, but it was not necessary to use additional magnification when using the Acrobat. At the operating level of magnification, the spacing between each 0.1 degree marker was roughly 1.5 centimeters (about 0.6 inch) on the viewing screen, while the whole-degree number markers were 2 to 3 centimeters (about 0.8 to 1.2 inches) apart.

Figure 1 shows the assistive device being used in the distance view during a titration. The Long Arm with the attached video camera is seen in the foreground. The student is adjusting the position of the stop-cock of the burette, and the camera is focused near the meniscus of the liquid in the burette. The gradations of the burette are seen on the LCD screen at the left of Figure 1, with the fluid meniscus just above the 28-cm^3 mark on the burette.

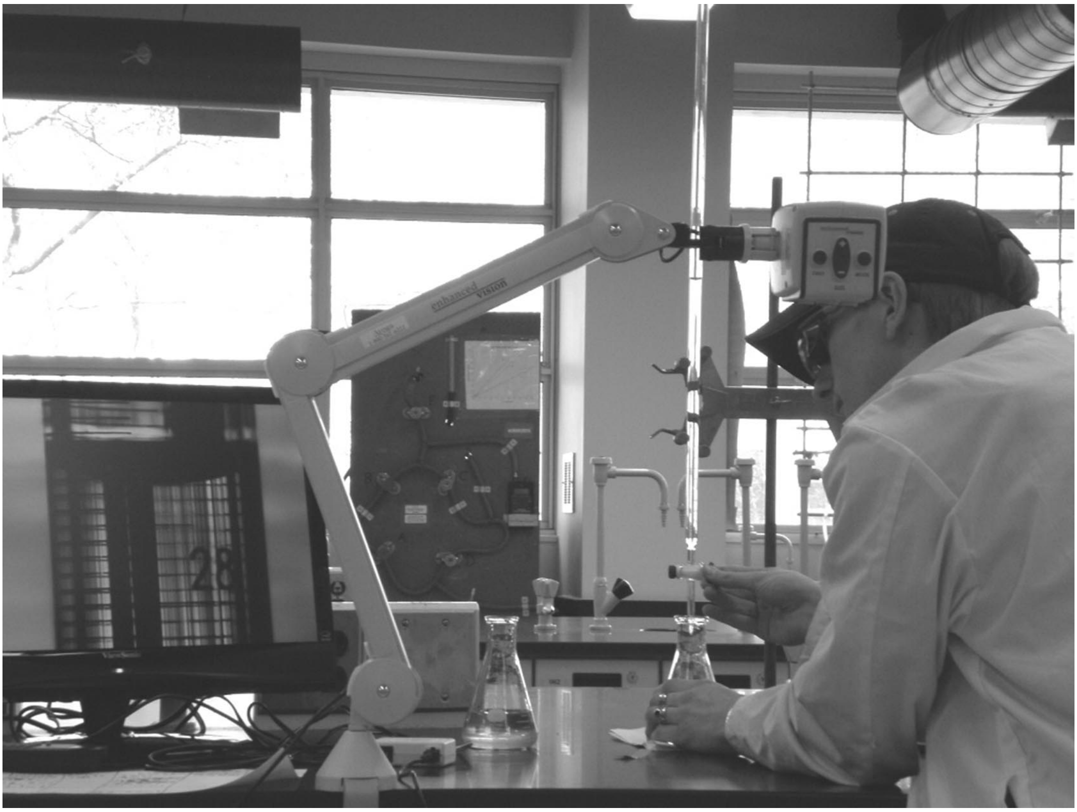

Figure 1. The apparatus being used in the distance view during a titration. The meniscus and the gradations of the burette are seen on the LCD screen at the left.

A significant but initially unanticipated use for the distance view mode of the device was to enable the student to view and record notes written on a chalkboard for the first time. When the camera had to be repositioned for a new task, it automatically focused on the new section without the need to readjust the magnification.

The read mode is used to view objects at a distance of typically less than 50 centimeters. The camera is automatically set to read mode when the camera is pointed within approximately 45 degrees below to 135 degrees below horizontal. In this setting, the camera is typically used to zoom in and focus on nearby objects that the user would like to see or manipulate with his or her hands. For instance, this setting was used to enlarge the type in lab notes or the markings of any piece of equipment, such as a beaker, pipette, voltmeter, or stopwatch, that was held in the user's hands. The camera has an extra reading lens that is folded in front of the camera lens to provide additional magnification in this setting. This lens is not used in the distance view. In practice, the read mode has been used to adjust dials or settings on an assistive device, to make measurements using a graduated cylinder, to place droplets of organic compounds on salt slides, and to enlarge handwritten notes. The stability of the camera allows the user to view a greatly enlarged image of his or her hands and what they are holding. It allows a visually impaired student to perform laboratory tasks independently that otherwise would require assistance.

The self-view is used to view the user operating the assistive device or anything that is located directly behind the camera. The camera is automatically set to self-view when the camera is pointed upside down and within approximately 45 degrees above or below horizontal. In this mode, the camera inverts the image so it is seen the correct way up. The image viewed on the display screen is a mirror image, with anything viewed in the mirror capable of being enlarged. This feature allows the user to zoom in on personal features of himself or herself while also positioning the camera. For example, the user could observe a device that is fastened to him or her, such as a radiation badge.

The USB bridge allows the camera to connect to a standard laptop or desktop computer through its USB port and uses the display of the computer as the viewing screen. It also allows the camera to be battery operated with a battery life of approximately three hours. In this configuration, the assistive device operates exactly as with the monitor with the addition of a few extra features. The computer-viewing screen can be divided to display both the camera images and the computer output, which allows the user to carry out any computer task (typing notes or inputting data) while simultaneously observing what is occurring in the camera's view. Furthermore, an image from the camera can be saved as an image file on the computer or a connected storage device for later study. These features make it possible to observe a chalkboard and simultaneously record personal notes. The image of the chalkboard can be saved at any time for later study or enlargement. In the laboratory, this feature can be used to save physical measurements for later study. For instance, if an experimental record is too small for the user to see even with the assistive device or there is not enough time to adjust the camera, a picture can be taken, and that image can be digitally enlarged at a later time to see the result.

Disadvantages of the device

There are two minor disadvantages to this assistive device. The first pertains to its setup and transportation, while the second concerns problems while using the equipment, as is discussed later.

The setup of this assistive device is straightforward and takes 5 to 10 minutes, depending on the location. The LCD panel requires the entire assistive device to have access to a 120-volt AC outlet. If one chooses a laptop as the display, the assistive device can operate entirely on battery for a maximum of about 3 hours.

This assistive device consists of several separate components, which makes it difficult for one person to carry the entire setup from one place to another. The equipment does not come with a travel case and, although a backpack or laptop bag can be used for the camera, Long Arm, and USB bridge, the LCD monitor is not designed for constant mobility. This problem was largely avoided by using two monitors, one kept in the chemistry laboratory and one in the physics laboratory.

The camera contains an autofocus feature that automatically adjusts the focus for optimal clarity when changing the magnification of the camera. This feature is effective as long as the viewing mode remains unchanged. However, particularly when changing from the distance view to the reading mode, the image sometimes becomes unclear. This problem can be easily rectified by setting the camera to the minimal magnification and then readjusting the magnification. The camera's autofocus feature is also much less effective when one is trying to focus on nearby, semitransparent objects, such as a beaker or glass slide. In such cases, the camera has a tendency to focus on what is behind the object as opposed to the object itself. This situation can be avoided by placing a dark sheet of paper immediately behind the object and readjusting the magnification.

CONCLUSIONS

The assistive device described here allows a student with low vision to participate almost fully and independently in a regular, experimental physics program that is so visually complex that it has hitherto been inaccessible to such students. Not only did it enable the student discussed here to set up the laboratory apparatus himself, it enabled him to read fine measurement devices, such as gauges, micrometers, and burettes. With this device, the student could read from a chalkboard or projection screen and record data or notes from a chalkboard on a computer while viewing the camera output on the same screen. The assistive device was easily and quickly set up. All the equipment except for the LCD monitor was easily transportable, and the monitor was inexpensive enough that a duplicate could be used to avoid transportation over long distances.

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