

CHAPTER 9

The Virtual Science Classroom

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If virtual schooling has not already come to your school, it likely will soon. High schools throughout the world are increasingly providing courses in the physical, chemical, and biological sciences that are delivered in whole or in part by web-based distance learning technologies. These courses provide a unique opportunity for students to learn science at an accelerated pace or get a second chance at a course in which they may have failed or done poorly. Virtual schooling also offers students the opportunity to enroll in a science course not taught at their home school or school district, interact with expert instructors in a particular field, and gain access to subject matter they may have otherwise missed because of personal or instructional situations (i.e., teenage moms, home-schooled students, expelled students, etc.). The current interest in virtual schooling is intense, particularly because it is seen by some as a vehicle for increasing graduation rates and reducing dropout rates (Web-Based Education Commission 2000).

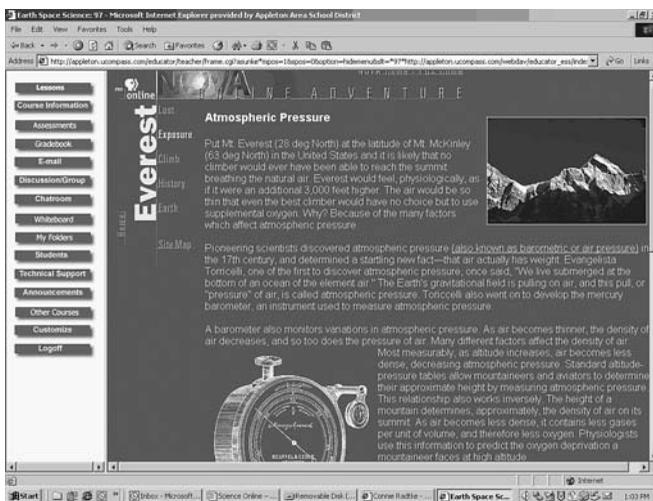
Those who question the reality of the virtual schooling movement need only to look at the current enrollments across the United States. Virtual High School (www.govhs.org), which began in 1996, now has over 200 online courses and 300 member schools, represented by 27 states and 24 international schools. Florida Virtual School (www.flvs.net), which started in 1997, served over 20,000 students in 2004–05. Furthermore, in 2005, the U.S. Department of Education estimated that 36% of school districts have students enrolled in distance education courses.

Many states have taken the lead by supporting statewide virtual school initiatives, while other states are leaving it up to individual schools or school districts to decide if and how to develop virtual schooling. As a consequence, high school teachers across the United States and around the world are now (or will soon be) exploring how to provide access to science for all students regardless of personal or institutional contexts or students' specific needs (i.e., remedial or advanced placement).

Virtual science classes typically offer opportunities for learning to take place through individual review of online lectures, virtual and at-home laboratory activities, and student-to-student as well as student-to-teacher interaction. Virtual schools are considered flexible because students can access course content 24 hours a day, 7 days a week, and nearly all year round. Students can proceed at a pace comfortable for their learning needs and can choose to engage with online lectures or do laboratories or assignments as they wish. Virtual science courses often integrate electronic resources into the course design that have been found to be effective with science learners. For example, websites that provide visualizations of scientific phenomenon such as remote sensing and image processing information for Earth science students are easy to embed into the online course environment. In a similar manner, any website can be

Figure 1.

Importing web resources into a virtual science course.



brought into a course as a resource for learners. Figure 1 is a screen capture from an online science course that links out to the PBS Online website for a desired resource about air pressure.

What the Research Says

Minimal research has been completed in the area of K–12 online schooling (Cavanaugh et al. 2004). There is evidence to suggest that students score equally well on exams in both virtual classrooms and face-to-face classrooms (Blomeyer 2002). Studies have also found that online courses enhance learner

independence and foster higher-order thinking (Tal and Hochberg 2003). Furthermore, parents report positive perceptions of online courses because they have the ability to access assignments and grades and to be more aware of what tasks the student is completing, allowing the parent to offer assistance and facilitate learning expectations (Chaney 2001).

Being a relatively new phenomenon, virtual science classrooms have not been extensively studied. Questions unique to science education need investigation to determine if virtual science classes are useful for all students. In addition, future research needs to examine how and when various technologies can be useful in the virtual science classroom.

One important finding that has come from the research is the importance of

what is known as *component architecture*. Component architecture essentially refers to implementing online lessons as a collection of smaller modules using a variety of technologies to deliver the content (Ferdig, Mishra, and Zhao 2004). This type of design allows for a more constructivist learning environment, with students having the opportunity to work on their interest areas or to receive remedial support in their specific area of need. The concept gained popularity in the last decade as educators began to discuss the possibility of reusable learning objects. If two different teachers were teaching chemistry online, for example, it would be foolish for each of them to build their own Periodic Table of the Elements. Multimedia Educational Resource for Learning and Online Teaching (Merlot; www.merlot.org) is one example of a repository of reusable learning objects where teachers can share such online content; science simulations, animations, tutorials, and other classroom materials for free.

In this chapter, we examine best teaching practices emerging within this new field and then showcase specific examples of how various technologies are used within virtual science classrooms.

Guidelines for Best Practices

Teaching science online requires a new set of teaching skills, although underlying principles of classroom-based science teaching such as a constructivist philosophy equally apply to facilitating science learning online. For example, both classroom-based and virtual science teachers need to scaffold students' scientific inquiry, set and communicate high expectations, and facilitate tasks that encourage active learning. Yet, new instructional strategies and approaches to teaching also are needed.

(1) Encourage active learning.

Although some virtual schools create their own science courses, a common pattern among emerging virtual schools is to purchase or license courses that have already been developed by existing schools. For example, the Appleton (Wisconsin) eSchool (<http://appleton.ucompass.com>), which began serving students in 2002–2003, provides online science course options that were licensed from Florida Virtual School, as well as courses that were developed locally. Often, courses are designed with activities, projects, lecture, assignments, and examinations in the absence of the actual instructor.

In a good course design, learning expectations are made clear to students, activities and assignments are clearly relevant to all possible students, exemplary course or online resources are built into the course, and appropriate assessment tools are used. Course design also should include clearly stated expectations about how long assignments may take to complete, assignment sequencing, and a calendar or automated reminders about due dates.

Online instructors of many prefabricated courses do not have the advantage of making last-minute changes in lectures, course resources, or assignments. In many courses, decisions about activity structures are made well before a course goes online. As a consequence, many teachers of virtual science classrooms have little control over major course components. But teachers do have flexibility and their pedagogical expertise can shine in the ways in which they foster communication to scaffold student learning.

(2) Encourage teacher-to-student interaction.

Online instructors may be best described as mediators of learning. They understand learning goals for students and provide opportunities for students to reach those goals. In virtual science classrooms, the teacher can structure learning tasks, open discussions with provocative questions, invite student participation, facilitate group collaboration, provide electronic mentoring, point to additional online resources, and structure transitions between learning activities. Many times the teacher's work is done through posts to discussion forums or via e-mail, although most virtual schools also expect teachers to be in regular phone contact with students. Although some online learning environments offer synchronous communications opportunities such as live "chat" or instant messaging, a defining feature in most online learning environments is asynchronicity. With asynchronous communications, students engage with the learning materials at their own pace and interact with peers and instructors via e-mail and discussion boards at a time convenient for their schedules.

Although 24/7 access to instructors via electronic communications is unparalleled, many teachers find that students expect immediate responses to their queries. With experience, online teachers learn to specify or limit the times they communicate via e-mail or web postings. Effective instructor e-mail response policies may include specific guidelines, such as "All posts will be answered within 24 hours on weekdays only." Since most communication is handled through text, effective online teachers develop a consistent style, tone, and format for messages to students.

(3) Encourage student-to-student interaction.

In addition to communications from the teacher, virtual courses often require student cooperation and communication. Student interaction can vary from simple e-mail exchanges between two students in a study group to a series of messages between students engaged in drawing conclusions from an analysis of, for example, an online database of buoy data (e.g., the National Data Buoy Center website at www.ndbc.noaa.gov). A significant task for teachers whose online courses require student-to-student interaction is maintenance of group activities, often requiring

explicit directions to students about how to interact and cooperate asynchronously in order to achieve the specified learning goals.

Teachers should post examples of excellent student discussions and provide feedback to students to help them improve their online discussion abilities. Selecting interaction structures and having a set of teaching strategies that fosters student-to-student interaction is important. Most online learning environments have multiple communication structures available (i.e., public, private, topical grouping, forums, town halls, etc.) The discussion structure chosen should be simple and easy for students to navigate. Teaching strategies such as providing a specific task to focus an online discussion or arranging the discussion like a debate can also help. Since students typically do not have a minimal period of time they are expected to be online, the structure and teaching strategies can keep students engaged until an assignment is completed.

(4) Encourage students to create and collect artifacts.

Creating artifacts (representations of student knowledge and understanding) allows students to learn concepts, apply information, and represent knowledge in a variety of ways. Artifacts represent students' understanding of the problem, their solutions, and the knowledge they gained. For example, in Project-Based Science (www.umich.edu/~pbsgroup), students use scientific tools to manipulate and revise video, audio, text, and graphics in the creation of their artifacts. These artifacts can then be collected in an electronic portfolio, a repository of artifacts representing student knowledge growth over time.

Examples of Best Practice

Active learning, interaction, and artifact creation are all best practice strategies that can be implemented online using various technologies. Perhaps the best way to showcase online science classrooms using those strategies is to present examples of the various components used in such a class. The components in virtual science classrooms include lectures, videos, discussions, inquiry assignments, simulations, and laboratories.

Lectures tend to be text based with a sprinkling of graphics. Often, links are embedded in the lectures to static and dynamic images or external websites with relevant content. These lectures often take the form of recorded PowerPoint presentations, and they can be accompanied by response assignments. One example of the online lecture is the Connecting Concepts project at the University of Wisconsin (<http://ats.doit.wisc.edu/biology/lessons.htm>). These online lessons in biology provide students with text and graphics followed by a table to check their understanding. Lectures can also be delivered via video presentation, which can take the form of

entire lectures or video examples of science experiments. The Vega Science Trust (www.vega.org.uk) has interviews with Nobel Prize winners as well as lectures from eminent scientists. Discovery School's section on Physical Sciences (<http://school.discoveryeducation.com/ontv/videoclips/physicalsci1.html>) has smaller video clips aimed at such things as the elements, force and motion, and the human brain. Steve Spangler Science (www.stevespanglerscience.com/video) has free videos that offer ideas for science lessons. Teachers could utilize shorter or longer clips from these free online resources to supplement their online instruction.

Discussions follow various formats. They can be asynchronous, with students and teachers posting when they have time. Or they can be synchronous, with participants each logging in at the same time. Asynchronous discussions provide an opportunity for questions and answers to be posted for all participants to see. Synchronous chats provide just-in-time support. Both provide opportunities for science teachers to assign group work and to monitor the group interactions. These discussions often take place within the online course. However, teachers may decide to have students connect to participants outside of the classroom. The Science Chat Forum (www.sciencechatforum.com) is an example of a multidisciplinary website for chatting about science topics.

The inquiry assignment is a third component within online classrooms. These assignments provide students with an opportunity to take ownership of asking important questions, investigating solutions, and reflecting on results. Chip Bruce at the University of Illinois has created the "Inquiry Page" (<http://inquiry.uiuc.edu>). These web pages highlight inquiry, but also provide students with a place to post inquiry projects. A science search yields inquiry projects ranging from Biology Workbenches to Biodiversity. A second example of online inquiry, and one that is familiar to most teachers, is the webquest. A webquest is an inquiry activity in which students use the web to provide solutions to suggested problems or questions. Many teachers like webquests because they provide directed web-based activities for students. Webquests can be found at (<http://webquest.org>); teachers can use submitted webquests or they can contribute their own.

Simulations as a fourth component of online science classes are probably the most widely known because teachers use them in both face-to-face and online classes (see Chapter 3). Simulations are different from virtual labs in that labs use simulations and other components to form lessons; simulations are often smaller and more specific explorations.

Laboratories in virtual science classrooms tend to be one of two types: the virtual lab and the at-home lab. One example of a virtual lab in an online science course is shown in Figure 2. In this lab, students are asked to observe a picture of a slide with cells from an onion root. Students are asked to observe and note certain features,

record their observations, and then draw conclusions by answering a series of provided questions. A report is then e-mailed to the teacher for feedback and grading.

Another common laboratory is the type students complete at home with materials found around the typical home. An example is shown in Figure 3. In the Effects of Air Pressure lab, students are provided with instructions to perform an investigation using a soda can, stovetop, and other household items. Students conduct the activity independently, answer the questions, and submit a report.

Other possible formats for laboratory investigations are possible, but not generally seen in virtual science classrooms to date. Teachers who have the flexibility to alter course assignments and designers of new virtual science classes may want to consider strategies such as having students share data collected individually and prepare a group report that clearly uses data to support conclusions or having them access existing data from a website.

Conclusion

Although one of the greatest benefits to virtual science courses is the access it provides to students, some caution is warranted. Students who are science-phobic, have limited English language abilities, or require accommodations for specific disabilities will need special attention if they are to be successful in virtual science classrooms. In the NSTA position statement, “Gender Equity in Science Education,” science teachers are admonished to “select only those curriculum materials that present culturally diverse male and female role models working in all disciplines

Figure 2.

Example of a virtual lab in an online science course.

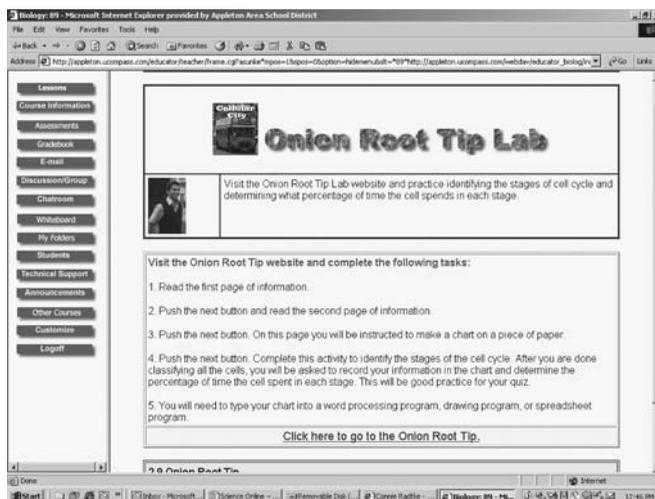
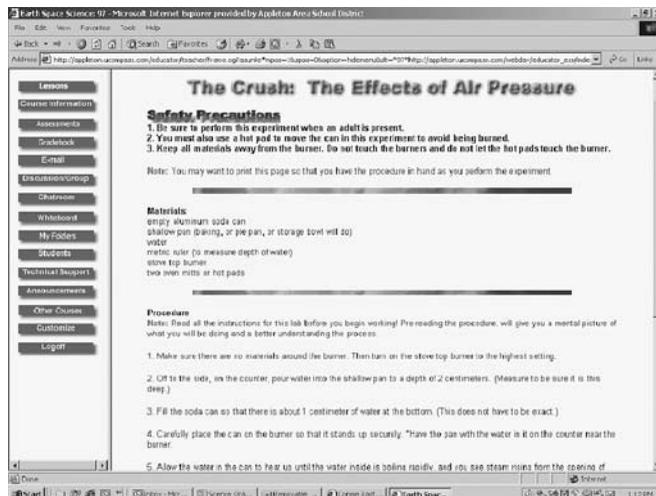


Figure 3.

Example of an “at home” laboratory.



and at all levels of science.” To make science content accessible for all students enrolled in a virtual science course, the teacher may need to add or change curriculum materials, online course resources, or links to external websites that are not accessible to students with specific disabilities. Such an act is not easy in most virtual school environments.

The current virtual science teacher usually has more control of communications methods than actual course content. It is critical, therefore, that teachers master the discussion and communications tools in the online learning environment and know how to use those tools to create accommodations that will reach all learners. By posing higher-order questions, facilitating dialogue, and finding or creating accessible learning materials that meet individual learner needs, instructors can be successful in helping all students of virtual science classes become most successful.