Policy Brief

Finance / High School—Graduation Requirements

Education Commission of the States • 700 Broadway, Suite 1200 • Denver, CO 80203-3460 • 303.299.3600 • Fax: 303.296.8332 • www.ecs.org

What Policymakers Need to Know About the Cost of Implementing Lab-Based Science Course Requirements

By Mike Griffith

June 2007

An increasing number of states have required that some – or all – Carnegie units in science for high school graduation be fulfilled by lab sciences. This policy brief examines:

- The research that supports implementing lab science requirements (as opposed to general science requirements) for high school graduation
- The number of states requiring science lab credits for high school graduation
- The costs associated with fitting schools with science labs – in terms of capital, equipment, operations, maintenance and other needs
- The alternatives to traditional labs, including portable labs, virtual labs and other options – and their respective benefits and disadvantages in terms of cost, space, teaching staff needs and student learning.

Lab experiences can vary by subject (biology, chemistry, physics, and other earth and life sciences), and can include many different types of activities. Two main concerns, however, should be at the forefront during the design, construction and outfitting of any lab: Will the lab allow each student to further his/her knowledge of science; and, is the lab safe for students and teachers? Policymakers, in considering both these questions, must consider the issue of cost. The following policy brief should help policymakers weigh the cost of implementing increased lab-based science courses.

Lab Courses Support College Readiness and Completion

There are various reasons behind state decisions to require all students to complete units in lab science rather than general science. These include:

1. Research on college readiness

Three ACT reports, "On Course for Success," "Crisis at the Core" and "Courses Count: Preparing Students for Postsecondary Success," examined the knowledge and skills students need to obtain in high school to be ready for postsecondary education. These reports suggest students who complete a series of lab sciences – biology, chemistry and physics – earned the ACT scores most closely associated with college readiness.[1]

2. Research on persistence to and completion of a bachelor's degree

Two Clifford Adelman studies – 1999's *Answers in the Toolbox* and 2006's *The Toolbox Revisited* – sought to identify the academic and other factors most closely associated with students' likelihood of earning a high school diploma, entering a postsecondary education program and completing such a program within a set number of years. Both studies found students whose high school coursetaking included more than two units of core lab science (biology, chemistry, physics) or two and a half units or more of all science, were most likely to earn a baccalaureate degree in the set number of years. Adelman notes in the 2006 update that this is a minimum – those students "at the highest level of academic curricular intensity" had completed an average of "3.63 units of core laboratory science..."

In addition, the 2006 *Toolbox* study considered three variables – Advanced Placement coursetaking, Carnegie units earned in foreign languages and "momentum in science" (a combination of highest math course taken with Carnegie units earned in core laboratory science). Of these three, only the science momentum proved to be statistically significant. Yet 34.3% of the students in the cohort studied in the 2006 report had taken *no more than 1 year of core lab science*. Adelman notes in the original *Toolbox* report: "[T]here is no reason why all students cannot reach the highest levels of the curriculum scale – at which point, of course, the scale itself can be abandoned. This ideal state will not come to pass without ensuring opportunity-to-learn, and, at the present moment, not all secondary schools can – or do, or will – provide that opportunity ... Many cannot offer the three basic laboratory sciences ... Poor and working-class students, students from rural areas, and minority students are disproportionately affected by this lack of opportunity-to-learn."[2]

Where States Are

Twenty-two states and the District of Columbia require or plan to require students to pass science courses with a laboratory component for high school graduation. As of June 2007, the following states require that students fulfill some or all of science requirements for high school graduation with lab courses:

1 lab: District of Columbia, Idaho, Kansas, Maine, New Mexico, New York, Washington
2 labs: Florida, Indiana, Maryland, Rhode Island, South Dakota
3 labs: Georgia, Tennessee, Virginia, West Virginia

The following states will implement or increase requirements effective with future graduating classes:

1 lab: Mississippi (2012)
2 labs: Idaho (2012), New Mexico (2013), Oregon (2012), District of Columbia (2011)
3 labs: Arkansas (2010), Delaware (2011), Indiana (2011), Kentucky (2012), Michigan (2011), Ohio (2014), Oklahoma (2010), South Dakota (2010)[3]

An increasing number of states plan to require all students to complete chemistry and physics, making necessary additional costs for gas lines into schools, hazardous chemicals, fume hoods, sinks and waste disposal. In contrast, biology is often taught in a classroom environment requiring relatively little lab equipment.

Science Labs Should Provide a Quality Learning Experience

In its simplest terms, a high school science lab is a room in which a student is able to gain hands-on experience in science. Courses in biology, chemistry, physics and even nutrition all require different equipment and materials to allow students to gain valuable experience. While sufficient space for different types of science courses might be found certain public schools (i.e., in older buildings, schools with declining enrollments and wealthy suburban schools), for the purpose of this policy brief it will be assumed that relatively few public schools have the space and funding available for separate labs for each type of science class taught. In this paper it will also be assumed that a high school laboratory space will be designed and equipped to allow students to carry out a range of scientific laboratory experiences.

What Should Students Learn in Science Labs?

Research has shown that many students' science lab experiences produce mixed results. Optimally, the National Research Council claims, a laboratory experience should produce the following result for students:

- Enhance mastery of subject matter
- Develop scientific reasoning
- Allow the student to understand the complexity and ambiguity of empirical work
- Develop practical skills

- Gain an understanding of the nature of science
- Cultivate an interest in science and in learning science
- Develop teamwork abilities.

Potential Costs: What Else Do Policymakers Need to Know?

While research supports the positive student outcomes of lab-based science courses, policymakers need to weigh a number of factors in order to determine the true costs of implementing lab science course requirements for all students. Among these factors are safety concerns and costs, and capital, equipment, operations and maintenance costs.

1. Safety Concerns and Costs

When equipping and maintaining a science lab, high schools must take into account specific safety issues, including broken glass, sharp instruments, possible electric shock, eye injury, inhaling or ingesting hazardous chemicals, the risk of fire, and even risks that can arise from working with animals or their remains.[4]

The issues of dealing with broken glass, sharp instruments, electrical shock and working with animals, alive or dead, can be addressed by having teachers and students take greater care in the laboratory area, resulting in little to no extra cost for schools. To prevent eye injuries, students and teachers should be equipped with either eyewear designed for impact safety (approximately $4 apiece) or goggles designed for protection against chemical splashes (about $8 apiece), depending on the type of experiments students will be conducting. Every lab should also be equipped with an eyewash station – either a portable station (approximately $200) that needs to be refilled with eyewash solution or an attached unit (approximately $350) that is connected to the lab's water system.

The lab safety issues that produce the highest cost for schools are those centering on hazardous chemicals and potential fires. Lab materials are defined as hazardous if they are radioactive, carcinogenic, flammable, or contain heavy metals or biological contaminates.[5] Hazardous materials must be disposed of according to local, state and federal rules and regulations.[6] School administrators should contact their state's Environmental Protection Agency branch for the proper disposal of any hazardous chemicals in their labs. According to the National Academy of Sciences, 88 common hazardous chemicals are used in high school science labs, each with specific requirements for their proper storage, usage and disposal (For a full description on the safe use of each of these chemicals, see Laboratory Chemical Safety Summaries from the Howard Hughes Medical Institute.)[7]

Flammable chemicals should be stored properly in a fire resistant cabinet and, when in use, should be kept away from open flames. A lab should be equipped with a fire blanket, as well as fire extinguishers capable of handling fires caused by ordinary combustibles, flammable liquids or electrical equipment. (Each extinguisher costs between $40 and $100 depending on their size.)

At a minimum, a high school science labs need to be outfitted with a lockable fire resistant storage cabinet (approximately $500 for a mid-sized cabinet) that can be secured to a classroom's walls or floors. Some chemicals require storage in a ventilated area, while others need to be kept below room temperature – obviously, storage of these chemicals brings with it additional storage costs. A lab housing hazardous chemicals likewise needs fume hoods (ductless fume hoods start at $1,400), protective clothing and rubber gloves. While some chemicals can be disposed of in the lab's drain or the trash, hazardous materials require more complicated disposal systems, which may incur further costs.

2. Capital, Equipment, Operations and Maintenance Costs

When contemplating adding laboratory space, a school or district must consider capital, equipment and operational costs. Capital costs are defined as expenditures needed to build a new facility or to reconstruct a current space so it may be used a laboratory. Equipment costs can include large purchases such as specialized computer equipment, or smaller purchases such as Bunsen burners and test tubes. Operational costs include all ongoing costs of operating a science lab program, including the purchase of chemicals, the proper disposal of hazardous material, and the cost of providing training to teachers and/or laboratory technicians. Below is a more detailed description of the types of costs of developing and operating science labs.

Capital

A properly constructed science lab costs between 70 and 100% more than a traditional classroom due to two factors: the greater square footage required per student than in traditional classrooms, and building requirements for labs that exceed those for traditional classrooms. These building requirements can include:

- A ventilation system that is separate from the school's system
- Additional water and electrical outlets
- Data lines
- A source of natural or propane gas
- Fire retardant wall coverings, flooring, countertop spaces and cabinets
- Insurance

A separate ventilation system for a lab ensures that any smoke or hazardous fumes will not be spread throughout the school.[8] A science lab requires additional water outlets not only for sinks but also for safety features such as eyewashes and fire suppression. Labs require a safe source of either natural or propane gas to provide fuel to Bunsen burners. Student areas with electricity, gas or water outlets should also be equipped with emergency shut-off controls readily available to the instructor but not easily accessible by students.

Given the sudden growth in certain districts and states, as well as the practice of establishing charter schools in buildings that need to be renovated, policymakers must also consider the cost of retrofitting existing space to add science labs. The cost of renovation will vary based on individual needs. One model other states may consider is that set in 2007 Texas H.B. 2237 (currently pending the governor's approval), which creates a new program offering districts competitive grants of $200 per square foot for science lab construction, or $100 per square foot for science lab renovation.[9] A 2005 report by the National Academy of Sciences notes, however: "Because of the expense of constructing or renovating laboratory space, the design should be future-oriented, supporting a vision of the science program over a decade or more."[10]

The Proper Size and Design of a Lab

1. Size: To ensure a quality laboratory experience, and to promote safety, the National Science Teachers Association (NSTA) recommends labs contain no more than 24 students per teacher. As for classroom dimensions, the NSTA recommends at least 45 square feet per student for a stand-alone laboratory and 60 square feet of space per student for a combination laboratory/classroom.[11] The NSTA has found that classes above this size result in a reduction in the quality of the students' experience and an increased risk of injury to students and teachers. Using the NSTA standards, the maximum size of a combination lab/classroom science lab (the model in which the majority of U.S. high school students receive lab instruction), with one teacher in attendance, would be 1,440 square feet. It would be possible to provide a laboratory experience with a greater number of students if additional teachers, or lab assistance, were present in the lab. For each new student added, however, there would have to be an additional 60 square feet of lab space available. Thus, two teachers, or a teacher and a lab assistant, can supervise a laboratory experience of up to 48 students, but the lab would need to be at least 2,880 square feet to meet NSTA standards.

2. Design: According to an NSTA safety checklist, every science lab should have two exits.[12] Exits should be positioned a minimum of 10 feet from any fume or exhaust hoods, and should be at least five feet wide to allow for disabled students, equipment carts and emergency exits. Doors should be equipped with locks and reinforced glass viewing windows or peepholes. Rooms should not have blind spots where students can work unobserved.[13] Windows should be situated on exterior walls and have covers allowing the room to be darkened.[14]

Many sources encourage high school science labs to include a preparation room ("prep room") that is separate from the chemical storage room and adjacent to up to two or three laboratories, primarily for instructors to prepare materials prior to experimentation or demonstration. Just as with a standard laboratory, prep rooms should be equipped with a workspace, fume hood, ventilation system, exhaust fan, fire extinguisher, utility cutoff and emergency exits, as well as eye/face wash stand and safety shower for those prep rooms where hazardous chemicals will be manipulated.[15]

How Many Science Labs Does a High School Need?

The following two scenarios use NSTA standards to determine how many science labs a high school with 1,000 students would need. (Each scenario assumes a school has five learning periods per day):

- **50% of the students enrolled in science classes with two lab experiences per week**: The school would require at least 2,880 square feet of lab space – which would be in use for about 85% of the school day.
- **50% of the students enrolled in science classes with three lab experiences per week**: The school would require at least 4,320 sq. feet of lab space – which would be in use for about 85% of the school day.

To answer this question, decisionmakers must additionally consider the question of sharing facilities. Will biology, chemistry, and physics all be taught using the same labs, or will rooms be designed for one discipline or a pairing of these disciplines (i.e., physics/chemistry or biology/physics)? It may be helpful for one or more labs to be dedicated to biology, with chemistry and physics sharing lab space, given that (1) more students generally take biology than chemistry or physics and (2) biology labs do not require the infrastructure needed to ensure a safe environment around the hazardous chemicals used in chemistry experiments. On the other hand, labs designed for teaching both biology and physics provide extra room to accommodate chemistry labs' equipment and storage needs. In either case, designing science labs to accommodate more than one science discipline helps prepare students for undergraduate science labs, which are becoming increasingly interdisciplinary.[16]

Equipment & Supplies

The equipment and supply needs of a high school science lab can be broken down into three basic groups: (1) those items that need constant replacement, such as chemicals used in experiments; (2) those items that do not need constant replacement but have a relatively short life span, such as test tubes and beakers; and (3) those pieces of equipment that have a longer life span, such as microscopes, storage cabinets and computer work stations. The following is a list of the higher cost items that labs should contain:

- Common lab equipment such as Bunsen burners, digital thermometers, microscopes and spring scales
- Advanced equipment which could include digital balances, chromatography instrumentation or spectrometers, etc.
- Computer work stations that add to the lab experience and have the ability to handle any additional computing needs
- Safety equipment such as eyewashes, fire extinguishers and fume hoods.

Operations & Maintenance

The additional operations and maintenance costs that science labs incur over traditional classrooms include:

- Teacher training
- The safe storage and disposal of hazardous chemicals
- Routine maintenance on lab equipment
- Potential hiring and training of a lab technician.

Alternatives to Traditional Labs

Having a fully equipped stand-alone laboratory may not be an option for every school, due to a lack of funding, space or qualified teaching personnel. For schools that cannot afford their own laboratories there exist several other options:

- Using current classrooms as joint classrooms/lab spaces
- Multiple schools sharing laboratory space
- Making use of portable labs
- Virtual labs.

While each of these options can be more cost effective than traditional stand-alone labs, each carries with it certain aspects that may negatively impact the quantity and quality of the learning experience for students. Each option is described in further detail below.

Joint Lab/Classroom Space

More than half the students in the country receive their laboratory experience in a room that functions as both a traditional classroom and as a science lab. This solution is most often used in schools lacking sufficient space for separate stand-alone science labs. While there is nothing wrong with combining traditional classrooms with science labs, these rooms still need to meet NSTA requirements, chiefly, the necessary square footage in the lab area and health and safety requirements.

Shared Lab Space

Some schools have chosen to share lab space with other schools within or outside of their district. Sharing lab space can be extremely cost effective for schools lacking the funding or space to offer the full science lab experience. While on paper this appears to be an ideal solution, many schools are prevented from sharing their lab space due to a few practical questions, namely:

1. Where will the lab be located?
2. Who is responsible for running and maintaining the lab?
3. How will students be transported to and from the lab?

A shared lab may be located at a high school, a building run by a school district or even by a third party – but each of these options raises the questions above. The section that follows describes various types of shared labs, along with their benefits and drawbacks.

Shared Labs Located at a High School

A high school may allow students from other schools to use its lab space, thus sharing the cost. The shared lab is run by the home school and is tailored to that school's science standards. The visiting school pays some form of rent for their use of the lab space. This system of shared space works well for the school where the lab is located – it allows them to continue their program and offset their cost with revenue from the visiting school. The system can also work well for the visiting school as long as it has similar laboratory needs to the school where the lab is located and are provided sufficient lab time.

District-Run Shared Labs

District-run labs may be housed in a school or a separate district building. These labs are funded and run by the district to meet its science standards. As long as the district is able to provide sufficient space and staff, district-run shared labs can reduce cost and provide students with a quality lab experience that they would probably be unable to enjoy in their individual schools.

High School Science Labs Run by Third Parties

Some shared lab spaces are run by an entity other than a school or district – most commonly a local two- or four-year college that rents its space to a local high school, saving the high school construction and operational costs. This type of system can be especially attractive to small schools/districts with relatively few students taking science classes with laboratory requirements. The problems that may arise with a lab run by a third party include a potential lack of available lab time, and the fact that the lab may not meet the schools specific needs and standards.

Shared Labs and Transportation

The one issue all shared science lab programs face is transportation. Even a school with a single class utilizing a shared space must organize transportation to and from the lab at least twice a week. A large school might have to transport multiple science classes to and from the lab at several points during the day. Not only is there a cost involved in creating a transportation plan, but a school must also determine how much of the school day students will miss while attending the labs – and what to do about this missed time.

Portable Labs

Many school districts, especially those in rural areas, are turning to portable labs to provide students with a science lab experience. These labs are usually run by a university, community college or government lab, and are contained within a truck trailer so they can be easily moved from school to school. Their popularity has grown to the point that there is now a Mobile Lab Coalition connecting mobile lab programs in eight states.[17] The issues that arise from the use of mobile labs include:

- **Lack of lab time for students**: Most mobile lab programs visit each school only once during the school year. The MdBioLab program can make a one-week visit to up to 32 high schools each school year.[18] While these visits do provide students with a lab experience that they might not otherwise have obtained, it does not come close to allowing students to have the recommended two or three science lab experiences each week.
- **Lack of space**: Most portable labs range from 30 to 54 feet in length. The Connecticut Bio Bus program operates a mobile science lab for up to 24 students out of a converted 40-foot school bus – with less than 20 square feet of work space per student, only about a third of the amount of recommended space per student.[19]
- **Difficulty coordinating the school curriculum with these limited labs**: Most mobile lab programs have pre-set courses that may or may not be aligned to a school's science curriculum.

Virtual Science Labs

With advances in computer hardware and software, it is now possible for schools to provide a laboratory experience in a virtual environment, allowing students to mix chemicals, dissect frogs and even manipulate the earth's environment on their desktop computer.[20] There is currently a debate in the educational community if virtual labs can provide students with the same experiences as traditional labs. Some limited evidence suggests virtual labs may be as effective as traditional labs – but there is not yet conclusive evidence to prove this point.[21] A number of educational organizations, such as The College Board, have recently begun to accept that some virtual labs can be as effective in teaching students as traditional labs.[22]

While there is still debate about the overall quality of the virtual lab experience, there is no debating that they produce a cost savings over traditional labs. Some virtual laboratories, such as the University of Virginia's, can be accessed for free over the Internet, while more advanced virtual lab programs can cost up to $6,000 per classroom.[23] The more advanced programs allow teachers to form their virtual laboratory experiments around the school's curriculum and their students' skill levels, whereas the free programs tend to lack any flexibility on how they are carried out. Virtual labs do not require the physical space traditional labs do, and most can operate off existing classroom computer systems. Thus these labs can produce both a savings in operational cost and can free up the classroom space (up to 1,440 sq. feet per lab) required by traditional labs.

The Future of Science Labs

As states and school districts increase their science requirements, there will be a growing need for quality lab experiences for all students. While at this time the traditional lab experience appears to provide the highest-quality experience, a lack of financial resources, staffing or space may limit traditional lab offerings, particularly in small or lower-resource schools.

While each of the alternatives to traditional labs has its benefits, virtual labs likely hold the most promise. They can be accessed at multiple times during the week – unlike mobile or shared labs. They do not have the equipment and materials costs of classroom labs, nor the transportation requirements of shared labs. While today's virtual labs may not produce the same student learning results as traditional labs, the speed with which technological advances are being made suggest that in the near future, virtual labs will be as effective – and much more cost-efficient – than traditional labs. State and local decisionmakers may wish to take this into account before expending precious educational resources on the construction or renovation of traditional labs.

Michael Griffith is a school finance analyst with the ECS Clearinghouse. He can be reached at mgriffith@ecs.org.

[1] ACT, Inc. and The Education Trust, *On Course for Success.* [report online] (ACT, Inc. and The Education Trust, 2004, accessed 5 June 2007); available from ACT: http://www.act.org/path/policy/pdf/success_report.pdf; Internet; ACT, Inc., *Crisis at the Core: Preparing All Students for College and Work*. [report online] (ACT, Inc., 2005, accessed 5 June 2007); available from ACT: http://www.act.org/path/policy/pdf/crisis_report.pdf; Internet; ACT, Inc., *Courses Count: Preparing Students for Postsecondary Success*. [report online] (ACT, Inc., 2005, accessed 5 June 2007); available from ACT: http://www.act.org/path/policy/pdf/CoursesCount.pdf; Internet.

[2] Clifford Adelman, *Answers in the Tool Box: Academic Intensity, Attendance Patterns, and Bachelor's Degree Attainment.* [report online] (Washington, DC: U.S. Department of Education, 1999, accessed 5 June 2007); available from the U.S. Department of Education: http://www.ed.gov/pubs/Toolbox/index.html; Internet; Clifford Adelman, *The Toolbox Revisited: Paths to Degree Completion from High School Through College.* [report online] (Washington, D.C.: U.S. Department of Education, 2006, accessed 5 June 2007); available from the U.S. Department of Education: http://www.ed.gov/rschstat/research/pubs/toolboxrevisit/toolbox.pdf; Internet.

[3] Jennifer Dounay, *High School Graduation Requirements: Science.* [report online] (Denver: Education Commission of the States, accessed 5 June 2007); available from ECS: http://mb2.ecs.org/reports/Report.aspx?id=902; Internet.

[4] Utah Department of Education Web site, *Science Lab Safety Rules*. Accessed 5 June 2007: http://www.usoe.k12.ut.us/curr/science/sciber00/safety/Rules.htm

[5] Cornell University Web site, *Environmental Health and Safety: Acutely Toxic Chemical List*. Accessed 5 June 2007: http://www.med.cornell.edu/ehs/forms/acute_waste_codes.pdf

[6] Cornell University Web site, *Drain and Trash Disposal of Chemicals*. Accessed 5 June 2007: http://www.med.cornell.edu/ehs/updates/drain_trash.htm

[7] Howard Hughes Medical Institute Web site, *HHMI Laboratory Safety Program: Laboratory Chemical Safety Summaries: Limitations*. Accessed 5 June 2007: http://www.hhmi.org/research/labsafe/limits.html

[8] Massachusetts Office of Health and Human Services Web site, *Indoor Air Quality*. Accessed 5 June 2007: http://www.mass.gov/?pageID=eohhs2subtopic&L=6&L0=Home&L1=Consumer&L2=Community+Health+and+Safety&L3=Environmental+Health&L4=Environmental+Exposure+Topics&L5=Indoor+Air+Quality&sid=Eeohhs2

[9] 2007 Texas H.B. 2237, accessed 15 June 2007: http://www.legis.state.tx.us/tlodocs/80R/billtext/pdf/HB02237F.pdf

[10] Susan R. Singer, Margaret L. Hilton, and Heidi A. Schweingruber, Editors, *America's Lab Report: Investigations in High School Science.* (Washington, D.C.: National Academies Press, 2005), 170

[11] *Ibid.*, 183.

[12] National Science Teachers Association Web site, "Take a Walking Tour for Safety," accessed 15 June, 2007: http://www.nsta.org/pdfs/SafetyTour.pdf

[13] Council of State Science Supervisors Web site, "Science and Safety: Making the Connection," accessed 15 June, 2007: http://www.chemis.pei.edu/CHEMIS/scisafe.pdf

[14] Science TEKS Toolkit Web site, Texas K-12 science facilities standards, Appendix III, accessed 15 June, 2007: http://www.utdanacenter.org/sciencetoolkit/downloads/safety/facilities/08_appendix_c.pdf

[15] 19 TEX. ADMIN CODE § 61.1036(C)(vi); Science TEKS Toolkit Web site, Texas K-12 science facilities standards, Chapter 5, Safety, accessed 15 June 2007: http://www.utdanacenter.org/sciencetoolkit/downloads/safety/texas_safety/chapter5.pdf

[16] Susan R. Singer, Margaret L. Hilton, and Heidi A. Schweingruber, Editors, *America's Lab Report: Investigations in High School Science.* (Washington, D.C.: National Academies Press, 2005), 171

[17] Mobile Lab Coalition Web site, accessed 6 June 2007: http://www.mobilelabcoalition.org/

[18] MdBioLab Web site, accessed 6 June 2007: http://www.mdbiolab.org/

[19] Connecticut BioBus Web site, accessed 6 June 2007: http://www.ctbiobus.org/

[20] The ChemCollective Web site, accessed 6 June 2007: http://www.chemcollective.org/applets/vlab.php; NetFrog 2002 Web site, accessed 6 June 2007: http://frog.edschool.virginia.edu/Frog2/; sciencecourseware.org Web site, *Virtual Courseware: Global Warming*, accessed 6 June 2007: http://www.sciencecourseware.org/eec/GlobalWarming/

[21] Marcel Satsky Kerr, Kimberly Rynearson, Marcus C. Kerr, "Innovative Educational Practice: Using Virtual Labs in the Secondary Classroom," *The Journal of Educators Online,* 1, no. 1, (2004): http://www.thejeo.com/Kerr%20Final.pdf

[22] College Board Web site, Online/Distance Learning AP Courses, accessed 6 June 2007: http://apcentral.collegeboard.com/apc/public/courses/teachers_corner/51274.html#nameHands

[23] The University of Virginia Virtual Lab, accessed 6 June, 2007: http://www.virlab.virginia.edu/FS/home.htm