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ABSTRACT

This paper discusses the components of key spaces found within elementary and secondary school science facilities, and highlights the common design features that facilitate quality science instruction in these areas. Three educational trends that have shaped today's school science education are also examined. Common design features highlighted involve the promotion of safety, the integration of the natural environment into the classroom, and the fostering of curiosity and creativity. (Contains 13 references.) (GR)

Science Facilities

National Clearinghouse for Educational Facilities

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The late astronomer Carl Sagan once said, "everybody starts out as a scientist. Every child has the scientist's sense of wonder and awe" (CSMEE 1998: 1). The science classroom is no longer simply a place where students become literate in key scientific concepts and terms, but rather a place to leam how to ask questions, test hypothesis, and convey ideas and information. To accommodate these activities, science facilities are being designed that promote in-depth leaming, foster curiosity, and enhance the interrelationship between science and the greater environment.

Educational Trends

The National Research Council's National Science Education Standards state that science education "should be developmentally appropriate, interesting, and relevant to students' lives; emphasize student understanding through inquiry; and be connected with other school subjects" (National Research Council 1995). This description captures much of the change affecting science education and its impact on facilities design. Three educational trends specifically affect science education.

Integrating science curriculums. Integration of science curriculums is occurring at two levels. First, the traditional boundaries between the life and physical sciences are being dismantled. Second, in general, the sciences are becoming more integrated with other disciplines such as math and history. The ethical, historical, and political issues within modem-day science—issues such as global warming, bioengineered food, and cloning—make science education an integral component within an interdisciplinary curriculum (National Research Council 1995). The implications for science facilities include considering

- designing "universal labs" that can accommodate multiple science curriculums and
- placing science facilities in a central location instead of an isolated wing.

Project-based learning. According to the American Association for the Advancement of Science (AAAS), science instruction should be hands-on and inquiry-based to promote and sustain student interest and enthusiasm in science. The AAAS argues that 40 to 80 percent of science education should be devoted to laboratory time (AAAS 1990). To accommodate this development, facilities should be designed to provide:

- adequate lab workspace for all students in the classroom and
- multiple spaces, such as project centers and conference rooms, for individual and small group work.

Integrating technology. "The global village may be a cliché," argues the National Science Teachers Association (NSTA), "but the global classroom is a reality" (NSTA 1999). In enhancing the science curriculum, teachers are looking beyond their classroom walls to develop more relevant and broad-based activities. Students are logging onto the Intemet to watch frog dissections, download photographs from orbiting satellites, and converse with experts. They are obtaining an in-depth analysis of the functioning of the human body and chemical reactions through interactive computer programs. And telecommunication connects classrooms with other classrooms, universities, and scientific facilities worldwide.

Key Spaces in Elementary School Science Facilities

Elementary school science programs should be centered around activities and hands-on learning. While science has traditionally been taught within the general classroom, some schools are developing "discovery" rooms that integrate math, art, and science activities. In either case, the space should be between 1,000 and 1,500 square feet—depending on class size, local and state building codes, and the amount of technology integration—and allow for individual study, small and large group work, and lecture-format instruction. The classroom should be directly accessible to outdoors to allow for the integration of the environment into the science curriculum.

In general, an elementary school science facility should have the following spaces (Maryland State Department of Education 1994: 23–26):

Wet area. The wet area requires a sink with hot and cold water, GFI-protected electrical outlets, and a large enough space for small groups to observe demonstrations.

Holding area. Science activities, including projects that can last from several days to several weeks, often require ongoing observation and experimentation. A space is therefore needed that allows students to observe, gather data, and store science projects.

Learning centers. To encourage active learning, multiple learning centers should be spaced around the perimeter of the room. The learning center may involve the use of computers, microscopes, or other materials. Students may work alone or in small groups to build models, work with laboratory kits, or plan projects. Movable tables and a flat counter top along the perimeter are best for this area; allow a minimum of two linear feet of space per student. Electrical and data outlets should be provided every four feet.

Storage room/preparation area. Science activities require a large number of supplies and materials. The storage room should be a minimum of 100 to 200 square feet and be equipped with a sink, electrical outlets, and storage. A space where teachers can prepare experiments or lab kits is useful. Storage should encompass multiple storage cabinets and bins, including bookshelves, open shelf storage, flat storage, and tote tray storage. The storage room should serve, and thus be accessible to, more than one science classroom. A walk-in storage closet may be a feasible option for a single science classroom.

The elementary school science facility will vary widely depending on the grade level. For example, grades 3 to 5 will require differently sized furnishings, additional equipment, and more elaborate activity centers than those found in grades K through 2 (Lowry 1997: 11). Nevertheless, all elementary school science facilities should have a large-screen television or video projection system. These can be mounted either from the ceiling or brought in on a rolling cart.

Key Spaces in Secondary School Science Facilities

Although middle school science curriculums differ from high school science programs, their facilities needs are comparable. Middle school programs traditionally conduct less sophisticated laboratory experiments, have a wider variety of activities—such as math, computers, health, and art—and do not focus as heavily on individual in-depth lab work (NSTA 1990; Texley and Wild 1996; Rakow 1998). High school science programs, on the other hand, are more project centered and question based. A good middle school science facility should, nevertheless, be comparable to high school programs in providing adequate resources and spaces.

The secondary science facility should be directly accessible to the outdoors and provide multiple spaces for lectures, demonstrations, small group or individual projects and experimentation, and project exhibits. Electrical and data outlets should be placed throughout the room and spaced for either computer workstations or laptops. Consideration should be given to advances in technology that may soon allow wireless networks (NSF 1999).

The science facility should accommodate a maximum of 24 to 28 students. Due to issues of supervision, safety concerns, and instructional goals, NSTA recommends a maximum class size of 24. All science facilities should provide handicapped students full access to science equipment and experiments (Office for Civil Rights 1999; Biehle 1995: 54).

Secondary science facilities should include:

Combination classroom/laboratory. This is a dedicated laboratory space that is shared by several science classrooms or serves as a combination classroom/laboratory. While the former option may be an efficient hub for several "houses," the latter option is usually more flexible in meeting the changing curricular needs of science instruction and the school in general. A combination classroom/laboratory should be a minimum of 1,400 to 1,500 square feet (1,200–1,300 sq. ft. in middle school) to provide adequate space for laboratory work. The two most common arrangements of combination spaces are

- fixed student workstations and a separate area for classroom instruction and
- movable tables that can serve for classroom instruction and as laboratory space when located near the utilities and sinks at the perimeter of the room (NSTA 1999).

The room should have a variety of cabinets and drawers above and below lab stations. Sinks and electrical outlets should be placed along the perimeter of the room. If the classroom is to have fixed workstations, three- or four-sided "utility islands" with sinks and electrical and data outlets can be spaced throughout the room. The tables and workspaces around the perimeter of the room should have flat, durable "lab" top surfaces. The room should have adequate natural and task lighting to grow plants, observe experiments, and draw. All science room, prep room, and storage room doors should lock.

It may also be beneficial to design the main science room as a more flexible and adaptable space—a type of "science studio" where individual students and groups engage in long-term, in-depth projects. Such a space might have high ceilings, minimal cabinetry, and outlets throughout that provide water, gas, electricity, and data capability (Maryland State Department of Education 1994; Biehle 1998: 1).

Preparation room. The preparation room should be directly accessible from the classroom and may be used for storage and teacher preparation. The room should be between 200 and 500 square feet, have a large window through which to supervise the classroom/laboratory, and have the necessary utilities—i.e., electricity and water—to prepare for and conduct classroom projects. The preparation room should have a phone, an acid-resistant sink with hot and cold water, an ice-making refrigerator, a full-size dishwasher, and the capacity to handle specialized fixtures such as an autoclave or distiller. The room should also have multiple base cabinets.

Storage room. Primarily used for the storage of chemicals, specimens, and materials, the room should be approximately 100 to 200 square feet (depending on the number of classrooms served) and accessible only from the preparation room or situated in between two science classrooms. The storage room should have the maximum possible linear feet of wall-mounted, adjustable shelving and base cabinets. To prevent sparks and potential explosions, there should be no electrical outlets in this room. A fire resistant storage cabinet and non-corroding acid cabinet (situated below eye level) should be considered for hazardous materials.

Greenhouse. A greenhouse can greatly enhance the curricular offerings of the science program. The greenhouse should range from 200 to 400 square feet; have separate thermostatic controls, access to ample water, a floor drain, and humidity control; and be able to function when school is not in session.

Teacher workspace and faculty offices. Science teachers should have their own workspace apart from any classroom preparation space. Separate science offices may be considered or science teachers may be placed with teachers from other departments to foster cross-disciplinary interaction and collaboration.

Resource room/small group workroom. A science resource and workroom can provide valuable space for student experimentation and inquiry and serve as conference and study spaces. The room should have a water supply and be furnished with movable tables and chairs, a whiteboard, multiple cabinets and shelving, multiple electrical and data outlets, and work counters with space for an aquarium or terrarium. Teachers should be able to supervise the workroom from the classroom.

Principles for Science Facility Design

Science can be taught in a wide range of settings, from a regular classroom to a state-of-the-art facility dedicated to science instruction. All of these learning environments, though, should have several common features to facilitate quality science instruction.

Promote safety. Safety is of paramount importance in the science classroom. Chemicals, bunsen burners, and dissection tools are but a few of the multiple hazards lurking in the science classroom. All science facilities should have a hands-free eye wash, fire blanket, fire extinguisher, and first-aid kit. Secondary school science facilities also should consider installing a fume hood and safety shower if the space is to be used for chemistry or advanced biology classes. A clearly marked master cut-off switch for utilities should be located at the front of the room or be easily accessible in the preparation room (avoid placing the cut-off switch near a bank of light switches). An HVAC system dedicated to just the science facilities will provide necessary air changes and adequate amounts of fresh air. Both the classroom and preparation area should have telephones to summon emergency technicians. Remember, a larger room or a smaller number of students can also increase safety.

Integrate the natural environment into the classroom. Investigating and understanding science can be greatly enhanced when students have access to the outdoors. Some examples include providing a nature trail, a garden, a weather station, a wetland area with a stream, or an outdoor classroom or greenhouse. Outdoor activities allow students another opportunity to experience science as a relevant, hands-on aspect of their daily lives.

Foster curiosity and creativity. "The science classroom," AAAS notes, "ought to be a place where creativity and invention are recognized and encouraged" (AAAS 1990). Science is as much about creativity and wonder as it is about logical thinking and factual knowledge. The design of the science facility can promote such goals through numerous means, such as turning the classroom and school into a "textbook." Exposed HVAC, plumbing, and electrical systems allow students to observe the electrical and mechanical workings of a complex system. Skylights or multiple windows allow students to observe weather patterns and the movement of the sun. Read-only displays of key school data, such as temperature and energy use, can transform the physical classroom into a teaching tool. In general, the science classroom should be an intellectually stimulating environment.

Science facility design can offer learning environments where inquiry, experimentation, and discussions are valued and encouraged. If every child is truly a scientist, then every science facility should have the potential to capture a student's interests and curiosity.

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Additional Information

See the NCEF annotated bibliography Science Facilities, online at *http://www.edfacilities.org/ir/hottopics.cfm.*

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