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ABSTRACT

This document includes the strategies being used by the state of Maryland to reach five goals and six essential outcomes regarding science education for their students. Also included is a discussion of seven recommendations made by committee members and reviewers of this effort to improve the quality and use of science laboratories in Maryland. The recommendations are: (1) Science education must be a high priority; (2) there should be a strong focus on the laboratory experience; (3) the "Maryland School Science Facilities Guidelines" should be updated; (4) advanced and specialized laboratory facilities and equipment need to be provided; (5) science teachers need continuing education; (6) partnerships among high schools, universities, private industry, and government should be encouraged; and (7) state financial support should be tied to science outcomes. Appendixes include a letter from the governor and a list of reviewers. (ZWH)

LOOK OF THE FUTURE:

Report of the Governor's Committee on High School Science Laboratories for the 21st Century

State of Maryland
August 1992

Governor's Committee on High School Science Laboratories for the 21st Century

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LOOK OF THE FUTURE:

Report of the Governor's Committee on High School Science Laboratories for the 21st Century

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THE UNIVERSITY OF MARYLAND

BALTIMORE COUNTY CAMPUS
Office of the President

August 3, 1992

The Honorable William Donald Schaefer
State of Maryland
State House
Annapolis, Maryland 21401

Dear Governor Schaefer:

On behalf of the members of the Governor's Committee on High School Science labs for the 21st Century, I am pleased to transmit to you our report.

I know that all the members of the committee share my conviction that high quality science education is vital to the future of Maryland and of the country. For that reason, we have felt privileged to be able to make a contribution toward achieving the goal of improving science education in Maryland's high schools.

Science education has received a great deal of attention and thoughtful examination in both Maryland and the nation in recent years. The committee benefitted enormously from the many studies, reports, and recommendations on science education and attempted to build its recommendations for science labs on the foundation that has been established by them. We received information and advice from national experts and from classroom teachers as we studied the subject and later in response to various drafts of our report. The process for bringing these recommendations to you has been a far-reaching and inclusive one.

The recommendations in this report provide the basis for improving the quality of science education in Maryland's high schools. We must be candid, though, and point out that these are not quick fixes. These recommendations will make a difference if there is a long-term commitment by the State of Maryland and by local school districts. We saw schools with outstanding science lab facilities, which could be even better, and we saw science labs that are clearly inadequate by any standard. The leadership that you have already provided in requesting this report makes us confident that our recommendations will indeed help make Maryland a national leader in high school science education.

Sincerely,

Michael Hooker
President

Enclosure

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INTRODUCTION

Sykesville, Maryland. October 17, 2014

The morning sun touches the sensor on Lisa and Jason Mallory's house. Their computer moves the sensor daily so that rain or shine, the sun's first rays always hit it at exactly 6:30 AM. They do not want their kids to miss any of the interactive science enrichment program which starts promptly at 7:00 AM. These days power outages are rare, but if one occurs, the light-sensor feature of their smart house package makes sure all systems are on time.

The children love working on the science enrichment program each morning before they leave for school. Like most families, their television and personal computer with built-in modem are compatible and make participation in such programs very easy. This early morning program for adolescents always includes a five-minute segment on careers in science and technology. Both young Mallorys are looking forward to high school so they can have more time in the science laboratory.

Lisa Mallory, like an ever growing number of workers, does not have to commute; she uses the family computer to connect to the London office of her company. She processes medical insurance claims. Her 25-hour work week is flexible, but generally she works while the kids are in school.

Jason Mallory is still a commuter. He finishes his coffee and heads out the front door. As he passes a sensor, the garage door opens and the electric switch disconnects its charging cord from his car. Jason smiles as he walks toward the car. He works for the car's manufacturer and his team built this car. It still amazes him that the factory employs fewer than 100 people and produces as many cars as they did 25 years ago with thousands of workers. And, the cars are tailor-made in 48 hours to orders placed by customers via computer--often from the comfort of their homes.

Jason enjoys his commute, for he does not have to fight through heavy, unpredictable rush hour traffic. He simply enters the code for a pre-programmed route that takes him to the homes of three fellow carpoolers and then to work. He helped develop the electronic guidance system and is delighted that it has not only eliminated traffic jams, it also has made automobile accidents rare.

To ensure that all Americans are ready for this type of future, science education in the United States has to be improved dramatically. A series of highly respected studies and reports have documented the serious deficiencies in scientific knowledge of American students. Further, analyses of the future needs of the American economy, with its emphasis on the creation and application of knowledge rather than the use of energy, reinforce the vital need for a work force that is scientifically literate and that includes an increased number of world-class scientists and engineers.

These national concerns are also Maryland's concerns. In our State, discussions among policy makers, educators and the business community have led to questions about the priority we need to place on science education, about the best means to increase interest in science among students, about how to raise the level of scientific knowledge and competence of all students, and about how to provide enrichment opportunities for the highest achieving high school students in Maryland.

In May 1990 the Maryland State Board of Education adopted ten goals for the State's public schools to meet by the year 2000. Significantly, five of these goals are related to improving student performance in science and mathematics.

Those five goals state that:

- Maryland will rank in the top five states in the nation on national and international comparisons of student achievement and other measures of student success.
- 50% of Maryland's students will achieve excellence levels of achievement in mathematics and science on state developed assessment measures.
- 95% of Maryland's students will achieve satisfactory levels of achievement in mathematics and science on state developed assessment measures.
- 100% of Maryland students will be functionally literate in mathematics.
- The number of Maryland students pursuing post-secondary studies in mathematics, science and technology will increase by 50%.

At present, two major policy documents provide direction for responding to the challenge of improving science education in Maryland. One is the February 1992 report of the Maryland Task Force on Mathematics, Science and Technology appointed by the State Board of Education and chaired by Dr. Freeman Hrabowski, Executive Vice President and Provost, University of Maryland Baltimore County. The other is the list of six "essential outcomes" for science education in all Maryland public schools which built upon the 1989 report of the Governor's Commission on School Performance (the Sondheim Commission).

These six essential outcomes are:

- Students will demonstrate their acquisition and integration of major concepts and unifying themes from the life, physical, and earth/space sciences.

- Students will demonstrate the ability to interpret and explain information generated by the exploration of scientific phenomena.

- Students will demonstrate ways of thinking and acting inherent in the practice of science.

- Students will demonstrate positive attitudes toward science and its relevance to the individual, society, and the environment and demonstrate confidence in their ability to practice science.

- Students will demonstrate the ability to employ the language, instruments, methods and materials of science for collecting, organizing, interpreting, and communicating information.

- Students will demonstrate the ability to apply science in solving problems and making personal decisions about issues affecting the individual, society, and the environment.

With these policies as background, in January 1992 Governor Schaefer appointed his Committee on High School Science Labs for the 21st Century. (See Appendix A for a list of committee members.)

Governor Schaefer charged this committee with the responsibility of making recommendations on how high school science facilities and equipment could support and reinforce the goal of improving the quality of science education in Maryland.

Quality mathematics and science education is essential for a healthy economy. Success in mathematics/science opens doors to careers, enables citizens to develop informed decisions, and provides our State with the knowledge to compete in this technological society. Donald Hutchinson, President, Maryland Economic Growth Associates, Inc./Maryland Chamber of Commerce

How the committee did its work

The basic working premise of the committee was that recommendations about facilities and equipment must be tied directly to curriculum goals. For that reason, the committee began by focusing on the major efforts to reform the content of science education. In addition to briefings and written materials about the two Maryland policy documents cited above, the committee heard a presentation on and discussed the recommendations of the long-term effort by the American Association for the Advancement of Science known as Project 2061: Science for All Americans. These discussions were greatly enhanced by the expertise of the committee members themselves.

Science goes on in many different settings. Scientists are employed by universities, hospitals, business and industry, government, independent research organizations, and scientific associations. They may work alone, in small groups, or as members of large research teams. Their places of work include classrooms, offices, laboratories, and natural field settings from space to the bottom of the sea. Project 2061: Science For All Americans

The second stage of the committee's examination involved visits to a number of science laboratories, including high schools and advanced research laboratories in the State. (See Appendix B.) The opportunity to observe these facilities and to discuss their use with teachers and science coordinators as well as with scientists in the private sector was extremely valuable to the committee's deliberations.

The result of the first two stages of investigation was the identification of a list of critical questions that needed to be answered. This process allowed the committee to understand clearly the assumptions that it was making and the choices that had to be faced in making specific recommendations. After developing a preliminary report, the committee shared its work with numerous educators, scientists and engineers. Thus, this document reflects the collective wisdom of the committee members and the reviewers. (See Appendix C.)

RECOMMENDATIONS AND ANALYSIS

SUMMARY

1. Science education must be a high priority in Maryland and in all local school systems.

2. Science education should include a heavy focus on the laboratory experience rather than being limited to textbooks.

3. The Maryland School Science Facilities Guidelines, developed and published by the Maryland State Department of Education in 1977, should be updated, republished and distributed to assist school systems in developing science laboratories for the 21st century.

4. More advanced and specialized laboratory facilities and equipment need to be provided on a selective basis to allow enrichment opportunities for students with the ability to take advantage of them.

5. Science teachers need continuing education in their field and increased support for the operation and maintenance of laboratory facilities.

6. Partnerships between high school science programs and universities, government laboratories and private industry need to be encouraged and supported.

7. State financial support for science facilities and equipment must be tied directly to fulfillment of the Maryland Science Outcomes.

RECOMMENDATION 1

SCIENCE EDUCATION MUST BE A HIGH PRIORITY IN MARYLAND AND IN ALL LOCAL SCHOOL SYSTEMS.

To achieve the goal of scientific literacy for all students, the State of Maryland must assure that science education is a high priority. Science needs to be considered as a "new basic" when the State Board of Education reviews graduation requirements. It is no less critical to the future than those areas of learning that we have traditionally thought of as the basics.

As science becomes more a part of our daily life, all citizens will need a basic understanding of scientific knowledge and ways of thinking. In addition, the economic vitality and competitiveness of the State will increasingly depend on a population that is scientifically literate and contains growing numbers of skilled scientists and engineers. The 1991 report by the Greater Baltimore Committee, Baltimore. Where Science Comes To Life, on the role of life sciences in Baltimore's future is a noteworthy example of this point.

A Scientifically Literate Citizen Might Ask

- Can using a professional lawn treatment service have a negative affect on the Chesapeake Bay?
- Is irradiated food safe to eat?
- Do certain automobiles or household appliances contribute to air pollution?

As Project 2061: Science for All Americans points out, achieving the goal of scientific literacy is not a matter of increasing the content of the science curriculum, but of concentrating on topics that are at the core of scientific understanding and teaching those better. To that end, the Project 2061 report describes the scientifically literate person as one who is aware that "science, mathematics, and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognizes its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes."

This formal commitment to science education must be put into practice at the local school level. Budget support for science, particularly laboratories (including equipment and supplies) and teacher training, must be increased if advances in science education are to be achieved.

Similarly, local schools and school systems need to provide adequate time for teaching science. The traditional one-period time slot is not the best way to teach science. Just as successful high school athletic teams are not limited to 45 minutes of practice each school day, successful science education needs extended class time. Finding ways to give students access to the science laboratories and their experiments will require serious discussion and innovative solutions. Being able to work in the laboratory during a free period, or in the evening, or on a weekend would encourage scientific inquiry by high school students. A variety of approaches, including the possibility of longer school days or restructuring the school day, may be necessary to accomplish this objective.

Rapid advances in technology are likely to make possible educational experiences in science on a much wider and fuller basis than is currently possible. Indeed, these breakthroughs in educational technology have the potential to transform the teaching of science. The use of multimedia computer stations can make every branch of science available to all students.

> Scientists thrive on curiosity -- and so do children. Children enter school alive with questions about everything in sight; and they differ from scientists only in not yet having learned how to go about finding answers and checking to see how good those answers are. Project 2061: Science for All Americans

Finally, despite the fact that the explicit focus of this committee was on high school science facilities, we believe it is important to emphasize that science education must be given a high priority in schools prior to high school. Nurturing interest in science among students must begin at the kindergarten level and include hands-on, laboratory-type experiences. Parents and communities should complement school-based science experiences by taking advantage of resources like the Maryland Science Center. Here children can actively "play" with science and further develop their natural curiosity--an essential characteristic for scientists and the scientifically literate. Also, the Maryland Science Week Commission can play a critical role by providing resources and ideas to parents for informal science education.

RECOMMENDATION 2

SCIENCE EDUCATION SHOULD INCLUDE A STRONG FOCUS ON THE LABORATORY EXPERIENCE RATHER THAN BEING LIMITED TO TEXTBOOKS.

This conclusion comes through clearly and emphatically in all the recent studies on science curriculum, including both the Project 2061 report and the Maryland science outcomes. This committee completely agrees.

For both the general population and those who will be scientists and engineers, the world of the fast-approaching 21st century will require an understanding of the methods and processes, as well as the application, of science. This kind of understanding will not come from merely hearing and reading about science or watching the teacher do an experiment, but requires that students have multiple, hands-on, real world experiences with science and technology.

A different way to express this critical point is that the goal of science education should be for all students to be able to ask basic scientific questions. Traditionally, too great an emphasis has been placed on memorization, a particularly great risk when the predominant learning tool is the textbook. Initially, understanding how to formulate the questions is much more important than knowing the answers. The next step is learning how to construct the answers. Achieving this goal would be a major step toward science literacy.

Two corollary points are tied to other recommendations. Inadequate budget support, mentioned in Recommendation #1, may lead to inadvertent over reliance on textbooks over laboratory experiences. Secondly, the critical role of the teacher suggests the importance of involving teachers as well as science supervisors in the planning and design of science laboratories.

Engineers have used supercomputers to learn about damage to buildings, bridges and other structures during an earthquake. Using San Francisco's 1989 quake as a model, engineers have compared earthquake simulations on a supercomputer with field studies of actual damage from the event. This information has helped state agencies decide whether to repair or rebuild damaged structures, and how to retrofit structures built before quake-resistant construction techniques were developed. Science and Engineering Research Benefits, National Science Foundation, 1991

RECOMMENDATION 3

THE MARYLAND SCHOOL SCIENCE FACILITIES GUIDELINES, DEVELOPED AND PUBLISHED BY THE MARYLAND STATE DEPARTMENT OF EDUCATION IN 1977, SHOULD BE UPDATED, REPUBLISHED AND DISTRIBUTED TO ASSIST SCHOOL SYSTEMS IN DEVELOPING SCIENCE LABORATORIES FOR THE 21ST CENTURY.

Much of the work and thought that went into the 1977 Maryland School Science Facilities Guidelines is still valid today. This guide formed a solid base for planning science laboratories in the 1980s and 1990s, and with some modifications would be useful into the next century.

As a result of our work, we have identified a number of principles and concepts that have implications for the design, construction and utilization of science laboratories. Colleges and universities ought to consider developing coursework addressing the elements of laboratory design to offer to science supervisors. The State Board of Education might want to consider requiring such preparation as part of the certification standards for science supervisors.

Some specific planning and design factors that should be considered in addition to those in the 1977 Maryland School Science Facilities Guidelines follow.

General

- Generic designs for science laboratories that can respond as science curriculums become integrated across science disciplines should be considered.

- The duration of time for science programs may vary from the standard 40-50 minute period per day for instruction and laboratory work.

- More students in the future will be taking more science and science-related courses.

Relationship to Other Activities

- Science facilities could be clustered together in a school building.

- Consideration should be given to locating the science facilities adjacent to other instructional programs in order to integrate curriculums--i.e., mathematics, computer labs, technology education, home economics, etc.

- A portion of each school site should be developed for environmental science activities.

Spatial Requirements

- The number of computers to be placed in each science laboratory should be reviewed and, if appropriate, additional square footage provided.

Support Facilities

- Space that is directly accessible from the science laboratory for long-term student projects should be provided. This space could be 200-300 square feet with utilities and ventilation for laboratory work.

- Student project spaces for short-term projects could also be provided in a separate space of 100-150 square feet or accommodated in the laboratory itself.

Building System Requirements

- In generic science laboratories, install one fume hood directly vented to the exterior.

- In addition to perimeter duplex electrical outlets, consider an electrical power distribution system to reach all parts of the laboratory--i.e., pull-down (retracting) lines, electrical power poles, etc.

- All electrical and electronic systems and circuits should include ground fault protection.

Building System Requirements (continued)

- Provide each science laboratory with a projection system or hookup to the classroom's TV receivers and printer, paper tray, laser disk player, modem and VCR.
- Provide each student with access to a computer-equipped student technology workstation.
- The computer-equipped portion of the workstation may be mobile.
- Provide a projection surface or pull-down screen for audio-visual purposes.
- Emergency shut-off valves or switches for electricity and gas that are easily accessible should be provided in each laboratory.
- The teacher and student workstations should be networked with the laboratory, but also have the capacity to function independently. Consideration could be given to networking with other areas of the building as well as external locations.
- Provisions should be made to darken the science laboratory for certain scientific experiments and audio-visual purposes.
- Emergency eye washes and showers with floor drains should be provided.
- Provisions should be made for chemical and biohazard disposal.

Handicapped Access

- An adapted laboratory station that can accommodate an individual in a wheelchair -- counter height, sink design, access to controls for water, gas and electric, etc.
- Handles, bars, and/or handrails where added support is required.
- Adapted safety equipment -- eye wash, shower, fire extinguishers.

Handicapped Access (continued)

- Specialized equipment for hearing impaired students -- visual aids, visual computer commands, amplifiers, decoders for closed captioned presentations and visual warnings signals.

- Specialized equipment for visually impaired students -- scientific measurement equipment that presents an auditory message (talking digital readers); electronic voice (talking) computers; braille printers and translators to printed English; recordings of workbooks, textbooks and other printed matter with recording and listening equipment; and audio warning signals.

Recommended Science Facility Planning Guide Resources

- DiBerardinis, Louis J., Janet Baum, Melvin W. First. Gari T. Gatewood, Edward Groden, and Anand K. Seth. Guidelines for Laboratory Design: Health and Safety Considerations. New York: John Wiley & Sons, 1987

- Maryland State Department of Education (MSDE), Model Educational Specifications for Technology in Schools. Baltimore: MSDE, March 1991.

- Maryland State Department of Education (MSDE), Maryland School Science Facilities Guidelines. Baltimore: MSDE. 1977

- Motz, LaMoine L., and Gerry M. Madrazo, Jr. Third Sourcebook for Science Supervisors. Washington DC: National Science Supervisors Association and National Science Teachers Association, 1988.

- Rosenlund, Sigurd J. The Chemical Laboratory: Its Design and Operation. Park Ridge, New Jersey: Noyes Publications, 1987.

- Texas Education Agency, Planning a Safe and Effective Science Learning Environment. Austin: Texas Education Agency, 1989.

Building upon the approach to science education that forms the basis of the recommendations of this Report, the specific guidelines on laboratories, facilities and equipment are likely to be altered over time as new technologies are refined and become more affordable.

RECOMMENDATION 4

MORE ADVANCED AND SPECIALIZED LABORATORY FACILITIES AND EQUIPMENT NEED TO BE PROVIDED ON A SELECTIVE BASIS TO ALLOW ENRICHMENT OPPORTUNITIES FOR STUDENTS.

This recommendation recognizes that in addition to the goal of achieving science literacy for all, the economic future of the nation and the State is dependent on producing more top scientists, engineers and technicians. As the pool of students with an interest in science grows and the basic science curriculum for all students improves, the number of students with the interest and ability to move beyond the basic level is likely to increase. It is critical to provide meaningful opportunities for these students.

In addition to noting the absence of even basic levels of science facilities and equipment in some schools, the committee also observed both the existence and effective use of first-rate science laboratories in others. Those effective examples provide a foundation on which the State needs to build.

The basic requirements described in Recommendation #3 for all high school science laboratories do not necessitate the most sophisticated facilities and equipment available. As universities, private industry and federal laboratories strive to keep up with the advances in technology, there may be more opportunities to recycle their equipment for use in high school science laboratories. Some recycling is already going on, but there should be ways to expand on this practice. Care must be taken to ensure that schools do not become repositories for obsolete equipment.

A number of options should be explored to provide enrichment opportunities for students. The State in collaboration with local school systems should develop regional centers that have more advanced science facilities that could be available to students from a number of different schools. Some sharing of facilities already has been done, but ought to be expanded. Special attention should be given to the development of magnet schools in parts of the State where they are not currently available. Institutions of higher education, working with science teachers and supervisors, should help with the establishment and operation of these facilities and actually serve as regional centers in some areas.

Moreover, the State should consider developing a model facility to provide access for both teachers and students to those state-of-the-art technologies that cannot be made widely available because of prohibitive costs.

Another possibility is to have specialized laboratories within some schools in addition to the general facilities for all students. The number and type of specialized laboratories at a particular high school would depend on the expertise of the faculty as well as on the willingness of industry partners to make equipment and expertise available. Portable equipment could provide more flexibility.

Distance learning technologies also can provide opportunities not currently available in many schools. If regional centers were developed around the State, connecting them to distance learning networks would greatly expand their capacity to provide access to science laboratory experiences that could not be made available to each individual school.

Finally, access to the advanced laboratory facilities of both State universities and private industry, discussed in more detail in a separate recommendation, would be another means of providing enrichment opportunities for advanced students in science.

RECOMMENDATION 5

SCIENCE TEACHERS NEED CONTINUING EDUCATION IN THEIR FIELD AND INCREASED SUPPORT FOR THE OPERATION AND MAINTENANCE OF LABORATORY FACILITIES.

The committee's examination of high school science laboratories led back to a familiar conclusion: the key to good science education is knowledgeable and motivated teachers. Centering science education in the laboratory experience and providing the kinds of facilities and equipment described in Recommendations #3 and #4 will have a real impact only if the teachers have the necessary background and interest.

A lesson learned from the dramatic increase in the availability of computers in schools over the past several years was that the level of teacher training was directly related to the level of the impact computers have on the learning process. It should be obvious that the same point transfers to other kinds of science and technological facilities and equipment. Specifically, there needs to be on-going training programs for teachers on the use of the equipment available to them.

Furthermore, the need for continuing professional development for teachers in the sciences is critical for at least two reasons. First, the advances and discovery of new knowledge in all the fields of science place a significant burden on the high school teacher who completed formal education years ago. Secondly, the emphasis on scientific literacy and on laboratory experience rather than reliance on textbooks requires a reorientation for teachers. Teachers become facilitators in the instructional process instead of explainers of the textbook. Teachers model scientific behavior. Like the Maryland Task Force on Mathematics, Science and Technology, the committee strongly urges the State Board of Education to take a close look at the nature of continuing education and certification requirements for science teachers in light of these considerations.

> Most elementary school teachers and many middle school teachers have not been required to have the mathematics and science background necessary to adequately teach these subjects. Likewise, the majority of these teachers are not trained in the use of technology.
>
> Although many secondary school teachers have stronger backgrounds in mathematics and science than elementary school teachers, they are not prepared to implement the latest teaching strategies (e.g., integration of technology, cooperative learning, thinking skills, application of concepts to current issues.) Report of the Maryland Task Force on Mathematics, Science and Technology, February 1991

By implication, the issues concerning continuing professional development for those currently teaching have relevance for colleges and universities preparing students to become the next generation of science teachers. Teacher preparation programs should focus on science literacy, the pivotal role of the laboratory experience, knowledge of and comfort with the advances in technologies for teaching science, as well as the new role of the teacher in teaching for conceptual understanding.

In addition to traditional, formal programs of continuing professional development and training, more opportunities for science teachers to work in industry and government laboratories would provide valuable continuing education. The Martin Marietta Graduate Fellows Program for graduates of the Governor's Academy on Mathematics, Science and Technology is an exciting step. Beginning during summer 1992, participants combine six to eight weeks working in research laboratories with workshops on how to relate this experience to their students and other teachers. They also will receive continuing support from University of Maryland System mathematicians and scientists upon returning to their schools. More opportunities of this type need to be available.

Finally, if we have knowledgeable, motivated teachers in up-to-date science laboratories, there must be a continuing commitment to provide both adequate operating budgets, particularly in the life sciences, and maintenance funds for basic and specialized equipment to allow teacher and laboratory to function in a way that can advance the quality of science education in Maryland.

> I'd like to see them [corporations] confer dignity, status and recognition on teachers... They can fund summer institutes for teachers. And they can teach schools how to reward teachers for teaching. Companies have learned how to confer money and prestige on engineers who stay at the drawing boards, or researchers who remain in the lab, but the only way for even the most outstanding teacher to get ahead is to become a principal or football coach.
> Ernest Boyer, President, Carnegie Foundation for the Advancement of Teaching, The New York Times, March 24, 1992

RECOMMENDATION 6

PARTNERSHIPS BETWEEN HIGH SCHOOL SCIENCE PROGRAMS AND UNIVERSITIES, GOVERNMENT LABORATORIES AND PRIVATE INDUSTRY NEED TO BE ENCOURAGED AND SUPPORTED.

A number of partnerships are actively functioning and producing impressive results. The Maryland Equipment Incentive Fund administered by the State Department of Education is entering its fourth year. Grants are made to local school systems for the purchase of mathematics and science equipment. The funds are leveraged by requiring that State dollars be matched by local funds and private sector contributions. There are many other exciting and innovative partnerships, the challenge is to build upon this foundation.

Our previous recommendations suggest a number of possibilities. First, a more systematic and comprehensive way of making available the high quality laboratory facilities in State universities, government research

SOME PARTNERSHIPS THAT WORK

- Funds from the Howard Hughes Medical Institute (HHMI) have provided research opportunities for Montgomery County teachers and students at the laboratories of the National Institutes for Health. Another HHMI grant makes possible week-long workshops for teachers in the DNA Learning Center of the Cold Spring Harbor Laboratory and supports a "Vector Van" (named after recombinant DNA vectors) to transport equipment and supplies to the schools.

- The Cooperative Satellite Learning Project housed at Laurel High School (Prince George's County) that involves NASA/Goddard Space Flight Center, Bendix Field Engineering Corporation, Falcon Microsystems, University of Maryland College Park and Capitol College.

- The Potomac Edison technology center in Western Maryland.

- The Johns Hopkins Space Grant Consortium is a cooperative effort among The Johns Hopkins University, The Johns Hopkins University Applied Physics Laboratory, Morgan State University, and the Space Telescope Institute. The corporate sponsors include Westinghouse, Computer Science Corporation, Bendix Field Engineering Corporation, and Martin Marietta. The Consortium sponsors programs for students and teachers to promote strong science, mathematics and technology education.

- W.R. Grace employees work with students of Atholton High School (Howard County) to stimulate their interest in science. Test scores are up and so is participation in science fairs and related activities.

- The Governor's Academy for Mathematics, Science and Technology, administered by the State Department of Education in cooperation with the University of Maryland Baltimore County and Towson State University, serves 120 elementary, middle and high school teachers each year.

- The Montgomery Education Connection Resource Bank is a data base of more than 4,000 volunteer experts in science and mathematics who come into classrooms as speakers, tutors, consultants or mentors.

laboratories and private industry as enrichment opportunities to high school students needs to be found. One possibility would be a program where these facilities make a commitment to work with a number of high school science students and provide regular supervised laboratory experiences. Creating more opportunities for high school science teachers to spend time in university and industry research laboratories also is important. Another possibility is to find ways for more scientists and engineers to share their expertise directly with high school students.

As noted above, these kinds of activities are already underway. They need to be refined and expanded for incorporation into every school's science program. There needs to be a better tracking of these partnerships as well. An encouraging development in this area is the CREST initiative (Combining Resources in Engineering, Science and Technology) funded by the Maryland Higher Education Commission that links higher education, business, industry, government laboratories and professional organizations with science and technical programs in Maryland's elementary and secondary schools. CREST is planning to publish a resource book on partnerships and could play a valuable clearinghouse role.

RECOMMENDATION 7

STATE FINANCIAL SUPPORT FOR SCIENCE FACILITIES AND EQUIPMENT MUST BE TIED DIRECTLY TO FULFILLMENT OF THE MARYLAND SCIENCE OUTCOMES.

Curriculum and laboratories are intertwined parts of the same whole, not separate topics. A State commitment to improving the quality and priority of science education needs to tie together the various pieces of State policy. An important step in starting to implement the recommendations in this report would be to begin providing State funds explicitly designated for achieving the standards for high school science laboratories[1] that have been identified here. However, as we noted initially, we do not believe our recommendations should be treated separately. Therefore, funds for science laboratories must be directly

[1] On April 29, 1992, the Maryland Board of Public Works approved the use of $2,000,000 of the State Public School Construction Capital Improvement Program for Fiscal Year 1993 for school construction projects to improve high school science laboratories. They also determined that projects will require local funding based upon the State/local shared cost formula utilized for funding through the State Public School Construction Program.

supportive of the curricular goals discussed in this report.

The State should establish a competition for science laboratory funds using a Request for Proposals type of process. Requests for those funds would include a description of how their use would support the Maryland science outcomes. The requests should be evaluated by a jury knowledgeable about the science outcomes. Funding might be divided into phases to allow monitoring of progress. High school science teachers and science coordinators, scientists from universities, government research laboratories and private industry, and experts involved in the national movement to rethink science education should be involved in both drafting the Request for Proposals and in evaluating the proposals that are submitted. Providing technical assistance to applicants as well as sharing reviewer's comments should be an integral part of this process.

While the specific criteria for review of applications needs to be developed by the panel, this committee recommends that the funds be broadly distributed across the State both to schools seeking to develop advanced laboratory facilities and to those proposing to meet the basic-level requirements. A long-term commitment by the State is essential if Maryland science education is to make significant advances.

We urge the State to go even farther and incorporate the principles and guidelines embodied in the Maryland science outcomes in the criteria for both new construction and renovation of schools that are eligible for State funds. There may, in addition, be other opportunities to connect State funding and curricular goals. For example, it may be possible to evaluate the use by local school systems of the federal funds under Title II, the Eisenhower State Grants program with respect to the Maryland science outcomes. The Maryland Equipment Incentive Program, described previously, also should require a clear relationship between equipment requests and curriculum goals. The spirit of this recommendation is to strengthen and facilitate systemic change in the way science is taught in Maryland's public schools.

> The next century will rest on a foundation of science and technology. Yet many of our schools aren't prepared or equipped to give students the scientific grounding that will be so essential when they enter the work force. Students are our best, and only, hope for the future -- but they must be given the tools and education to succeed. Editorial, The Evening Sun, June 2, 1992

APPENDIX A

STATE OF MARYLAND
OFFICE OF THE GOVERNOR

IN REPLY REFER TO PG

WILLIAM DONALD SCHAEFER
GOVERNOR

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January 13, 1992

Dr. Michael Hooker
President
University of Maryland Baltimore County
5401 Wilkens Avenue
Baltimore, Maryland 21228

Dear Dr. Hooker:

A variety of state (Task Force on Mathematics, Science and Technology of the Maryland State Board of Education) and national (Project 2061, NSF's Statewide Systemic Initiative) efforts have been undertaken to enhance elementary and secondary science education. The early signs from many of these efforts are positive. However, it appears that little, if any, attention has been directed towards facilities. I am especially concerned about science laboratories in high schools. High school students have moved beyond the hands-on science experiences which can be done at one's desk. They must have laboratory facilities and equipment that enable them to think and function as scientists-in-training.

In order to prepare scientists for the next century, our efforts to improve science instruction must be accompanied by an examination of existing facilities and the identification of what facilities and equipment are needed to support the science curriculum into the 21st century. Accordingly, I am establishing the Governor's Committee on High School Science Labs for the 21st Century. I am pleased to appoint you Chairman of the Committee. Dr. Yale Stenzler, Executive Director, Interagency Committee on School Construction will provide staff support to your Committee.

The Committee is requested to include the following tasks in its work:

(1) Examine current and projected science education curriculum and determine their impact on facilities and equipment;

(2) Visit several high school science labs, industrial scientific labs, and scientific business establishments to determine if effective;

(3) Identify the facility requirements to support the science education curriculum including the establishment of specific design criteria and features;

(4) Identify the types of technological equipment that are required to support the instructional program;

(5) Develop financial resources to support the implementation of the required facility changes and the acquisition of the required equipment;

(6) Disseminate the findings and design guidelines.

I ask that the Committee submit its report to me no later than May 15, 1992. Prior to sharing the report with me I hope that you seek reactions from classroom teachers and experts in other states. It is my expectation that our study of high school science facilities will become a valuable resource for all states.

The task that you are about to begin is vitally important. Your willingness to accept this responsibility is greatly appreciated.

Sincerely,

Governor

APPENDIX B

SCIENCE LABORATORIES AND FACILITIES VISITED BY COMMITTEE MEMBERS

Baltimore Polytechnic Institute, Baltimore, Maryland

EA Engineering, Science and Technology, Inc., Hunt Valley, Maryland

Eleanor Roosevelt High School, Greenbelt, Maryland

The Johns Hopkins University, Baltimore, Maryland

Northwestern High School, Baltimore, Maryland

MARTEK Corporation, Columbia, Maryland

Maryland Science Center, Baltimore, Maryland

NASA/Goddard Space Flight Center, Greenbelt, Maryland

Northwestern High School, Hyattsville, Maryland

Oakland Mills High School, Columbia, Maryland

Oxon Hill High School, Oxon Hill, Maryland

Patterson High School, Baltimore, Maryland

Quince Orchard High School, Gaithersburg, Maryland

South Hagerstown High School, Hagerstown, Maryland

Southwestern High School, Baltimore, Maryland

University of Maryland at Baltimore, Baltimore, Maryland

University of Maryland Baltimore County, Baltimore, Maryland

Watkins Mill High School, Gaithersburg, Maryland

APPENDIX C

REVIEWERS

The draft report that was discussed by the committee on May 15, 1992 was distributed for comments. Written comments were received from the following individuals:

Ron Barnes, *Supervisor of Science, Baltimore County Public Schools*

Jay Brill, *Consultant, Technology and Disabilities*

Karen Bundy, *Supervisor of Science, Allegany County Public Schools*

Bill Burd, *Supervisor of Science, Queen Anne's County Public Schools*

Thomas Custer, *Coordinator of Science, Anne Arundel County Public Schools*

Timothy Durkin, *Teacher, Liberty High School*

Jeanne Marie Ecton, *Teacher, North Hagerstown High School*

James W. Harr, *Supervisor of Science, Charles County Public Schools*

William Hunter, *Supervisor of Science, Harford County Public Schools*

James Kaufman, *Director, Laboratory Safety Workshop, Curry College, Milton MA*

Paul S. Keyser, *Supervisor of Science, Howard County Public Schools*

Greg Letterman, *Teacher, Watkins Mill High School*

Michael Marchizza, *Teacher, Largo High School*

LaMoine Motz, *Coordinator, Science Education, Oakland County Schools, Waterford MI*

Glen Moulton, *Supervisor of Science, Calvert County Public Schools*

Wayne Moyer, *Coordinator, Secondary Science, Montgomery County Public Schools*

Aline Novak, *Teacher, Clear Spring High School*

George Patrinicola, *Specialist in Science, Baltimore County Public Schools*

Timothy Perry, *Teacher, Mt. Hebron High School*

REVIEWERS (continued)

Walter Plosila, *President, Montgomery County High Technology Council*

Salvatore Raspa, *Supervisor of Instruction for Science, St. Mary's County Public Schools*

Dan Richardson, *Supervisor of Science, Worcester County Public Schools*

Mary Ann Sankey, *Teacher, Mt. Hebron High School*

Paulette Shockey, *Curriculum Specialist, Secondary Science, Frederick County Public Schools*

Peter H. Smeallie, *Consultant Federal Programs, New Jersey Institute of Technology*

Virginia Sutula, *Teacher, Laurel High School*

Joyce Swartney, *Associate Dean, Natural and Social Sciences, Buffalo State College*

Samuel Walker, *Supervisor of Science, Wicomico County Public Schools*

Russell G. Wright, *Director, Event-Based Science Project, Montgomery County Public Schools*

Brad Yohe, *Supervisor of Science, Carroll Public Schools*

Douglas Yust, *Teacher, Westminster High School*

APPENDIX D

COMMITTEE MEETING DATES AND LOCATIONS

February 6, 1992	NASA/Goddard Space Flight Center Greenbelt, Maryland
February 19, 1992	Quince Orchard High School Gaithersburg, Maryland
March 11, 1992	EA Engineering Science and Technology, Inc. Hunt Valley, Maryland
April 13, 1992	Maryland Science Center Baltimore, Maryland
May 15, 1992	University of Maryland Baltimore County Baltimore, Maryland

The Committee was assisted by:

Allen Abend, *Coordinator, School Construction, Maryland State Department of Education*

Laslo Boyd, *Associate Vice President for University Relations, University of Maryland Baltimore County*

Joy Boyer, *Office for Science Policy and Legislation, National Institutes of Health*

Susan Boyer, *Director, Academic Outreach, University of Maryland Baltimore County*

Mary Ann Brearton, *Specialist in Science, Maryland State Department of Education*

Bonnie Copeland, *Deputy State Superintendent of Schools, Maryland State Department of Education*

David Dymecki, *Principal, Ayers Saint Gross, Architects*

Keith Garland, *Manager, Research and Development, Martin Marietta Corporation*

Nicholas Hobar, *Assistant State Superintendent for Instruction, Maryland State Department of Education*

Particia Hoben, *Program Officer, Pre-college and Public Science Education Program, Howard Hughes Medical Institute*

Gertrude Jeffers, *Executive Assistant, Office of the Governor*

Bonnie Kalberer, *Assistant to Associate Director for Science Policy and Legislation, National Institutes of Health*

Judith Leasure, *Director, Corporate Facilities, EA Engineering Science and Technology, Inc.*

Joyce Murphy, *Senior Research Associate, Office of Educational Research and Improvement, U.S. Department of Education*

Eileen O'Keefe, *Assistant to the Director, Office of Science, Alcohol, Drug Abuse and Mental Health Administration*

Kim Parks, *Programs Assistant, Office of the Governor*

Judith Sachwald, *Executive Assistant for Education, Office of the Governor*

Mary Lewis Sivertsen, *Senior Research Associate, Office of Educational Research and Improvement, U.S. Department of Education*

Allan Spencer, *Executive Assistant, Electronic Systems Group, Westinghouse Corporation*

Yale Stenzler, *Executive Director, Interagency Committee on School Construction*

James Strandquist, *Supervisor of Science, Prince George's County Public Schools*

Richard Tagler, *Associate Director, Mission Operations and Data Systems Directorate, NASA/Goddard Space Flight Center*

State of Maryland
William Donald Schaefer, Governor
State House Annapolis MD 21401