A HOSPITAL/ SCHOOL SCIENCE FAIR MENTORING PROGRAM FOR MIDDLE SCHOOL STUDENTS

B. Torres,1 R. F. Harris,2 D. Lockwood,2 J. Johnson,2 R. Mirabal,2 D. T. Wells,2 M. Pacheco,2 H. Soussou,1 F. Robb,2 G. Kuhn Weissman,1 and A. R. Gwosdow1

1Massachusetts General Hospital/Timilty Partnership, Massachusetts General Hospital, Boston 02114; and 2James P. Timilty Middle School, Roxbury, Massachusetts 02109

The Massachusetts General Hospital (MGH) and the James P. Timilty Middle School established a partnership to enhance science education, promote faculty development, and improve the health status and academic performance of all Timilty students. This article describes one of the Partnership’s Science Connection programs, the Science Fair Mentoring Program, designed to enhance middle school science education, inform urban early adolescents about professions in the health field, inspire them to pursue postsecondary study in the health sciences, and prepare them for rigorous academic work in high school. In this program, hospital-based clinical and research staff mentor young adolescent students. The authors describe the planning, implementation, and evaluation of the Science Fair Mentoring Program as an innovative learning experience.


Key words: science education, outreach program

Inspired by an acute shortage of nursing staff in the mid-1980s, administrators at Boston's Massachusetts General Hospital (MGH) noted the dearth of qualified job applicants from among Boston residents and began to discuss with the Boston Public Schools ways that the MGH might help improve Boston's public school students' science and health education. MGH believed that to increase student study of science at the secondary level, intervention should take place at the middle school level, when students can plan ahead for high school as well as college (3). To combat this crisis in science education (7, 8, 11), MGH, a major Harvard-affiliated teaching and research institution, established a partnership in 1988 with the James P. Timilty Middle School, an innovative inner-city school serving primarily low-income students.

Together, the MGH/Timilty Partnership developed Science Connection programs to enhance middle school science education, educate urban early adolescents about professions in the health field, inspire them to pursue postsecondary study in the health sciences, and prepare them for rigorous academic work in high school. In the Science Fair Mentoring Program described herein, hospital-based clinical and research staff mentor young adolescent students. Content is ~70% physiology related.

MGH/TIMILTY PARTNERSHIP

The James P. Timilty Middle School is a city-wide magnet school serving ~600 students enrolled in the sixth, seventh, and eighth grades. The Timilty School is located in Roxbury, an urban Boston neighborhood. Timilty students represent a broad spectrum of ethnic and racial diversity, with 46% of African American heritage, 39% Hispanic, 9% Caucasian, 5% Asian, and less than 1% Native American. Eighty-two percent are eligible for the federally sponsored free or reduced
lunch program, 22% have limited English skills, and about 25% receive some special needs services.

In 1986 the Timilty Middle School began “Project Promise,” a supplemental program that permitted extended teaching hours, team teaching, and time for teachers to have regular collaborative planning meetings (5). The school’s strong leadership and dedicated staff are known for developing innovative links with community institutions. The Timilty has twice been recognized by the US Department of Education as a National Secondary School of Excellence, in 1989 and 1996. In 1996 the Timilty School’s National Academic League Team won the statewide title and represented Massachusetts in national competitions. Standardized test scores of Timilty students rank among the highest in the city, and the school prepares a large number of students who are accepted into Boston’s Examination Schools. Average daily attendance in 1995–1996 was 94%. Today the Timilty Middle School is considered one of the top middle schools in the City of Boston and the United States.

MGH is a private, nonprofit, academic healthcare organization affiliated with Harvard Medical School. Established in 1811, MGH is recognized internationally as a center of excellence in medical care, research, and education. The MGH employs ~8,000 individuals in over 500 employment categories.

The MGH/Timilty Partnership has developed a variety of science and family-oriented programs, such as the Science Fair Mentor Program, a series of Family Science Nights, Career Explorations Program, Speakers Bureau, Family Center, and Annual Health Fair. The objectives of these programs are to provide curriculum support, increase student achievement, expose students to educational and career opportunities, improve the physical and mental health of students and their families, and provide summer education programs.

The Science Fair Mentoring Program was one of the first partnership programs, and Science Fair Mentoring is currently the flagship program of the MGH/Timilty Partnership. In 1996 the mentors in the program were recognized by the United Way of Massachusetts Bay as “Champions of Change” and by Boston’s Private Industry Council as “Best in Class” for innovative curriculum programs in Boston Public Schools.

This article will focus on the MGH/Timilty Science Fair Mentoring Program as an innovative educational tool designed to support the middle school science curriculum, increase academic achievement of early adolescent students, motivate students in their academic and professional goals, and bolster students’ confidence in their capacity to achieve in the field of science. The specific goals of the Science Fair Mentoring Program are to increase student interest in science, give students an understanding of the scientific method, and have students produce a science fair project.

**BOSTON PUBLIC SCHOOLS SCIENCE CURRICULUM**

Under the leadership of Superintendent Thomas Payzant, who came to Boston in September 1995, the Boston Public Schools have recently developed a new system-wide curriculum. Boston Public Schools’ new Citywide Learning Standards for Science (1) are being phased in over a 3-year period beginning with the 1996–1997 school year. The science curriculum contains grade-specific content areas (Table 1), identifies scientific tools that middle school students should learn how to employ, and states processes of scientific inquiry that students should learn to use. The developers of the new science curriculum sought to align their work with recent curriculum standards developed by the National Science Foundation (9) and the state of Massachusetts.

Students are expected to learn to use specified scientific technologies. For example, sixth graders should become competent in the use of a simple compound microscope, an ammeter, a voltmeter, an electric motor, and a seismograph printout. They should learn to measure science phenomena using sensors interfaced with a graphing calculator and should practice this skill in each of the middle school years. Seventh graders are expected to master the use of a microscope, a triple-beam balance, a pH meter, a thermometer, computers, CD-ROMs, laser disks, an overhead...
projector, an SRL camera, and techniques for plant and animal preservation. Eighth graders are to learn how to use microscopes, telescopes, mirrors, lenses, and spectrophotometers.

In conjunction with work on specific content areas and mastery of scientific tools, students in each of the three middle school grades will be expected to work on the following skills and processes:

- identifying questions that can be answered through scientific investigations;
- designing and conducting a scientific investigation;
- using appropriate tools and techniques to gather, analyze, and interpret data;
- developing descriptions, explanations, predictions, and models using evidence;
- thinking critically and logically to make the relationships between evidence and explanations.

In addition, sixth graders are also asked to learn to

- recognize and analyze alternative explanations and predictions;
- communicate scientific procedures and explanations;
- use mathematics in all aspects of scientific inquiry.

In each of the three middle school years, teachers will expect each of their students to complete two "projects" from a list of possible science activities given in the citywide curriculum. The list includes the creation of a science fair project. A science fair project is required of all students at the Timilty Middle School and is one of the goals of this program.

**SCIENCE FAIR PROJECTS**

Many of Boston's middle school science teachers prepare students for a science fair to be held in each school in February. School-wide winners present their projects at the Citywide Science Fair in March. Massachusetts also has a state science fair in April that is primarily focused at the high school level, and outstanding middle school students are selected to exhibit their projects. Typically, teachers teach five classes with a total of ~125 students, so time to help individual students is limited. Varying proportions of the city's middle school classes actually do complete the science fair project.

The Timilty School had already been invested in the science fair before the school began to work with MGH, inviting judges from outside the school to evaluate students' work. During the first two years of the Partnership, nurses came to the school to help a few selected students plan and execute their projects. They also accompanied those students to the public library to help them research their topic. In 1990 a joint school/hospital team developed a more formal mentoring program that transported an average of 20 students a year (every other week for 4 mo) to MGH to meet one-on-one with mentors who helped them prepare their science fair projects. In 1994–95, with additional funding for staff and for transporting students, the Partnership expanded the number of students served by the Science Fair Mentoring program to fifty. In 1995–96 the program paired 72 middle school students with 80 MGH mentors; the 1996–97 program paired 65 students with 71 mentors. These pairs met eight times from September to February in a structured mentoring program.

**TABLE 1**

Middle school science topics for the Boston Public Schools

<table>
<thead>
<tr>
<th>Grade</th>
<th>Life Science</th>
<th>Earth and Space Science</th>
<th>Physical Science</th>
<th>Chemical Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>6th</td>
<td>Human body systems</td>
<td>Earth properties and processes</td>
<td>Energy, electricity, magnets, motors</td>
<td>Food chemistry</td>
</tr>
<tr>
<td>7th</td>
<td>Varieties of life on earth</td>
<td>Rocks, geologic events, disasters</td>
<td>Force, motion, machines</td>
<td>Solids, liquids, gases</td>
</tr>
<tr>
<td>8th</td>
<td>Single cell life, multicellular organisms</td>
<td>Rocks, volcanoes, earthquakes</td>
<td>Optics, pressure, density</td>
<td>Structure of matter</td>
</tr>
</tbody>
</table>

VOLUME 18 : NUMBER 1 – ADVANCES IN PHYSIOLOGY EDUCATION – DECEMBER 1997
SCIENCE FAIR MENTORING PROGRAM

Staffing. The Partnership has two part-time staff whose responsibilities include coordination of the Science Fair Mentoring Program. The staff support the mentor-student dyads through careful planning, close attention to detail, and frequent consultation with mentors and teachers.

The Director of Science Programs for the Partnership (from MGH) is a research scientist who also runs a laboratory (at MGH) and teaches at Harvard Medical School and MGH Institute of Health Professions. For the Science Fair Mentoring Program, the Director of Science Programs recruits mentors, plans mentor and student orientations, serves as a resource person, and manages schedules and logistics, including project finances.

The School Science Coordinator, based at the Timilty School, is a certified science teacher by profession. For the Science Fair Mentoring Program, the School Science Coordinator facilitates communication for mentors, students, and teachers. In addition, the School Science Coordinator makes sure that students have accomplished their interim science fair assignments before their next MGH visit and coordinates student schedules and absences, manages the MGH/Timilty Alumni Group, and coordinates Family Science Nights and scientist visits to the classrooms.

In 1995 MGH helped the Timilty School install telephone lines for computer modems. This enabled the students, mentors, and teachers to send messages between the science classrooms and the hospital via e-mail. In 1996 the Timilty Middle School participated in NetDay, which provided access to the World Wide Web for the entire school.

Selection and preparation of students. Seventh and eighth graders who take part in the MGH/Timilty Science Fair Mentoring Program are placed in home-rooms with the seventh- and eighth-grade science teachers. Students are encouraged to apply for these Science Connection home-rooms if they have a strong interest in science. The science teachers make the final choices. The science teachers seek students who have responsibly completed assignments the previous year. The classes include students with a wide range of academic talent, but all students chosen have a strong curiosity about science and have demonstrated a high degree of responsibility for maintaining their academic work.

Incoming sixth graders fill out application forms, signed by parents, if they want to be in the Science Fair Mentoring Program. Science teachers observe sixth-grade applicants' participation and responsibility in science class during the first month of school. They then confer with their fellow team teachers in the sixth-grade cluster to evaluate the candidates' diligence in completing homework assignments in other subjects. The teachers seek a balance. Ideally, they identify students who might not have support at home but who meet the other criteria.

At the students' orientation in September, each student receives a student handbook that explains the purpose of the Science Fair Mentoring Program, reviews policies and procedures, outlines the scientific method, discusses how to design a science fair project, offers a glossary of scientific terms, and gives a map of MGH and a schedule of meetings with mentors. Students also receive an agenda book to record homework assignments that are discussed with their mentor that need to be accomplished between visits.

Selection and preparation of mentors. During the summer months the Director of Science Programs for the Partnership solicits mentors using the hospital's internal newsletter and fliers. Any employee, nursing student, or graduate student can apply. Interested employees receive a packet of information detailing the program and the mentor commitment and are asked to complete a Science Fair Mentor Profile form.

For mentors, an orientation meeting is held in September. At this meeting "Senior Mentors" are introduced and paired with new mentors. Senior mentors serve as advisers or coaches to new mentors. Partnership staff is also available throughout the program for advice or support. At the initial meeting employees receive a mentoring handbook that includes a copy of the informative essay "So You Want to be a Science Fair Mentor," the schedule for meeting students, highlighting goals for each meeting, the deadline for the student's research paper, a copy of the middle school science curriculum, and information about mentoring...
middle school students. At the orientation meeting staff and Timilty science teachers discuss goals of the Science Fair Mentoring Program and present information about adolescent development and cultural diversity.

Schedule. The Science Fair Mentoring Program begins with a joint mentor-student breakfast at the Timilty Middle School in late September. Students travel to MGH in mid-October for a hospital tour and their first official mentoring session with their mentors. Several weeks later a field trip is arranged for students to meet their mentors at the main branch of the Boston Public Library or the Boston Museum of Science to research possible topics for their projects. Students are asked to finalize their topic with the help of their mentors during the November meetings. During the early December meetings students should finish outlining their report, and between mid-December and mid-January students should work on their experiments and begin a poster with the guidance of the MGH mentors. The first draft of the student report is usually due at the beginning of January. At meetings in January and early February students are given classes in presentation skills so they can practice their oral presentation. Just before the mid-February school science fair, the mentored students display their projects at MGH for the hospital community to see. All science fair projects are displayed in mid-February during Science Fair Week. In April the hospital sponsors a mentor thank you breakfast for mentors, students, teachers, parents, and all MGH staff involved in the program. This ceremony is complete with awards and speeches by the students, who publicly thank their mentors. Finally, in May, a school-wide assembly is devoted to honoring the students’ science fair accomplishments, which includes the majority of Timilty students. In 1996, 75% of Timilty Middle School students completed a science fair project.

Science fair projects. Timilty teachers emphasize the need for students to design an experimental project, not a descriptive one. One experienced MGH mentor says she thinks the simplest project can sometimes be the best; the important thing is to experiment, not describe. Students are encouraged to pursue their own interests. Topics sometimes relate to the mentor’s field, but not always. Some students design experiments they can perform at home, others used hospital technology with their mentors’ help. Computer-generated graphs are common project components. Some sample topics are presented in Table 2.

During the 1994–1995 school year, an outside evaluator developed program assessment tools for the Science Fair Mentoring Program. The evaluator surveyed student, teacher, and mentor participants. The evaluator’s report served as a basis for improving the program for 1995–1996. The 1995–1996 participants took part in a presurvey and, later, in a postsurvey. Key 1996 findings included the following:

- 99% of student participants believe the program will have long-term benefits for them, especially in the areas of education and careers.
- 78% of students indicate they would like to have a career at MGH.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Topic</th>
<th>Mentor’s Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>6th</td>
<td>What metals can you copper plate?</td>
<td>Molecular Biology</td>
</tr>
<tr>
<td></td>
<td>Which type of exercise makes you stronger?</td>
<td>Occupational Therapy</td>
</tr>
<tr>
<td></td>
<td>Is there a connection between depression and eating disorders?</td>
<td>Pediatric Medicine</td>
</tr>
<tr>
<td></td>
<td>How many bacteria can you find in your house?</td>
<td>Neurology</td>
</tr>
<tr>
<td>7th</td>
<td>Does smoking affect the circulatory system during exercise?</td>
<td>Surgery</td>
</tr>
<tr>
<td></td>
<td>DNA—What animal is related to T. Rex?</td>
<td>Neurogenetics</td>
</tr>
<tr>
<td></td>
<td>What are the effects of different environmental conditions on the growth of cells?</td>
<td>Endocrine</td>
</tr>
<tr>
<td></td>
<td>Why is washing hands important for surgery?</td>
<td>Neurogenetics</td>
</tr>
<tr>
<td>8th</td>
<td>What are effects of touch and massage?</td>
<td>Operating Room</td>
</tr>
<tr>
<td></td>
<td>How do people react when they receive testosterone?</td>
<td>Reproductive Endocrine</td>
</tr>
<tr>
<td></td>
<td>What are birthmarks, and how do they affect us?</td>
<td>Pathology/Dermatology</td>
</tr>
<tr>
<td></td>
<td>What is the effect of black light on color?</td>
<td>Buildings and Grounds</td>
</tr>
</tbody>
</table>

TABLE 2
Some Projects in the Science Fair Mentoring Program
• 71% of students report they are more interested in science than before the program.

• 80% of the students rated the chance to learn about research as great or good.

• When asked what they liked best about the program, students most often said “knowing their mentor” and “going to the hospital.”

• The mentors’ most common response about what they liked best about the program was their “relationship with their student” and “the satisfaction of teaching science to children.” Seventy percent felt they improved their teaching skills by working with these students, and over 50% felt they gained from the opportunity by performing a community service.

• 65% of the students reported having more confidence in carrying out a science experiment, and 66% of the mentors reported that students had increased confidence in carrying out a science experiment.

• 56% of students said they learned the scientific method through this program (as opposed to 9% in 1994–1995), while 76% of mentors reported that students had increased confidence in using the scientific method.

Both mentor and student comments included yearnings for more time to work together, although some mentors noted that they had trouble fitting the program into their demanding work schedule. Mentors felt that the mentor handbook, the student agenda book, the initial orientation, and the follow-up by school staff, all new elements of the program, were helpful supports. Students cited the assignments written by their mentor in the agenda book, the student handbook, and the presentation skills workshop as being their most helpful supports. Science faculty felt that facilitation by the school science coordinator, use of the student agenda book, communication with mentors, and the availability of e-mail all helped the program. MGH staff felt that students’ scientific skills and their self-confidence increased as a result of the mentoring program. Increased efforts to teach the scientific method were rewarded by better student understanding of what the scientific method entails.

The evaluation indicates that the MGH/Timilty Science Fair Mentoring Program has made strong progress in meeting program goals of supporting middle school curriculum, increasing academic achievement of early adolescent students, motivating students in their academic and professional goals, and bolstering students’ confidence in their capacity to achieve in the field of science.

As a result of the Science Fair Mentoring Program, the level of science education at the Timilty School has risen significantly since the program began in 1990. The number of students annually exposed to MGH science laboratories has risen from 12 in 1990–1991 to about 75 in 1995–1996. School-wide participation in the science fair has risen from 25% in 1990–1991 to 75% in 1995–1996. All Timilty students now perform hands-on science in Timilty classroom laboratories equipped with supplies and equipment from MGH.

DISCUSSION

Mentoring. Two types of mentoring relationships have been identified: “primary relationships,” which can be intense, involve strong commitment, and emotional openness, and “secondary bonds,” which are friendly but much less intense, more short-term, and more governed by structure, tangible goals, and boundaries (4). The MGH/Timilty Science Fair Mentoring Program falls in the latter category. It is highly structured, carefully facilitated, and focused on specific teaching goals, i.e., the teaching of the scientific method through the design and completion of a science fair project.

The elements that contribute to the success of the mentoring program include the structuring of tasks, which can be used as “scaffolding” for building relationships (4). Freedman (4) reports that it is imperative to offer support to mentors, not leave them in isolation. He also notes that paid support staff are key, and programs that rely on volunteer coordination tend to be less successful. Support staff are often the “glue” that keeps the disparate elements of the program flowing smoothly.
School-wide dissemination. More Timilty Middle School students apply for the Science Connection homerooms than can be accommodated. The school wants to spread out the benefits from the MGH mentoring experience. This year, two students who were mentored at MGH proceeded, on their own initiative, to share with their friends in other homerooms what they learned from their mentors about how to do a science fair project.

Timilty science teachers strive to have all students complete a science fair project. With 75 students mentored by MGH professionals, the teachers have more time to devote to helping the other students with their projects. Numbers of schoolwide participants have been increasing in recent years. Science teachers increasingly use more laboratory-type activities in the classroom because their students are more ready for this work after completing science fair projects. In 1996, for the first time, the assembly celebrating Science Fair achievement was truly a “whole school” event.

Follow-up. In 1996 the Partnership initiated the MGH/Timilty Partnership’s Science Alumni Network. The primary goals of this Alumni Network are to keep students connected to science through a variety of activities, maintain their interest in science during high school, and track the long-term progress of Science Fair Mentoring Program Alumni. Participants take after-school field trips and hear science-related speakers. They are offered support in learning about postsecondary education resources related to their science interests.

One former participant in the Science Fair Mentoring Program received full scholarships to two nursing schools and is presently pursuing her nursing degree. Another student won a prize at the Citywide Science Fair in 1996 and attributed his success to the MGH/Timilty Science Fair Mentoring Program.

Systemwide efforts. Boston, one of the nation’s major medical centers, has developed school-to-career programs in the health field through “ProTech” programs under the aegis of the city’s Private Industry Council. As of 1996, 12 Boston hospitals are involved with three public high schools in health ProTech programs. These programs offer academic course work that integrates topics from the health field into high school science courses. In the 12th grade, students work part time in the hospitals in their chosen career field while continuing their academic work in school. ProTech prepares college-bound students as well as non-college-bound students to become skilled workers in local hospitals. Most Boston ProTech graduates are inner-city students who attend Boston’s many colleges or universities.

With the existence of Boston’s health ProTech programs, students introduced to serious science through the MGH/Timilty Partnership now have pathways within the school system to pursue and maintain that interest throughout their high school years.

The new science curriculum in Boston represents current aspirations and goals for the teaching of middle school science in the Boston Public Schools. The MGH/Timilty Partnership works closely with the Boston Public School Science Department to share its curriculum and hands-on activities with other Boston Public School students and teachers. This includes conducting inservices for Boston Public School science teachers at the middle and high school levels.

Broader goals. In addition to teaching inner-city middle school students to use the scientific method, the MGH/Timilty Science Fair Mentoring Program responds to two broad societal needs. First, it helps prepare students from low-income neighborhoods for well-paying jobs, thus broadening their economic opportunities. Second, it helps combat the widespread scientific illiteracy that characterizes much of American society in this increasingly technological age (7, 8, 11). Science education programs, like the one described herein and others (2, 6, 10), bring science to life for young adolescents, help these youth develop an integrated picture of the physical world, and help them to become scientifically literate citizens (12). Such programs are crucial and will benefit us all.

This work was supported by a grant from the Howard Hughes Medical Institute.


Received 21 February 1997; accepted in final form 22 August 1997.
References