Cell Biology Education
Vol. 3, 162–180, Fall 2004

Articles

The University of Alabama at Birmingham Center for Community OutReach Development Summer Science Institute Program: A 3-Yr Laboratory Research Experience for Inner-City Secondary-Level Students

Marilyn A. Niemann,*† Michael L. Miller,* and Thelma Davis‡

*Community OutReach Development Center, University of Alabama at Birmingham, Community Health Services Building, 933 19th Street South, Birmingham, AL 35294; ‡AH Parker High School, 900 4th Street North, Birmingham, AL 35205

Submitted December 31, 2003; Revised March 23, 2004; Accepted March 25, 2004
Monitoring Editor: Eric Chudler

This article describes and assesses the effectiveness of a 3-yr, laboratory-based summer science program to improve the academic performance of inner-city high school students. The program was designed to gradually introduce such students to increasingly more rigorous laboratory experiences in an attempt to interest them in and model what "real" science is like. The students are also exposed to scientific seminars and university tours as well as English and mathematics workshops designed to help them analyze their laboratory data and prepare for their closing ceremony presentations. Qualitative and quantitative analysis of student performance in these programs indicates that participants not only learn the vocabulary, facts, and concepts of science, but also develop a better appreciation of what it is like to be a "real" scientist. In addition, the college-bound 3-yr graduates of this program appear to be better prepared to successfully academically compete with graduates of other high schools; they also report learning useful job-related life skills. Finally, the critical conceptual components of this program are discussed so that science educators interested in using this model can modify it to fit the individual resources and strengths of their particular setting.

Keywords: secondary, molecular biology, biochemistry, multiyear summer, research laboratory internship.

INTRODUCTION

University-sponsored summer high school science courses and research opportunities are certainly not a new idea. Such programs have existed since the late 1950s, when the launch of sputnik triggered the "space race" funding of many such National Science Foundation (NSF) summer science programs to interest more high school students in pursuing science as a career. In the past, however, most of these programs were limited either in duration or scope and were usually available to only a few select students.

The University of Alabama at Birmingham Center for Community OutReach Development (UAB CORD) Summer Science Institute is a 3-yr progression of summer programs that has long been the dream of our center. Students are introduced to basic scientific concepts and laboratory skills as rising sophomores, i.e., during the summer between ninth and 10th grade. These skills are then developed and extended as students become rising juniors, i.e., during the summer between 10th and 11th grade. Finally, they are assigned their own research project as rising seniors, i.e., during the summer between 11th and 12th grade. The "seed" for this program was planted more than 10 yr ago by UAB's Office of Minority Recruitment and Retention as the Summer Science Education program. In 2001, the CORD center assumed responsibility for and renamed it the student Research Internship program for rising seniors. It then went through a "growth spurt" in 2000 with the piloting of the rising sophomore student BioTeach program. Finally, it

DOI: 10.1187/cbe.03-12-0027
† Corresponding author. E-mail address: mniemann@uab.edu.
Marilyn Niemann was involved in both developing and implementing as well as compiling and analyzing the data assessing the effectiveness of this program.

"blossomed" in 2001 with the institution of the rising junior ChemTeach program, all of whose students were graduates of the previous year's BioTeach program. Thus, our vision of a 3-yr summer science laboratory program to train the next generation of scientists continues to thrive, and in 2003, we celebrated our second "graduating class." Consequently, now seemed an appropriate time to describe this program, discuss the philosophy underlying it, and assess its performance.

What is unique about this Summer Science Institute program is not only its initial appeal to inner-city youth from an underachieving school system, but also its retention rate, i.e., its ability to engage students in a multiyear commitment rather than for just a single summer (Crawley, 1998; Dooley *et al*., 2000). Its scope is also rather novel, beginning, as it does, with laboratory-based courses in molecular biology and biochemistry and culminating in individual summer laboratory research projects supported at each level with background scientific lectures, seminars, and University facility tours as well as data analysis and communication workshops. Its short-term goals are to 1) interest local high school students in pursuing a career in science and better prepare them for it, 2) give students a better idea of what it is like to do "real" science, and 3) teach students important science-related life skills, e.g., critical thinking; record keeping; verbal, written, and visual communication (Cox, 1998; Exstrom and Mosher, 2000; Moreno, 1999; NRC, 1998). The overall purpose of this program, however, is to develop improved approaches to learning that not only teach specific concepts, but also provide students with lifelong learning and problem solving skills (Evans *et al*., 2001; NRC, 1998). To determine if we have met these objectives, the following information derived from these first 3 yr of laboratory observations, individual discussions with facilitators and students, interviews with program supervisors, and responses to mentor/laboratory supervisor, facilitator, student, and course surveys and evaluations has been compiled and analyzed.

PROGRAM OVERVIEW

Student Profile

The Birmingham City School System is the largest city school system in Alabama. There are 65 schools: 33 elementary (K–5), 13 middle (6–8), 9 primary (K–8), and, as of the 2003–2004 academic year, 10 high schools that are attended by more than 34,000 students. Consequently, it has all the challenges typically associated with an urban district in the United States. During the 2001–2002 school year, 78 percent of the system's children came from families who were living below the poverty line, 58 percent came from single-parent families, and more than 95 percent were African Americans. Also, beginning with the class of 2002, students were required to pass both the mathematics and science subsets of the Alabama High School Graduation Exam (AHSGE), in addition to reading and language, to receive a diploma. The mathematics test assesses the students' ability to 1) perform basic operations on algebraic expressions, 2) solve equations and inequalities, 3) apply concepts related to functions, 4) apply formulas, 5) apply graphing techniques, 6) represent problem situations, and 7) solve problems, involving a variety of algebraic and geometric concepts. The science test assesses the students' knowledge of 1) the nature of science (scientific process), 2) matter (e.g., states, transfer, change, types), 3) diversity of life (e.g., classification, structure, function), 4) heredity (e.g., mutations, DNA, traits), 5) cells (e.g., structure, function, reproduction), 6) interdependence (e.g., populations, ecosystems), 7) energy (e.g., transformations, waves), and 8) force and motion (laws). More than 90 percent of the 2002 senior class was eligible to graduate, based on their results on this examination. Of these 1,700 students, 1,378, or 81 percent, indicated their intent to attend college, while 952, or 56 percent, were reported as "prepared to pursue a major in mathematics, science, or technology" (Birmingham Urban Program Annual Report, 2003).

Student BioTeach

Students are recruited from the above Birmingham high schools at the end of their ninth-grade year to participate in our student BioTeach program. By this time, most students have taken physical science but not biology. The rationale for offering the students a biology-based laboratory course at this time was to better prepare them for their 10th-grade high school biology course. We also hoped that such students could serve as "aides" to BioTeach-trained Birmingham high school science teachers, which is now a recommended summer professional development course for Birmingham high school biology teachers. The major acceptance criterion is that students demonstrate an interest in and aptitude for science. This is substantiated by, among other things, teacher recommendations, course selection and grades, extracurricular activities, and an interview.

This program is a 6-week, 3 d per week introductory laboratory and lecture course in molecular biology taught by UAB faculty and staff featuring 2- to 3 d-long experiments on microorganisms, DNA, genomes, protein crystallization, and viral antibody–antigen interactions. Students work in cooperative learning laboratory groups of six under the supervision of an NSF GK-12 fellow or high school science teacher facilitator (Moreno, 1999). To ensure that these laboratory experiments are as meaningful as possible, the students are provided with hands-on activities to make critical abstract concepts more understandable. They also participate in weekly mathematics workshops to help them analyze and interpret their experimental data and in English workshops to teach them to communicate these results effectively. Critical thinking is stressed in this course. Consequently, students are required to participate in a group debate at the end of the course. Each debate focuses on a moral or ethical issue raised by the technological advances in molecular biology illustrated by their laboratory experiments (Dooley *et al*., 2000; Evans *et al*., 2001; NRC, 1998). The students work in their laboratory cooperative learning groups and decide who will present each of the debate arguments. Three students argue the affirmative position, and three argue the negative position. Individual students arguing each position give their side's introductory remarks, another their rebuttal, and the third their summation. Finally, to compensate the students for the fact that they might have to choose between working or attending this summer science enrichment program, they are paid a $1,000 stipend upon the satisfactory completion of the course requirements. These course requirements include, but are not limited to, their debate presentation as well as facilitator evaluations; completion of individual laboratory, class, and homework assignments; ability to follow course rules and regulations, especially with regard to laboratory safety; and various accountability issues, such as attendance, as well as returning their laboratory coats, library cards, and identification badges at the end of the summer. Their debate presentation is assessed by the audience, who votes by clapping for the winning side of each debate, as well as a jury of science and English teachers, who select the first-, second-, and third-place group winners. The satisfactory completion of their other course requirements is assessed by their group facilitators, their "course master," and the program coordinator.

Student ChemTeach

Students who have successfully completed the preceding summer's student BioTeach course are invited back for the succeeding summer's ChemTeach course. The major re-admittance criteria are a favorable recommendation from their previous summer's student BioTeach facilitator and the satisfactory completion of the closing ceremony group debate requirement. Of the 19 students recruited for the inaugural summer 2000 student BioTeach program, 16 elected to return for the summer 2001 ChemTeach program, while 13 of the 18 summer 2001 BioTeach students chose to return for the summer 2002 student ChemTeach program, and 15 of the 18 summer 2002 BioTeach students chose to return for the summer 2003 ChemTeach program (Figure 1). New 10th-grade Birmingham high school students were recruited to fill vacancies. Again, the major acceptance criteria for these new ChemTeach students, like those for the BioTeach students, was a demonstrated interest in and aptitude for science. As in the student BioTeach program, such interest and aptitude was substantiated by, among other things, teacher recommendations, course selection and grades, extracurricular activities, and an interview.

This program, like the student BioTeach program, is a 6-week, 3 d per week intermediate laboratory and lecture course in biochemistry rather than molecular biology taught by UAB faculty and staff that features extended 2-week research units (Pratt, 1998) on protein purification, structure and function, and immunology. Students continue to work in cooperative learning laboratory groups of six under the supervision of an NSF GK-12 fellow or high school science teacher facilitator (Moreno, 1999). The major difference between this course and the students' previous BioTeach course is that student BioTeach experiments are shorter and essentially unrelated, whereas student ChemTeach experiments are longer and more intellectually challenging, and the data from succeeding experiments build on the results of the preceding ones, which is more like the way actual scientific research is done (Cox, 1998). To make these laboratory experiments more understandable, the students are also given two traditional daily classroom lectures by UAB "experts in the field," who provide relevant background information and explain the significance of each experimental unit. Thus, not only are laboratory experiments immediately put in a conceptual context by the lectures, but the experiment dictates the lecture, rather than just punctuating it. Thus, as in "real" scientific research, the need to know is driven by the experiment, not just illustrated by it (Moreno, 1999). In addition, as in student BioTeach, weekly mathematics workshops help students analyze and interpret their experimental data, while English workshops teach them to

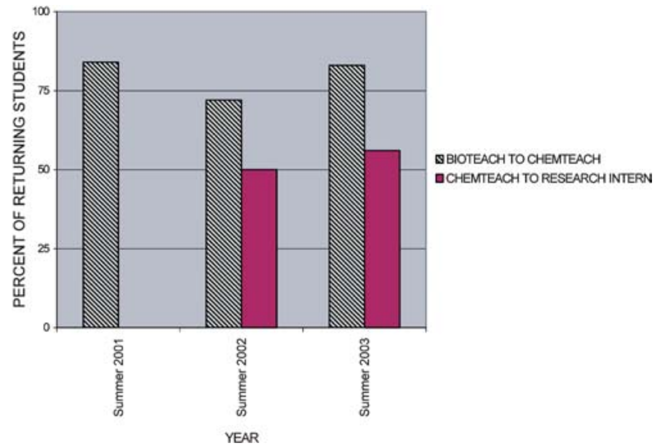


Figure 1. Percentage of preceding year's students returning for succeeding year's program.

communicate these results effectively. Record keeping is stressed in this course. Consequently, students are asked to present a group "research" talk that is based on their results from one of the 2-week experimental units at the end of the course (Dooley *et al*., 2000, Evans *et al*., 2001; NRC, 1998). The students work in presentation groups of three—one student from each laboratory cooperative learning group—so that each presentation group will have three sets of experimental data for their talk. Individual students from each group present their group's laboratory experiment introduction, another explains their methods, and the third explains their results as well as discusses their importance and/or significance. Finally, to compensate the students for the fact that they also might have to choose between working or this summer science enrichment program, ChemTeach students, like BioTeach students, are paid a $1,000 stipend upon the satisfactory completion of the course requirements. These course requirements include, but are not limited to, their laboratory experiment talk as well as facilitator evaluations; completion of individual laboratory, class, and homework assignments; ability to follow course rules and regulations, especially with regard to laboratory safety; and various accountability issues, such as attendance, as well as returning their laboratory coats, library cards, and identification badges at the end of the summer. Their laboratory experiment talk is assessed by a jury of research scientists and science educators who select the first-, second-, and third-place group winners, while the satisfactory completion of their other course requirements is assessed by their group facilitators, their course master, and the program coordinator.

Student Research Internship

Students who have successfully completed the preceding summer's ChemTeach course are invited back for the succeeding summer's Research Internship program (Lewis *et al*., 2002). Like the student ChemTeach course, the major re-admittance criteria are a favorable recommendation from their previous summer's student ChemTeach facilitator and the satisfactory completion of the closing ceremony group laboratory experimental talk. Of the 16 original summer 2000 BioTeach students who took ChemTeach in 2001, 8 chose to return for the summer 2002 Research Internship program, while of the 18 summer 2002 ChemTeach students, 10 chose to return for the summer 2003 Research Internship program (Figure 1). New 11th-grade students and, in exceptional cases, 12th-grade students are recruited to fill vacancies. Again, the major acceptance criteria for these new research interns, like those for the Bio- and ChemTeach students, are a demonstrated interest in and aptitude for science. As in the student Bio- and ChemTeach programs, this is substantiated by, among other things, teacher recommendations, course selection and grades, extracurricular activities, and an interview.

In this program, unlike in the student Bio- and ChemTeach courses, however, the number of student positions depends on the number of UAB research faculty and staff volunteers, rather than the size of the teaching laboratory. To encourage such volunteers, nonfaculty laboratory personnel are offered a $1,000 stipend to compensate them for the time and effort required to train and supervise these students. Interestingly, although all laboratories accepted this stipend, only 21 percent indicated that it was a "very important" factor in their decision to admit such a student in their laboratory. Participating departments have included: Anesthesiology, Biochemistry and Molecular Genetics, Biology, Biomedical Engineering, Cardiovascular Medicine, Cell Biology, Chemistry, Civil and Environmental Engineering, Electrical and Computer Engineering, Geographic Medicine, Gerontology, Medicine, Microbiology, Neurobiology, Pathology, Pediatrics, Pharmacology, Physical Therapy, Physics, Physiological Optics, Physiology and Biophysics, Preventive Medicine, and Psychiatry and Behavioral Neurobiology.

In addition, this program, unlike the student Bio- and ChemTeach courses, is an intensive 9-week, 5 d per week advanced seminar and laboratory experience in scientific research. The program begins with a week-long orientation that introduces students to research laboratory techniques and equipment through our current ½-d public and/or middle school forensic science laboratory activity. This is followed by our day-long high school DNA fingerprinting, sickle cell, and HIV (human immunodeficiency virus) McWane Science Center GENEius experiments. Each student then spends the next 8 weeks working on a laboratory project under the direction of UAB research faculty and staff (Moreno, 1999). In addition to laboratory research, students participate in weekly mathematics workshops designed to help them evaluate and use statistical analysis to present their experimental data as well as in English workshops to learn how to effectively communicate their results. Verbal, written, and visual communication is stressed in this course. Consequently, these interns are required to produce a professional-quality poster (Figure 2), i.e., one that would be acceptable for presentation at a professional meeting, not just a school science fair, as well as give brief scientific and lay oral presentations on their laboratory research results at the end of the program (Dooley *et al.*, 2000; Evans *et al.*, 2001; NRC, 1998). Their audience would include other interested fellow research interns and ChemTeach, BioTeach, and high school or middle school students participating in concurrent science-related CORD programs as well as invited parents and friends, high school teachers and administrators, community leaders, and university faculty and staff. Finally, to compensate the students for the fact that they might have to choose between working or this summer enrichment program, these research interns are also paid an $1,800 stipend upon the satisfactory completion of the course requirements. These course requirements include, but are not limited to, their poster presentations as well as mentor/supervisor evaluations; completion of individual English and mathematics workshop class and homework assignments; ability to follow course rules and regulations; and various accountability issues, such as attendance, as well as returning their laboratory coats, library cards, and identification badges at the end of the summer. Their poster presentations are assessed by a jury of research scientists and science educators, who select the first-, second-, and third-place individual winners, while the satisfactory completion of their other course requirements is assessed by their mentors/supervisors, their course master and supervising teacher(s), and the program coordinator.

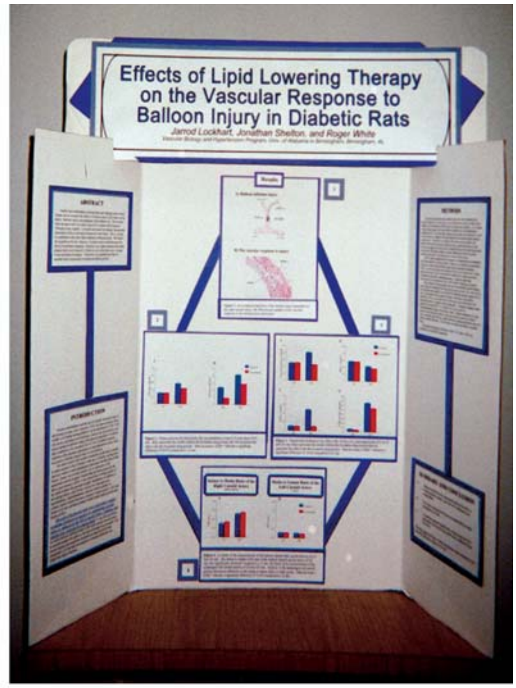
CRITICAL CONCEPTUAL COMPONENTS

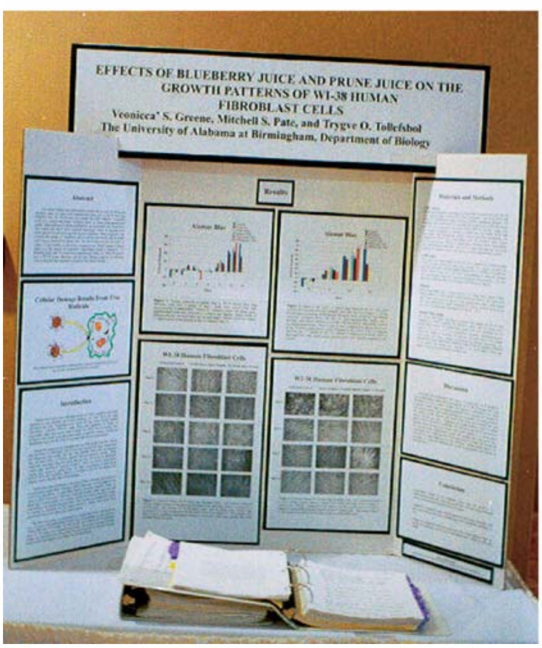
The Program Should Mimic the "Real" Scientific Experience

Experimentation is the most effective method of learning science. While doing experiments may not be as efficient as lecturing, when you delete the laboratory, only words remain, and science is not about words. After all, science textbooks themselves are simply the collected laboratory notebooks of the past. Doing laboratory work is fun and is the main reason that most scientists choose science as a career. The laboratory experience, furthermore, is essential, not just as a tool to learn science, but also as a method to learn life skills, e.g., planning ahead, organizing, problem solving.

Therefore, as much as possible, these programs try to "wean" the students away from the "cookbook" classroom science experiments to which they have become accustomed and introduce them to the more creative, inquiry-based approach of "real" scientific research (Cox, 1998). This includes, but is not limited to, teaching the students how to keep a laboratory notebook and encouraging them to objectively record their experimental observations as well as answer the critical thinking questions from their laboratory protocols (Moreno, 1999) and realize that all experiments may not work the first time or every time they attempt them (Lewis *et al.*, 2002). In addition, experiments begin with the most basic skills and concepts and build on them, sequentially culminating in their closing ceremony presentations, which are run like a scientific meeting (Evans *et al.*, 2001; Exstrom and Mosher, 2000).

The above transition process begins in student BioTeach. Here, although for the most part students continue just to follow standard laboratory protocols to complete experiments, they also perform state-of-the-art scientific experiments using equipment and technology that is not generally available to the average high school student (Cox, 1998; Exstrom and Mosher, 2000). In addition, during some experiments, such as the Parasite Genome module (http:/main.uab.edu/cord/show.asp?durki=54607), they collect meaningful research data that actually help advance scientific knowledge (Evans *et al.*, 2001). Thus, they finally discover the fun and joy of science. Not surprisingly, therefore, by the end of this course, almost all of the students say that they will be back next summer for ChemTeach.





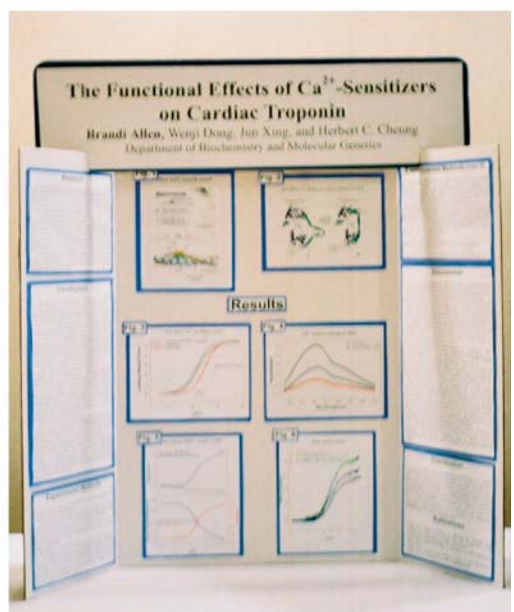


Figure 2. Sample research intern scientific posters. Upper left, first-place winner from 2000. Upper right, third-place winner from 2001. Lower left, representative poster from 2002. Lower right, representative poster from 2003.

The above transition process then continues in student ChemTeach, where again, students continue to follow laboratory protocols, although they are asked to answer more critical thinking and analysis questions than in student BioTeach (Moreno, 1999). In addition, while these students continue to perform state-of-the-art scientific experiments using equipment and technology that are not generally available to the average high school student (Cox, 1998; Exstrom and Mosher, 2000), the experiments are now more intellectually demanding (e.g., enzyme kinetics) as well as more focused and sustained. That is, the students spend the entire course investigating one fairly well-known and commercially important protein, collagen, from several different research perspectives (Moreno, 1999; Pratt, 1998), such as its purification, its structural role in the extracellular matrix, and its susceptibility to digestion by certain enzymes, and they immunologically determine its concentration in various organs as well as in commercial products. Not surprisingly, as the program becomes more rigorous, fewer students indicate that they will be back for the third and final year of the program. Thus, by the end of the student ChemTeach, only about half of the students report that they will be back the next summer for the Research Internship program.

The above transition culminates in their third and last summer with the student Research Internship program. In this program, student ChemTeach graduates are placed in UAB research laboratories. This student research internship course has been redesigned and integrated as the culminating laboratory experience in a comprehensive 3-yr summer high school student scientific research training program. Consequently, these students are now better versed in basic laboratory techniques than before and require less training and supervision (Table 1). They are able to make more of a contribution to their mentor's research program. Thus, we anticipate that having such a student in the research laboratory will eventually be considered an honor and a privilege, and we will have many more mentors applying for this program than available students.

We try to match the students' perceived research interests with the research focus of their assigned laboratories. A great bond of mutual respect and pride in their joint accomplishment is evident between the students and their mentor/supervisors during the closing ceremony poster presentations. This occasionally translates into continued professional relationships between them (Table 5b, Question 4). Indeed, one of our current goals for this program is to develop such "postgraduate" training/experiences for these students during their senior year summer to further assist them in their college/career choices. In fact, a few of our graduates have already entered UAB as undergraduates (Table 2) and have been offered fellowships to work in these programs as facilitators themselves (Crawley, 1998).

Science Is a Journey, not a Destination

Science is different from most other academic subjects in that it is as much about the process of discovery, i.e., the way the science is done, as about mastering its important vocabulary, facts, and concepts. Consequently, in this program, all learning is laboratory driven rather than lecture driven (Exstrom and Mosher, 2000; Moreno, 1999). That is, lectures are subordinate to the laboratory, which is the focal point of student learning. Thus, all activities, lectures, seminars, and tours are chosen to enrich the students' laboratory experiences. In addition, the mathematics workshop sessions teach the students how to analyze and interpret their experimental data, while the English workshop sessions teach them to communicate these results as effectively as possible during their closing ceremony presentations.

Science-Related Life Skills

There are several reasons why it is imperative that all high school students be literate in science (Moreno, 1999). Not only have major scientific discoveries always had long-lasting effects on society, but today, such technological advances are affecting our lives at an ever-increasing rate. Advances in medicine and changes in health care delivery systems, for example, now require that potential patients have sufficient medical knowledge to participate in making informed decisions about their own care and treatment. Many political decisions, such as regulations concerning the environment, also require an understanding of fundamental scientific concepts. In addition, many moral issues, such as what public health restrictions, if any, should be placed on the lifestyle of people who are HIV positive, require an appreciation of underlying scientific principles. Consequently, by learning how the scientific enterprise operates as well as applying the scientific method to everyday decision making, students can develop the life skills required for survival in our increasingly complex world. Thus, as previously detailed in the Program Overview description of each of the following programs, we emphasize critical thinking in preparation for the student BioTeach group debates, record keeping in preparation for the student ChemTeach group scientific talks, and verbal, written, and visual communication in preparation for the student research intern individual research poster presentations. In addition, although this program is basically a scientific enrichment experience and not just a job, we nevertheless try to teach the students basic job skills, such as showing up on time, calling in when sick or otherwise unable to attend laboratory sessions, dressing appropriately, being individually accountable within groups, working hard but with sufficient support to be able to produce a final presentation product that they can be proud of, and accepting the consequences of their actions (Tables 3a, 4a, 5a, Question 3).

Professional Development

In the quest to improve scientific literacy in precollege students, it is hard to imagine any better situation than scientists and teachers working together with students in an inquiry-based, hands-on program (Evans *et al.*, 2001; Moreno, 1999) like this Summer Science Institute. Consequently, the professional development goals of this program are not only to show NSF GK–12 science undergraduate and graduate fellows as well as university research mentors and supervisors how to teach science to high school students, but also to expose high school science teachers to the process and/or "habits of mind" as well as the current concepts of "real" scientific research (Derosa and Krauss, 1997). Our main source of facilitators for this program is the University NSF GK-12 teaching fellows. These fellows are required to have 10 contact hours per week with precollege students and to work anywhere from 1 to 5 d per week, depending on

Table 1. Mentor/supervisor assessment of research intern laboratory performance (2001–2003)

QUESTIONS

RESPONSES (% TOTAL STUDENTS)
R = Returning Students (20); N = New Students (30)

STUDENT INTEREST AND MOTIVATION

1. How engaged did the student appear to be in the lab work?
2. How motivated did the student appear to be?
3. How focused did the student appear to be?
4. Did the student ask questions?
5. What kind of questions did the student ask?

STUDENT LABORATORY SKILL-LEVEL

6. How well did the student read and follow written directions?
7. How well did the student listen to and follow oral directions?
8. Did the student use lab supplies, reagents, and equipment appropriately?
9. Did the student work "safely" in the lab?

STUDENT DATA COLLECTION AND ANALYSIS

10. Did the student record daily lab notes?
11. What was the quality of the student's lab notes?
12. Did the student include experimental data in the lab notebook?
13. Was data appropriately identified and labeled?
14. Did the student quantitatively analyze (e.g. graph) appropriate data?
15. How well organized was the student's lab notebook?
16. How neat was the student's lab notebook?

OVERALL STUDENT PERFORMANCE

17. How would you rate the student's understanding of the goals of his/her research project?
18. How well did the student work with other lab members?
19. What was the usual lab role of the student?
20. How well did the student complete assigned lab tasks?
21. How would you rate your student's overall performance in the lab during this summer?

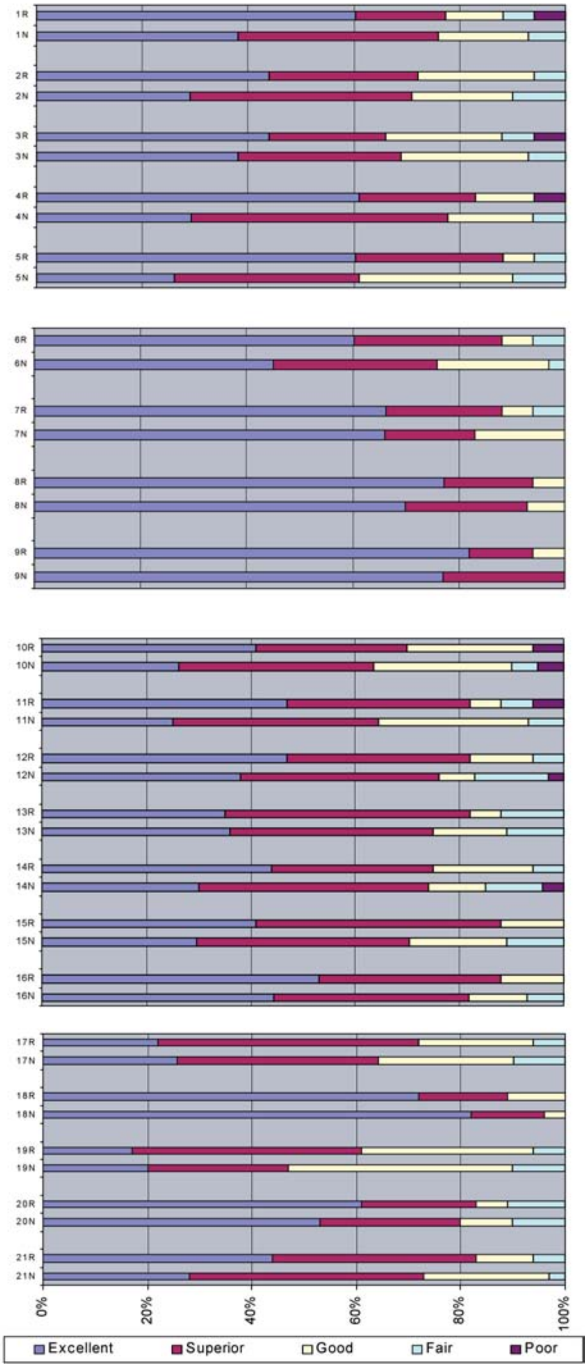


Table 2. Colleges/universities summer science institute graduates are attending

Year	College/university	State	Number	High school	Major	Fellowship
2000	University of Alabama at Birmingham	AL	1	Ramsay	Chemistry	SEPA
2001	University of Alabama at Birmingham	AL	3	Carver	Health-related professions	SEPA
				Huffman	Biology	SEPA
				Tarrant	Psychology	HPPI
2002	Alabama A & M	AL	2	Ensley	Biology	
				Parker	Engineering	
	Auburn	AL	1	Parker	Chemical engineering	Yes
	Berea College	KY	1	West End	Nursing	
	Clairmont McKenna	CA	1	Ramsay	Economics	
	The College of Wooster	OH	1	West End	Anthropology	
	University of Alabama at Tuscaloosa	AL	1	Ramsay	Pre-medicine	
	University of Tennessee	TN	1	Jackson-Olin	Chemistry	
	United States Marines		1	Parker	Forensic science	

their schedules. In addition, we have at least one high school science teacher working with the students in each course (Derosa and Krauss, 1997). Such teacher-facilitators are selected from graduates of our teacher BioTeach summer program. All these facilitators are under the supervision of a CORD "course master" or supervisor. All facilitators also undergo laboratory training under the direction of the appropriate CORD course master or supervisor before the course begins.

Each 2- to 3-d module of the student BioTeach course is under the scientific supervision of a CORD staff member, who is assisted by an NSF GK–12 fellow lead facilitator. They are responsible for the scientific execution of each laboratory. In addition, this CORD course master is responsible for overall teaching continuity by developing and presenting several "bridging" activities designed to make the key concepts of each module more understandable and interrelated to the students. This allows the high school science teachers the opportunity to see activities in action that they might then want to use in their own classrooms during the academic year (Cox, 1998). In addition, since the summer of 2002, the student BioTeach English workshop debate sessions have been taught by a high school debate teacher, while the mathematics workshop data analysis sessions continue to be taught by a university science-mathematics instructor.

Student ChemTeach is also under both the scientific and teaching supervision of a CORD staff member course master. This course master is again responsible for both the scientific and pedagogic aspects of this course. In keeping with our desire to gradually make these courses more scientifically rigorous, however, both the English and mathematics workshops are now taught by college-level instructors. Thus, for the participating high school science teacher(s), it is hoped that the Bio- and ChemTeach courses will model how science laboratories should and can be taught to high school students.

Finally, the student Research Internship program is again under the supervision of a CORD staff member course master. This course master is also responsible for both the scientific and pedagogic aspects of the program. In addition, both the English and mathematics workshops are taught by college-level instructors. By visiting all student research interns in their laboratory placement every week, this program's supervising teacher(s) will, it is hoped, become aware of the various types of research activities and facilities on campus and will utilize this network, not only in their own professional development, but also in inviting such professors to speak at their school(s) or bringing their science classes for appropriate campus tours during the school year (Derosa and Krauss, 1997).

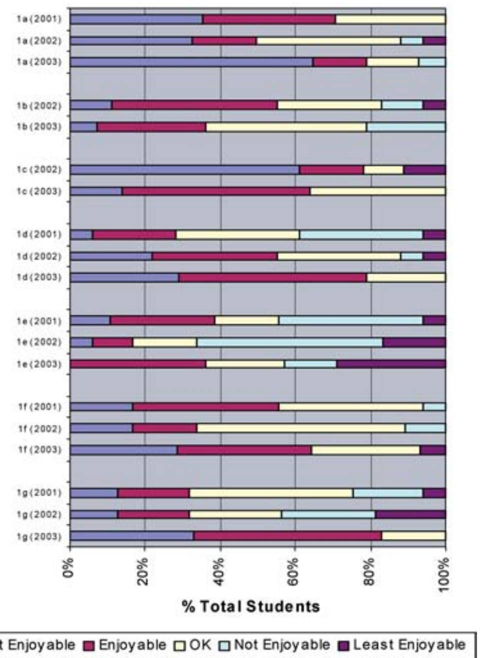
ARE WE ON THE RIGHT TRACK? ASSESSMENT AND EVALUATION

Do the Students Learn Science?

At the end of the summer 2001 BioTeach course, students were asked to write a brief description of what they had learned from each module. These evaluations indicated that they learned and retained a lot more about the individual experiments than might have been expected, especially given the "smorgasbord" nature of the course. For example, students reported learning that "The cloudier the cultures meant more bacteria" (from the Microbial Techniques module); "Certain places in DNA have a sequence where EcoR1 can cut the DNA" (from the Mealworm DNA module); "[the] Tsetse fly [carries] Sleeping Sickness, and it's kind of an epidemic in Africa" (from the Parasite Genome module); "Lysozyme is the stuff found in tears and the white stuff in eggs," "Gravity affects how the crystals form," and "You could grow better crystals in space" (from the Lysozome Crystallization module); "HIV goes into T cells," "When the count of T cells goes below 200 you are diagnosed with AIDS (acquired immunodeficiency syndrome)," "Most people die when they have HIV/AIDS because their immune system is so badly damaged they can catch other illnesses very quickly. So when that happens a common cold is very bad," and "...HIV is always changing itself..." (from the HIV module). In addition, the inclusion in 2002 of "bridging" activities rather than lectures to further illustrate and clarify such key concepts was reported to be "enjoyable" by many of the BioTeach students (Table 3a, Question 1b).

Although there is more "lecturing" in ChemTeach than in BioTeach and most students reported that this was not their "most enjoyable" program component (Table 4a, Question 1b), they also reported that the more informal daily laboratory lectures (Table 4b, Question 10) as well as the more formal scientific seminars (Table 4b, Question 11) were "informative" if not "interesting." Analysis of the content-

Table 3a. BioTeach student course evaluation

QUESTIONS	RESPONSES
1. Rate each of the following program components: a. Laboratory experiments b. “Bridging” activities c. Use of classroom computers d. English debate workshop e. Math data analysis workshop f. Scientific seminars g. Group debate presentation	

based post-test results also indicated that all students learned significant amounts of information about various aspects of the course and that almost every test question was answered correctly by somebody in the class, so that, as a group, these students successfully retained nearly all the information presented in the course (Figure 3). For example, in answer to a question on how you might purify and characterize an altered Alzheimer protein from the brain, one student wrote the following:

> I assume that the protein found in a normal brain are (sic) already known. Then of these Alzheimer brains we’d run extracts on a gel, then cut out the bands and sequence them. To be safe though we’d do the same with normal brains. We’d [normalize] the average amount of the different proteins found in the diseased brains, and the average amount of the different proteins found in the normal brains. If a protein(s) [difference] is found in the diseased brain we would then crystallize the protein to get its structure because we want to find its active site. We would then design synthetic [molecules] to inhibit [its function] by blocking the active site and counteract the effect of the protein.

All interns seemed to have a very positive research experience (Table 5b). Most rated their laboratory experience from “great” to “good” (Question 6). Most also reported that they “learned a lot” or that this program provided them with additional research opportunities and that they did things they did not think they were capable of (Question 4). For example, when asked to write a lay summary of their research for their high school newspaper, one 2002 student, a newcomer to our program who ultimately turned out to be our first-place poster winner, wrote the following:

> Hypertension or high blood pressure is a condition that involves increased pressure on the arterial walls. Over 60 million people have high blood pressure, including 32% of Alabamians. In my laboratory, we did research on arteriosclerosis and hypertension. Arteriosclerosis is actually a chronic disease in which thickening and hardening of the arterial walls impairs blood circulation. Atherosclerosis is a form of arteriosclerosis in which plaque containing cholesterol and lipids is deposited on the inner walls of the arteries. Basically, our research was trying to monitor aortas and how well they function under stress and injury. From my experience, I learned several scientific techniques involving laboratory rats. Rats and other animals are used because their organs function similar to ours. Observations were made on the relaxation and contraction rates of their aortas. This program was an overall good learning experience since I wanted to major in science.

Another 2003 3-yr graduate of the program wrote:

> This summer, UAB’s Community OutReach Development Center (CORD) gave me the opportunity of working as an intern in a real scientific laboratory. My placement was in UAB’s Wallace Tumor Institute and my mentors were Peter Burrows, Dettie Herren, and Haito Li. During my internship I worked on a project in which my experiment was based on cancer research. Since cancer is a serious and prevalent disease in the U.S., I took my experimental project seriously because who knows, maybe one day my research could take the world a step closer [to] finding a cure for cancer.

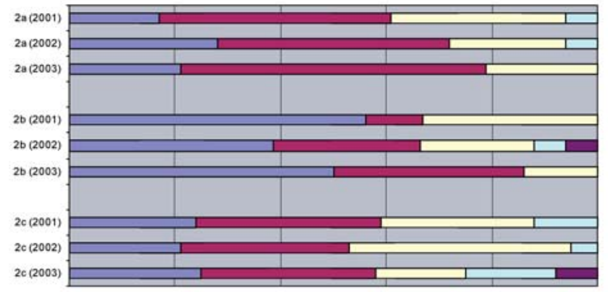
Table 3a. (Continued)

2. How much did you learn about the following "life skills"?

   a. Critical thinking

   b. Laboratory notebook record keeping

   c. Giving a formal public presentation



3. How much did you learn about the following "job skills"?

   a. Being on time

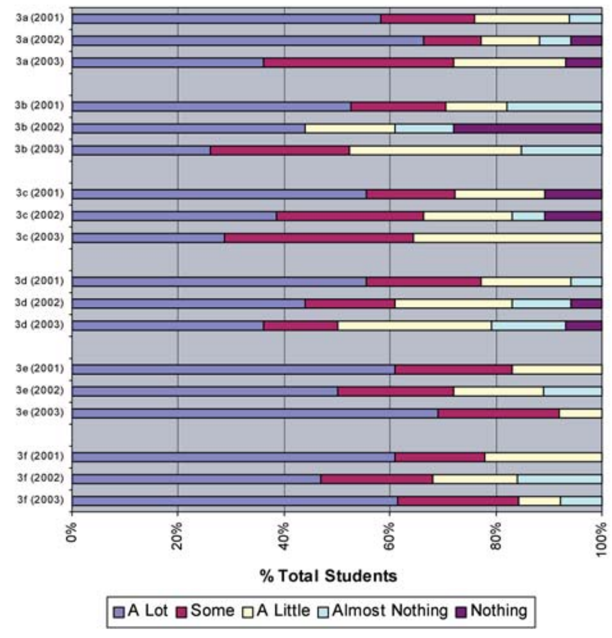
   b. Calling in sick

   c. Dressing appropriately

   d. Working independently

   e. Meeting deadlines

   f. Following rules and regulations



During my 9-week stay, I learned about the components of the body's immune system and how those components work together as a defense system against hazardous microbes. In particular, the components I mainly focused on were immunoglobulin alpha and immunoglobulin beta (Iga/IgB) associated with the class II major histocompatibility complex (MHCII) in B cells and in T cells. Growing cells was a big part of my job and it was my responsibility to keep those cells growing. Cells were the basis of my experiments and therefore I had to learn a great deal about them. The B cells in our bodies are designed to recognize foreign antigens. When these antigens are recognized, B cells bind to T cells through the MHCII molecule. Since Iga/IgB are associated with MCHII, they accompany one another to the surface of the B cell forming the B cell antigen receptor (BCR). It was my job to see if T cells express the same molecules on their surfaces as B cells do. This was done by stimulating cells with different antibodies designed to trick them into thinking that they were activated. Once the cells were activated I looked to see whether or not they expressed Iga/IgB. Sometimes my results weren't all that [good] but I guess that's why it's called experimental research.

Are the College-Bound Graduates of this Program Now Better Prepared To Successfully Academically Compete with Graduates of Other High Schools?

Not surprisingly, research interns who have been through all 3 yr of the Summer Science Institute program perform better than those who have not gone through such extensive training (Table 1). That is, not only is the mode of returning research interns' percent scores consistently higher than that of the newly recruited research interns, but it is often upshifted to an even more positive response. This difference is most pronounced, possibly because of our emphasis on critical thinking during their previous BioTeach and ChemTeach courses, in the number (Question 4) and type (Question 5) of questions the returning research interns ask their mentors/supervisors. In addition, returning research

Table 3b. BioTeach student course evaluation

Questions	Answers Percent total number of students **(Bold numbers indicate the mode)** 2003	2002	2001
4. How would you characterize your overall laboratory experience:			
a. Boring	0	18	0
b. A waste of time	0	0	0
c. Learned a lot	21	29	22
d. Did things I didn't think I was capable of	7	0	6
e. Provided me with a better idea of what it is like to be a "real" scientist	**71**	**53**	**72**

interns are reported to be considerably more engaged in their laboratory work (Question 1) as well as to demonstrate more leadership qualities in developing and working on their laboratory projects (Question 19) and produce, possibly again because of our emphasis on keeping good laboratory notebooks during their previous BioTeach and ChemTeach courses, higher-quality laboratory notebooks (Questions 10, 11). Returning research interns are also rated as being more motivated (Question 2), having higher overall performances (Question 21), and having a better understanding of the goals of their research project (Question 17). Interestingly, although there was almost no difference in the ability of all interns to listen to and follow oral directions (Question 7), returning interns were reported to be much better at reading and following written directions (Question 6) than newly recruited ones. Consequently, it is not surprising that many of our 2002 first-time 3-yr graduates of this program have gone on to pursue postsecondary educational training, most even in science (Table 2).

In follow-up questionnaires (Table 6), most of the 30 percent of responding students also reported that their Summer Science Institute experience helped them in their current high school science courses (Question 3) and anticipated that it would continue to help them in their college courses as well as in their future job or careers and adult life (Question 4). Students also reported that their specific Summer Science Institute experiences in learning laboratory techniques, keeping a laboratory notebook, and

Table 4a. ChemTeach student course evaluation

QUESTIONS — RESPONSES

1. Rate each of the following program components:
   a. Laboratory experiments
   b. Laboratory lectures
   c. Use of classroom computers
   d. English scientific talk workshop
   e. Math data analysis workshop
   f. Scientific seminars
   g. Tours (library, X-ray crystallography, etc.)
   h. Group laboratory experiment talk

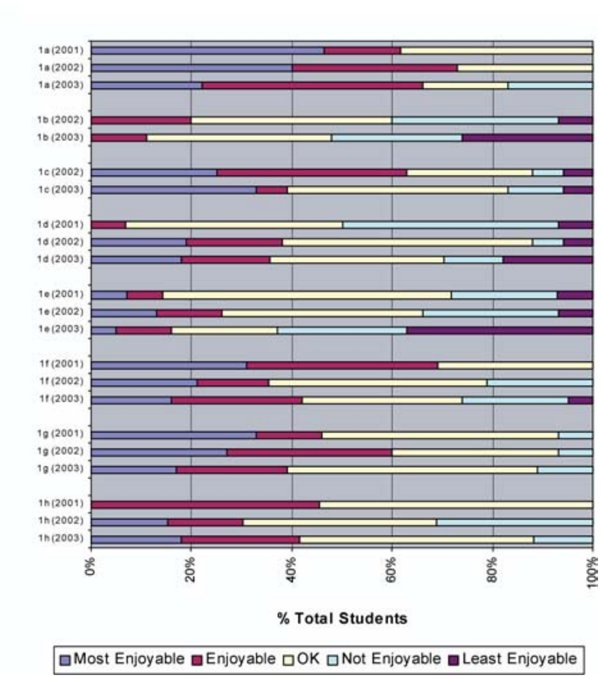


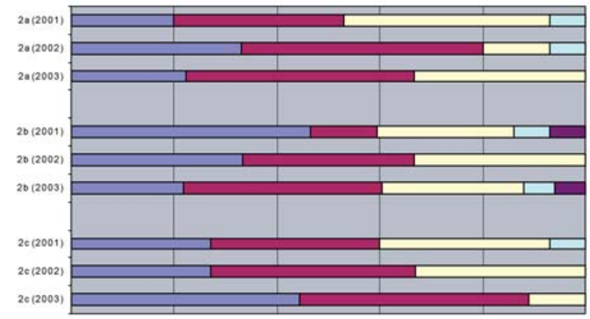
Table 4a. (Continued)

2. How much did you learn about the following "life skills"?

   a. Critical thinking

   b. Laboratory notebook record keeping

   c. Giving a formal scientific presentation



3. How much did you learn about the following "job skills"?

   a. Being on time

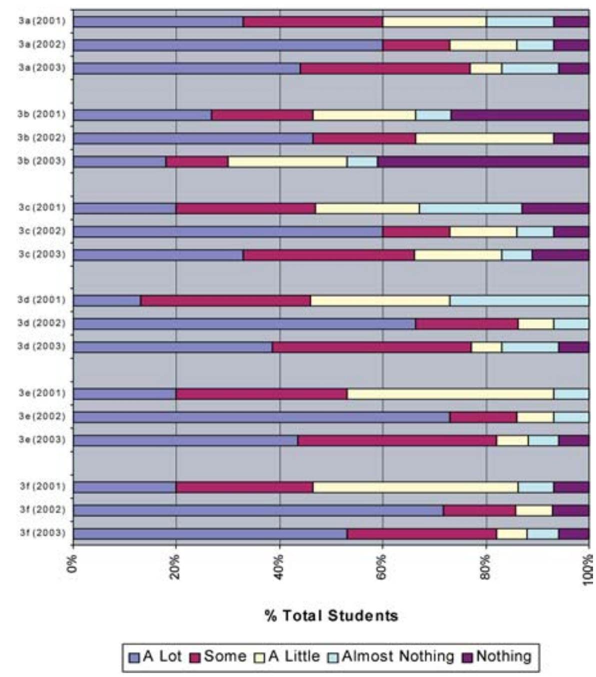
   b. Calling in sick

   c. Dressing appropriately

   d. Working independently

   e. Meeting deadlines

   f. Following rules and regulations



building real self-confidence as well as in the science-related life skills of critical thinking, problem solving, and communication were "very helpful" in their current school science courses (Question 5). Some student comments were: "My experience with the Summer Science [Institute] helped me a lot on the science part of the exit exam." "[The Summer Science Institute] made me more interested. Because I found out how fun that [school science courses] could be. They weren't at all boring." "I feel that I enjoy science more than I [used] to before enrolling in [The Summer Science Institute]." "It has changed my attitude toward science because I'm more excited about science and I want to know more." ". . .in the ninth grade I thought science was so boring. After the program, I found out what I want to major in college." "It is really good for minority youth to gain confidence and learn new things about science."

Does this Program Provide the Students with a Better Idea of What it Is Like To Do "Real" Science?

BioTeach students reported that their "most enjoyable" program components were the use of classroom computers and laboratory experiments, while their "least enjoyable" program component was the mathematics workshop (Table 3a, Question 1). In addition, when asked to characterize their overall laboratory experience, the majority of students responded that it provided them with a better idea of what it is like to be a "real" scientist, which was followed by the statement that they had learned a lot (Table 3b, Question 4). For example, one student wrote, "To help find cures and help

Table 4b. ChemTeach student course evaluation

Questions	Answers Percent total number of students **(Bold numbers indicate the mode)** 2003	2002	2001
4. Characterize your overall laboratory experience:			
a. Boring	0	0	6
b. A waste of time	0	0	0
c. Learned a lot	20	33	35
d. Did things I didn't think I was capable of	15	6	18
e. Provided me with a better idea of what it is like to be a "real" scientist	**65**	**61**	**41**
10. What did you think of the daily laboratory lectures:			
a. Interesting	14	25	6
b. Informative	**32**	**50**	0
c. Too technical	18	0	35
d. Too many	11	10	18
e. Too long	4	5	**41**
f. Boring	21	10	0
g. A waste of time	0	0	0
11. What did you think about the weekly scientific seminars:			
a. Interesting	22	27	21
b. Informative	**67**	**73**	**50**
c. Too technical	11	0	14
d. Boring	0	0	14
e. A waste of time	0	0	0

[do] research to help others, really gave me a new high. Furthermore, it gives you [an] understanding of what scientists are [trying] to do this day and age," while another wrote, "This program has brightened my view of biology and outlook on science telling me how important science is to [the] existence of man." Interestingly, possibly because this was the first time they were required to keep such extensive laboratory notes, the students felt that, of the science-related "life skills" (Table 3a, Question 2), they learned the most about how to keep a laboratory notebook. This was followed by thinking critically and giving a formal presentation. Similarly, ChemTeach students reported that their "most enjoyable" program component continued to be laboratory experiments, while their "least enjoyable" program components were the English and mathematics workshops (Table 4a, Question 1) The use of classroom computers, however, was now not quite so "enjoyable" as in BioTeach. Interestingly, even though the ChemTeach experiments were challenging, often demanding, and at times difficult, nearly all students successfully rose to the challenge. In addition, although a few experiments did not work well and some students who were accustomed to performing "simple" experiments with straightforward results became discouraged, others became completely engaged and volunteered to repeat experiments on their own (Lewis *et al.*, 2002). Again, despite the increased academic rigor of this course over BioTeach, most of the students, when asked to characterize their overall laboratory experience, continued to respond that it provided them with a better idea of what it is like to be a "real" scientist, followed by statements to the effect that they had learned a lot (Table 4b, Question 4). Somewhat surprisingly, considering our emphasis on record keeping in this course, the students seemed to feel that, of the science-related "life skills" (Table 4a, Question 2), they learned less about keeping a laboratory notebook in ChemTeach than they did in BioTeach. They also seemed to feel that they learned more about giving a formal scientific presentation, while their perspective about how much they learned about critical thinking remained about the same.

Research interns reported that their "most enjoyable" program components continued to be laboratory research, followed by the tours of various campus facilities (Table 5a, Question 1). Interestingly, although laboratory work was consistently the students' favorite component in each course, its "enjoyability" rating actually increased as the students advanced through the program and the science became more rigorous. The students' increased interest in UAB facility tours might also be indicative of increasing career interest. Tours of the Gross Anatomy Laboratory and the Critical Care Unit were rated "most interesting," while the Mentor/Supervisor Research Panel discussion was rated "least interesting" (Table 5a, Question 11). The interns' "least enjoyable" program component continued to be the mathematics workshop (Table 5a, Question 1c). Substantial improvement in the 2003 research interns' perceived critical thinking skills, however, was reported, compared with their 2001 BioTeach level. In addition, most of these students reported that they had finally learned how to give a formal scientific presentation (Table 5a, Question 2).

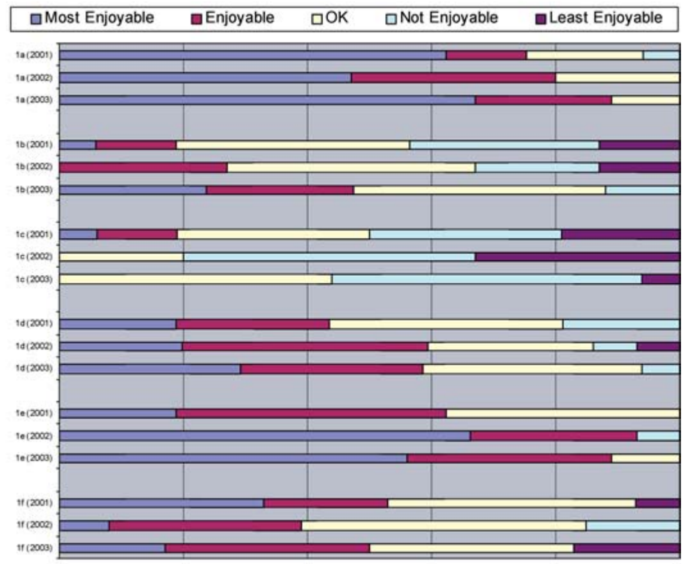
Do the Students Learn Other Useful Life Skills?

Although our goal was to improve the students' critical thinking skills in BioTeach, most students reported that the specific science-related life skill that they learned the most about was how to keep a laboratory notebook (Table 3a, Question 2). With the inclusion of weekly debate-specific English workshops taught by a high school debate teacher during the summer of 2002, however, not only was there an up-shift in the students' perceived "enjoyability" of the English workshop, there also was an up-shift in the students'

Table 5a. Research intern student course evaluation

QUESTIONS	RESPONSES (% TOTAL STUDENTS)

1. Rate each of the following program components:
   - a. Laboratory research
   - b. English scientific poster workshop
   - c. Math data analysis workshop
   - d. Friday scientific seminars
   - e. UAB facility tours
   - f. Poster presentation



2. How much did you learn about the following "life skills"?
   - a. Critical thinking
   - b. Laboratory notebook record keeping
   - c. Giving a formal scientific presentation

3. How much did you learn about the following "job skills"?
   - a. Being on time
   - b. Calling in sick
   - c. Signing in/out
   - d. Dressing appropriately
   - e. Working independently
   - f. Meeting deadlines
   - g. Following rules and regulations

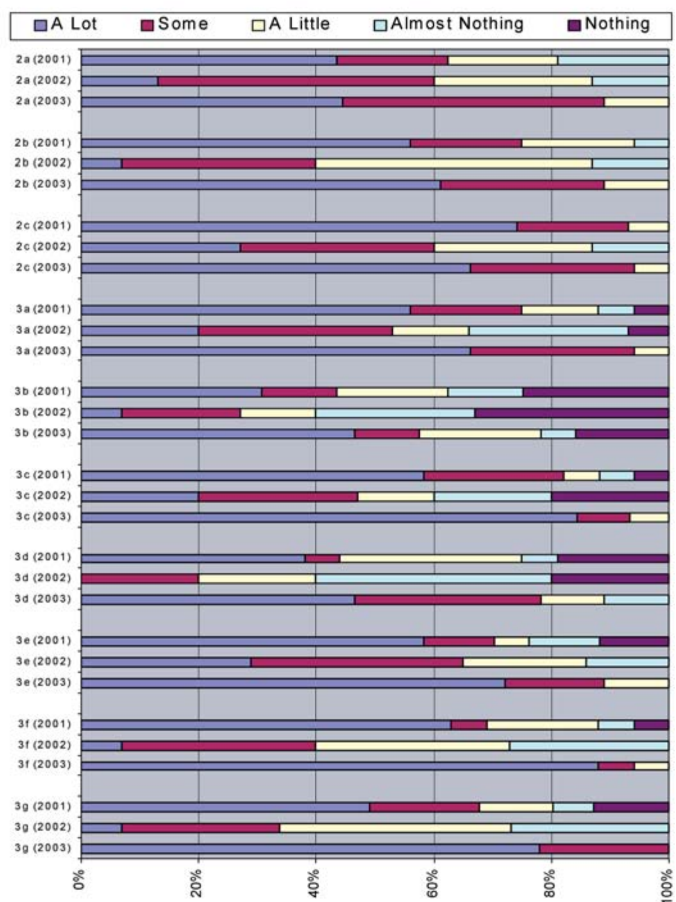


Table 5a. (Continued)

11. Rate the following UAB tours:

   a. Animal Facilities

   b. Hypertension clinic

   c. Gross anatomy laboratory

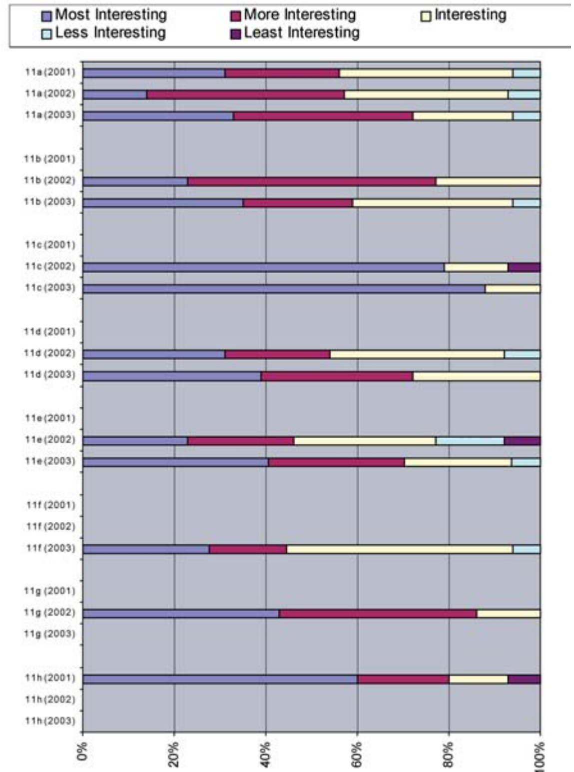
   d. Biomedical engineering laboratories

   e. Health related professions laboratories

   f. Mentor/Supervisor Research Panel

   g. Sickle cell clinic

   h. Critical care



perceived "enjoyability" of the group debate presentation (Table 3a, Question 1). In addition, most students reported learning "a lot" about other job-related skills, such as meeting deadlines, following rules and regulations, and being on time, as well as working independently, dressing appropriately, and calling in sick (Table 3a, Question 3). For

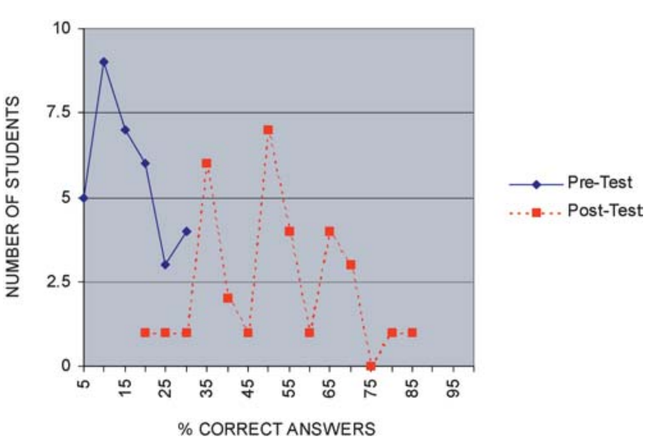


Figure 3. Percentage of pre- and post-test questions answered correctly by ChemTeach students.

example, one student wrote, "I learned a lot about how to work in the real world and I want to pursue a job in science in general or biology."

Since our goal in ChemTeach was to improve the students' record keeping skills so that they would be able to give a coherent group research talk based on their laboratory experiments, it was gratifying to discover that the 2003 ChemTeach students reported learning more about giving a formal scientific presentation (Table 4a, Question 2) than they did in their previous year's BioTeach course (Table 3a, Question 2). It was, however, somewhat disappointing that they also reported learning less about keeping a laboratory notebook. Perhaps they felt that they had already learned how to do this in their previous year's BioTeach course. In any event, most students again reported that they continued to learn "a lot" about other job-related skills, such as following rules and regulations, meeting deadlines, and being on time, as well as working independently, dressing appropriately, and calling in sick (Table 4a, Question 3).

Since our goal in the Research Intern program was to improve the students' verbal, written, and visual communication skills, it was very gratifying to discover that most of these interns reported that the specific science-related job skill that they learned the most about was giving a formal scientific presentation (Table 5a). It was also interesting to note how much more the 2003 research interns felt they had

Table 5b. Research intern student course evaluation

Questions	Answers Percent total number of students **(Bold numbers indicate the mode)** 2003	 2002	 2001
4. Characterize your overall laboratory experience:			
a. Boring	0	0	0
b. A waste of time	0	0	0
c. Learned a lot	25	**56**	**45**
d. Did things I didn't think I was capable of	30	17	23
e. Provided me with additional research opportunities	**45**	28	32
5. Characterize your supervisor/mentor:			
a. Helpful	47	33	47
b. Intimidating	0	0	0
c. Too busy to give you the guidance you needed	0	6	0
d. Did not let you take ownership of your project	0	0	0
e. Caring and concerned about your research progress	**53**	**61**	**53**
6. Rate your research laboratory for next year's research interns:			
a. Great	**61**	**33**	—
b. Good	33	**33**	—
c. Fair	6	27	—
d. Poor	0	7	—
e. A waste of time	0	0	—
7. What did you think about the weekly scientific seminars:			
a. Interesting	17	27	25
b. Informative	**84**	**67**	**50**
c. Too technical	0	0	20
d. Boring	0	7	5
e. A waste of time	0	0	0

learned about critical thinking than in their previous 2002 ChemTeach and 2001 BioTeach courses (Tables 3a, 4a, 5a, Question 2). In addition, even higher-mode percentages of these students reported learning "a lot" about other job-related skills, such as meeting deadlines, following rules and regulations, working independently, and signing in and out, as well as being on time, dressing appropriately, and calling in sick, suggesting that these skills do indeed need to be re-emphasized each year of the program.

CHANGE OVER TIME

Like any pedagogic endeavor, this program is a dynamic, not a static, process. It has been and will continue to be, like the science it tries to teach, constantly evolving and changing in order to be responsive to the needs of its students as well as to take advantage of the expertise and talents of its facilitators. Change is inevitable. We hope, however, that such change has led and will continue to lead to improvement, as the administrative goal of this program is to make it so well organized and easy to run that it will continue well beyond the tenure of those of us who developed, piloted, and tested it.

Addressing Perceived Student Weaknesses

Overall student satisfaction with this program appears to be high. No research interns have ever reported being "bored" (Table 5b), and only 6 percent (Table 4b), or one, of the 2001 ChemTeach students and 18 percent (Table 3b), or three, of the 2002 BioTeach students have reported being "bored." Coincidentally, this is the same number of BioTeach students who typically choose not to continue in the program. Since these evaluations are anonymous, however, we cannot be sure whether or not these students are one and the same. Alternatively, perhaps we did not adequately screen these students that year. Regrettably, especially in this 15-year-old age group, some apparently very good students sign up for this course primarily for the money, not because they are really interested in learning more about science. One of these "bored" BioTeach students consistently rated all aspects of this course poorly, while the other two just seemed to think that "lecturing" was "boring." To address this possibility, we introduced the hands-on "Bridging Activity" in 2003 to decrease the amount of "lecturing" necessary to teach the important scientific concepts in this course. Interestingly, the one "bored" ChemTeach student also rated several other aspects of this course as "less enjoyable" but nevertheless characterized the overall laboratory experience as one in which he or she had "learned a lot" as well as "boring."

As in any educational endeavor, we try to balance what we feel we "must" teach the students with what we feel may be the best and/or "most enjoyable" way for the students to learn. Not surprisingly, as reported above, a good way to do this in BioTeach seems to be with activities rather than lectures. In keeping with our desire to make ChemTeach more academically rigorous, however, we have increased the amount of "lecturing" to be more in keeping with what the students might experience in college. One disturbing possible consequence of this strategy, however, seems to be an increasing trend in the percentage of ChemTeach students who perceive that these daily laboratory lectures are

Table 6. Summer science institute student tracking questionnaire

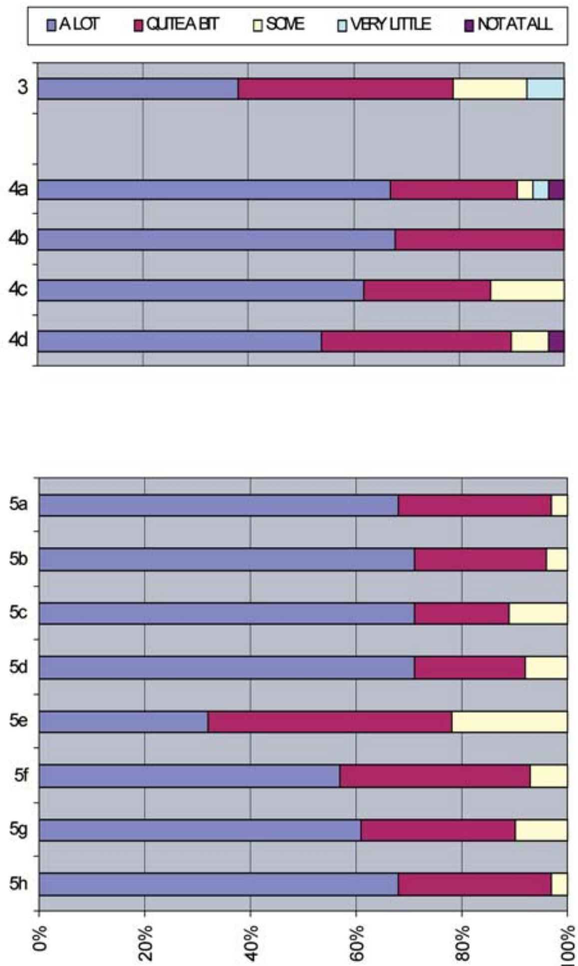
QUESTIONS

3. How much do you feel your Summer Science Institute experience has helped you in your current science courses?

4. How much do you anticipate that your Summer Science Institute experience will help you in your:
   a. future high school science courses
   b. future college science courses
   c. ultimate job or career
   d. adult life as an informed citizen

5. Which of the following aspects of your Summer Science Institute experience have you found to be most helpful in your current school science course(s)?
   a. knowledge (concepts, facts, vocabulary, etc.)
   b. laboratory techniques
   c. keeping a laboratory notebook
   d. scientific communication
   e. statistical analysis of data
   f. problem solving
   g. critical thinking
   h. building self confidence

RESPONSES (% TOTAL STUDENTS)



"boring" (Table 4b, Question 10). Perhaps after 3 yr, the lecturers are also getting a little "bored" with their presentations. Consequently, in an effort to address this perceived student weakness, we have selected and will be training a new ChemTeach course master this summer.

Whenever individual supplementary program components, such as specific seminars and/or tours, are perceived as "not interesting" by a substantial number of students, we try, if possible, to replace that component with one we hope the students will find more interesting and/or useful. There are, however, several aspects of each course that are immutable if we are to meet the experiential goals of this program, such as the English and mathematics workshops as well as the closing ceremony presentations. Our biggest challenge in this regard has been the mathematics workshops (Table 3a, Question 1e; Table 4a, Question 1e; Table 5a, Question 1c), even though our original instructor had developed many excellent practical activities that illustrate some of the more difficult mathematic concepts for the students. Consequently, in an effort to address this perceived student weakness, we have again selected and will be training a new BioTeach/ChemTeach mathematics instructor this summer.

Evolution of the English and Mathematics Workshops

As stated in the Introduction to this paper, the CORD Research Internship component of the Summer Science Institute began in 2001 as an outgrowth of the previously existing UAB Office of Minority Recruitment and Retention Summer Science Education program. Consequently, when we took over the administration of this program, we also inherited the English workshop poster preparation and presentation tradition from two very capable members of the English department. They literally showed us how it was done. For the sake of simplicity, therefore, the inaugural 2001 ChemTeach closing ceremony presentation was also a group poster presentation. In addition, the previous summer's inaugural 2000 BioTeach class was required to write a library research paper on one of the experimental modules covered in their course. This requirement, however, did not seem dynamic enough for our envisioned closing ceremony. In keeping with the integrated progressive philosophy of this newly established Summer Science Institute, we therefore substituted a group debate for the individual research paper requirement.

During the second 2002 year of this institute, the research intern poster English workshop was taught by two English graduate students following their predecessors' "lesson plans" as modified by the scientists among us. In addition, to cover the entire gamut of forms of scientific communication, these instructors taught the ChemTeach students, again from "lesson plans" provided by the scientists among us, how to write a group scientific paper and present a group scientific talk on one of their experimental units. This task, however, proved to be a little overwhelming, not only for the students but also for the instructors. Fortunately for our 2002 BioTeach students, however, we were able to locate a high school debate teacher who was willing to teach their English workshops. This, as you can see from the student survey (Table 3a, Question 1d), greatly enhanced and continues to enhance student satisfaction with this course requirement.

After the above series of trials and errors, we came to the conclusion in our 2003 Summer Science Institute that the best organization for our English workshops was to have a high school debate coach teach the BioTeach sessions, while the course masters of the ChemTeach and Research Internship programs teach their scientific talk and poster English workshops, respectively. Thus, in our ChemTeach English workshop, the students begin by writing a laboratory report; they then compare and contrast the information presented on the same scientific discovery as reported in the original journal article, a science magazine, such as *Scientific American,* and a reputable newspaper, such as the *New York Times.* Next, they learn what information is presented in the different parts, i.e., Abstract, Introduction, Materials and Methods, Results, and Discussion, of a scientific paper/talk by studying several journal articles. Finally, the students are instructed and shown how to give a scientific talk as well as how to practice for their own. These activities are coupled with seminars and tours on how to use the campus libraries; they also include laboratory meeting sessions during which the students orally present a library paper that they have written on their experimental background as well as discuss their group's laboratory data. In our research intern English workshop sessions, the students then build on what they learned in ChemTeach by spending the first half of the course learning how to prepare and present the various parts of a scientific poster, i.e., the Abstract, Introduction, Materials and Methods, Results, and Discussion, by collecting data (e.g., Is a person's height related to the number of hours of sleep he or she gets each night) and producing a group "mock" poster proving or disproving their hypothesis, which is evaluated and critiqued by their facilitators and peers. They then spend the last half of the course putting together and presenting the various sections of their own research poster—first deciding on a title, next writing an introduction, then describing the methods they used, and finally discussing at least one quantitative figure of their results.

Because science and mathematics are so interdependent, we also wanted to incorporate a mathematics component into this program. Therefore, during the inaugural 2001 Summer Science Institute, we included a statistics session in all three programs. We felt that such a course would be the "lowest common denominator" to unify the diversity of laboratory experiments and research projects in this program and yet still be of interest and use to the greatest number of students. Interestingly, possibly because of a systemwide curricula emphasis on mathematics that academic year, that summer's students seemed to most enjoy and be the best prepared for their mathematics workshop sessions (Table 3a, Question 1e; Table 4a, Question 1e; Table 5a, Question 1c). Consequently, the statistical analysis of data has continued to be the focus of our research intern mathematics workshop. During that inaugural summer, however, it also became clear that the BioTeach and ChemTeach students were not analyzing their laboratory data. Consequently, in keeping with our desire to gradually make this program more rigorous as well as progressively build on the preceding years' knowledge, during the 2002 Summer Science Institute, we decided to redesign our BioTeach and ChemTeach mathematics workshops to teach the students how to quantitatively express, analyze, and, most importantly, draw conclusions from the data they collected each week. Nevertheless, students continued to rate the mathematics workshop component of each program as the "least enjoyable." During the 2003 Summer Science Institute mathematics workshops, therefore, we tried not only to teach the BioTeach students how to analyze their laboratory data, but also how to select and/or construct their required presentation graphs from that information that supported their debate arguments, while in ChemTeach, we developed activities using lemon juice and/or food coloring to illustrate how to make serial dilutions and used scientific notation, i.e., understanding very large and very small numbers, and candy to demonstrate the principles of enzyme kinetics. In addition, we added a "lab math" session to our orientation week to teach the research interns some of their mentor/supervisor-requested mathematics skills, such as how to make up various kinds of solutions and calculate the size or concentration of unknowns from a standard curve.

Course Master/Facilitator Training

Course masters are selected by the program coordinator from volunteering university CORD scientific staff for the Summer Science Institute at the beginning of the year. Since all course masters are scientists, they generally have the scientific background necessary to understand and supervise the laboratory experiments. Planning meetings to discuss and coordinate course content and administrative details are held by the workshop instructors as well as by the course masters and the program coordinator as required. These course masters are next trained in the specifics of their course a month or so before the program begins by the developer of each of the program's experiments. For example, each of the BioTeach module developers trains the BioTeach course master, along with an NSF GK–12 fellow lead facilitator, how to do the required experiment; the ChemTeach course master is similarly trained in the 2-week experimental units of ChemTeach by its developer. In addition to making sure that the laboratory experiments run as smoothly as possible for the students, the course masters' main responsibility is to provide the students with an explanation of how the preceding experiment leads to the succeeding one, as well as to point out the everyday relevance of these experiments to the students. Additional facilitators are trained during ½-d sessions the week before the program begins by the appropriate course master.

Future Directions

Because of the lack of available laboratory space on campus, from 2001 to 2002, we conducted the Bio- and ChemTeach courses at the newly constructed, state-of-the-art George Washington Carver Birmingham City High School. It has superior, although limited (no gas, cold room, etc.), teaching laboratories as well as excellent computer facilities (two classrooms containing 24 computers as well as three computers in each laboratory classroom). Its nonuniversity location, however, made laboratory supply, reagent, and equipment transfers tedious, and it was therefore more difficult to recruit university volunteers. Now that our new campus laboratories and classrooms have been renovated, starting in 2003, we were able to conduct the entire program from the university. All of the facilitators and most of the students indicated that this was an improvement. Many students apparently felt that attending the university for the summer is more impressive than attending another high school.

An average of 60 students participate in this Summer Science Institute each year. Since 2001, therefore, almost 200 rising 10th-, 11th-, and 12th-grade students have completed this program. In addition, we always have many more students applying than we can accept into this program. For example, in 2003, we had more than three times as many students apply for our BioTeach program as we could accept, about 10 times as many ChemTeach applicants, and almost twice as many research interns. Consequently, we hope that our new campus facilities will eventually allow us to double the number of students in this program. Such an increase should have more of an impact on the overall science education within the Birmingham City School System. We also eventually envision recruiting students from the more affluent suburban school districts and perhaps charging them a minimal "tuition" to help offset the stipends we pay the Birmingham City School students.

Finally, although the university will always have a scientific consultant role in this program, we hope that the Birmingham City School System will eventually be able to assume some administrative and financial responsibility for this program, since, once established, this program should be fairly self-sustaining (Lewis *et al.*, 2002). Judging from the response of the school board to an abbreviated special presentation of student closing ceremony talks in 2001, there is much political enthusiasm for such an expansion of this program. This would then free up our resources to develop analogous programs for Birmingham middle school students.

ACCESSING MATERIALS

We hope that interested parties will find the additional detailed and specific "lesson plan" information for these individual programs posted on our following Web sites helpful:

For an overview of the Summer Science Institute programs: http://main.uab.edu/cord/show.asp?durki=38595

For an overview of the student BioTeach program: http://main.uab.edu/cord/show.asp?durki=38811

For the student BioTeach Parasite Genome module protocol: http://main.uab.edu/cord/show.asp?durki=54607

For an overview of the student ChemTeach program: http://main.uab.edu/cord/show.asp?durki=37821

For an overview of the student Research Intern program: http://main.uab.edu/cord/show.asp?durki=37822

ACKNOWLEDGMENTS

We would like to thank all our fellow CORD program directors, UAB research faculty mentors, laboratory supervisors, course masters, lead facilitators, assistant facilitators, teachers, technical assistants, judges, lecturers, workshop instructors, seminar speakers, administrative staff, students, parents, and anyone else who contributed in any way to the development, support, and implementation of this program.

We would also like to thank Spencer Horn for supplying us with the demographic data on the Birmingham City School System, Jonathan Williams for secretarial assistance, Kit Hodge text editing, Anita Saxena for help with cropping the photographs, Melanie Venable for help in formatting the tables and figures, Eric Blackwell for help with the electronic submission of the manuscript, and Lee Meadows and Joseph Baggott for their critical reading of the manuscript.

These Summer Science Institute programs were supported by funds from the UAB provost office, the UAB CORD center, the National Institutes of Health Science Education Partnership Award (SEPA) grant R25 RR15633, the National Science Foundation GK-12 grant 0139108, the Robert Wood Johnson Foundation, and Holt and Gretchen Cloud.

REFERENCES

Birmingham Urban Program Annual Report (2003). Montgomery, AL: Alabama State Department of Education.

Cox, A.M. (1998, March). The scientist's apprentice. Sci. Teacher *65*(3), 39–41.

Crawley, P. (1998, March). Extracurricular opportunities. Sci. Teacher *65*(3), 37–38.

Derosa, D.A., and Krauss, R.D. (1997, October). Scientist/Educator partnerships provide rich learning opportunities. Scientist *11*(21), 9–10.

Dooley, E., Bardwell, G., and Bethea, C. (2000, March). Mentors in medicine. Sci. Teacher *67*(3), 36–39.

Evans, C.A., Abrams, E.D., Rock, B.N., and Spencer, S.L. (2001, May). Student/Scientist partnerships. A teacher's guide to evaluating the critical components. Am. Biol. Teacher *63*(5), 318–323.

Exstrom, C.L., and Mosher, M.D. (2000). A novel high school chemistry camp as an outreach model for regional colleges and universities. J. Chem. Educ. *77*(10), 1295–1297.

Lewis, J.R., Kotur, M.S., Butt, O., Kulcarni, S., Riley, A.A., Ferrell, N., Sullivan, K.D., and Ferari, M. (2002). Biotechnology apprenticeship for secondary-level students: teaching advanced cell culture techniques for research. Cell Biol. Educ. 1, 26–42.

Moreno, N.P. (1999, July). K-12 science education reform—a primer for scientists. BioScience *49*(7), 569–576.

[NRC] National Research Council. (1998). Every Child Is a Scientist: Achieving Scientific Literacy for All. Washington, DC: National Academy Press.

Pratt, H. (1998). Focusing on achievement: lessons from the TIMSS report. Sci. Teacher *65*(3), 30–33.