Title
Biomedical Research Mentorship: The Young Investigators' Innovative High School Program

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Introduction

The Need for Mentorship

As students enter junior high school and are exposed to career planning, some students choose science as a possible career. Yet, if these students are asked "What does a scientist do?," many have little or no idea about what a career as a research scientist entails. There are also students who do not choose a career in science because they have not been truly exposed to science or the scientific process. As students continue into their high school years, most college bound students take chemistry, biology, physics, or other integrated science courses. These are classes that routinely perform structured laboratory experiments in the classroom setting. These labs, however, primarily use a "cookbook" approach in which all steps of the experiment are outlined for the student, rather than being research based. Students also have little or no exposure to the technical instruments used in research (Turner et al, 1998). In order to stimulate interest and curiosity in the basic sciences, it is necessary to expose interested students to the research process. One way of granting students such exposure is through mentorship.

Mentoring relationships have been around for a long time, perhaps even predating Socrates and Plato. Such relationships provide role models for the students (Russ, 1993; Guthrie and Wynne, 1971) and offer them opportunities not available through standard educational curricula (Beck, 1989; Guthrie and Wynne, 1971). These programs not only clarify future goals for the student, but help increase personal and academic growth (Davalos and Haensly, 1997; Ritchie and Rigano, 1996; Guthrie and Wynne, 1971).

The Young Investigators' Program

The Young Investigators' Program was initiated by Dr. Cynthia Husted in 1996 with the aim to provide high school students who have a strong interest in the biological sciences with the opportunity to participate in a multidisciplinary approach to scientific research and inquiry. The program was coordinated through the Neuroscience Research Institute's Center for the Study of Neurodegenerative Disorders at the University of California at Santa Barbara and the Santa Barbara High School District. The Young Investigators' Program introduced high school juniors and seniors to research scientists and placed them in a lab for at least one academic year to conduct original research. One of the goals of the program was to recruit and expose students from underrepresented groups, i.e. females and minorities, to the university setting and scientific research. This program showed students the dedication and commitment necessary to pursue a career as a scientific researcher, and that the goal of being a scientist is attainable.

The Young Investigators' Program had five primary aims: 1) provide pre-college students with the opportunity to participate in state-of-the-art research and acquire original data, 2) emphasize a multidisciplinary approach to problem solving, 3) provide a forum for young students to explore their scientific interests, 4) encourage students to pursue scientific careers, and 5) offer pre-college students exposure to university-level work, in terms of both academics and research. Each of these goals were approached in the context of biological sciences, giving students from Santa Barbara high schools a biological and biomedical alternative to the physical sciences approach available through another successful high school mentorship program offered at the University of California, Santa Barbara, the Apprentice Researchers at QUEST Program (Bressler-Hill and Goodchild, 1993).

Methodology

The format of the Young Investigators' Program evolved a great deal over the course of its first three years of existence. The original pilot program began in the summer of 1996 with a very informal curriculum. The format of the third and fourth years were a direct reflection of the lessons learned in its first two years.

During the third year, the program was managed by two full time coordinators, who designed a formal curriculum for the participating students. Funding for the program was provided through grants from the Howard Hughes Medical Institute, the University of California Biotechnology Program, and the Apprentice Research at QUEST program. Laboratory and meeting facilities were donated by the Department of Molecular, Cellular and Developmental Biology at the University of California, Santa Barbara and the Neuroscience Research Institute. All mentors generously volunteered their time.

Each year, the program was initiated by informational visits to the four local high schools, in which the program coordinators introduced the program to interested potential applicants. Advanced Placement biology and chemistry classes were most often visited, although students not in such courses were also encouraged to attend the informational meetings. Because of the large target group, a formal application process was used. Applicants were required to answer several short essay questions, obtain two letters of recommendation, submit official transcripts and SAT scores, and attend a formal interview. Since past students were typically involved in many extracurricular activities aside from the Young Investigators' Program, it was often difficult for some students to set aside enough time for consistent attendance during the school year. This was addressed during recruitment lectures and applicant interviews, in which the necessary time commitment during the school year was made specifically clear. Only those students willing to make their participation a priority were encouraged to apply.

A total of seventeen students from Santa Barbara high schools participated in the Young Investigators' Program since its inception. Of these, fifteen students were seniors and two were juniors. The students' mean age was 17 years. All students were enrolled in college preparatory courses in high school. The Young Investigator's Program also strived to maintain a strong element of diversity in its students. Of the seventeen students, 17.6% were of Middle Eastern descent, 17.6% were Asian-American, 11.8% were Chicano, and 52.9% were Caucasian. 47.1% of the students were women. Students were selected on the basis of academic merit, enthusiasm for learning, and potential for intellectual development.

The curriculum of the Young Investigators' Program was divided into two distinct phases. The first phase took place over an eight week period during the summer. During this summer phase of the program, students attended daily sessions designed to prepare them for the original research that they would participate in during the academic school year (September to June), the second phase of the program. The summer curriculum included lectures and assigned readings on each of the research projects that the students could choose to work on during the school year. Students were required to keep journals, and were also given an additional opportunity to provide feedback and express concerns during biweekly individual meetings in which the students met with the coordinators on an informal one-on-one basis.

While ordinarily it might be difficult for a high school student to understand the concepts and jargon used in advanced scientific research, this problem was addressed by an innovative format implemented in the second year of the program. In addition to the introductory reading assignments, during the morning before each project was presented by a professor, graduate student, or staff researcher, "pre-lectures" were given introducing the topics and covering basic concepts necessary for a thorough understanding of the more advanced lectures. These "pre-lectures" covered topics ranging from protein structure to membrane dynamics to introductory bioengineering. Some of these "pre-lectures" were given by students from previous years, who not only served as role models by demonstrating their accomplishments in the program, but also by giving advice that demonstrates the essence of the program. The advanced lectures were then followed by lab experiences and demonstrations designed to expose students to an opportunity to see the research taking place in the labs. Short term research projects were also assigned for the students to complete, such as a project in which students were required to find information using the UCSB Library and the World Wide Web. Students were given exposure to computers by allowing them to design a program web page describing the program's history, objectives, and participants. The format of the summer program was intended to give each student the background necessary to make an informed decision of which project to work on during the school year.

Additional motivation for the students during the summer portion of the program was provided by the implementation of a point-based incentive system. Originally, a point-based system was avoided in favor of a more informal, self-paced environment in which self-motivation was the primary impetus for student participation. This approach was revised as student feedback indicated that a more structured program with incentives would help motivate them. Because students are accustomed to being graded and rated in relation to one another, a similar format was instituted as a motivational tool. Students responded well to this added element, and the friendly competition actually contributed to the learning environment. Short quizzes were given every morning after a reading assignment. Several short-term research assignments were assigned, including the library project and two literature reviews. A final was given which covered all of the topics addressed in labs and lectures.

After the final, the students were allowed to use all of their accumulated points to "bid" on the research group, or lab, of their choice, in which they would work exclusively during the academic year. The student who bid the most points on a given lab was then given the highest consideration for placement in that lab. Student compatibility with the research group and their availability during the school year were also considered in placement. Research topics that were available to the students included multiple sclerosis, *Tetrahymena* genetics, developmental biology, the etiology of macular degeneration, protein structure as it relates to HIV, AIDS and Alzheimer's Disease, and cognitive processing of language.

Once each student was assigned a research group and a corresponding mentor, the final assignment of the summer was a research proposal for the school year. The purpose of the proposal was threefold: it provided the student with experience in writing a scientific paper; it gave the student a chance to research his or her topic to a greater extent than that presented in the regular curriculum; and it served as an informal contract between the student and mentor by demonstrating the student both understood the material and had an idea of what was expected during the school year. The proposals were required to be written in the format of a typical grant proposal, thus exposing students to the administrative aspects of scientific research. Each student, with the help of his/her project mentor, was required to write a four to five page proposal including sections for 1) an abstract, 2) specific aims, 3) background, 4) methods, 5) significance of proposed research, 6) ten or more references, and 7) a project timeline.

Each student then met with his/her assigned mentor at the end of the summer to establish a research schedule that was convenient for both mentor and mentee. Each student was required to work 10-20 hours per week during the academic year. Some students used their experience during the school year to obtain credit through their high schools to fulfill either community service requirements or science "major" requirements. During the school year, students gained the trust of their mentors and were given increasing levels of responsibility as the year progressed. Their final projects included writing a research paper outlining the work done by the student during the course of the year and a presentation to students participating in the program the following year.

Results & Discussion

Student feedback was obtained from their journal entries and from an eight question free response survey to evaluate the summer portion of the program. Since the long-term usefulness of such a program in its first years is difficult to evaluate, the project objectives were measured by these comments. Feedback was positive each year, with very few exceptions, and helped illustrate the success in reaching the original program goals:

1) *Provide precollege students with the opportunity to participate in state-of-the-art research and acquire original data.*

Students not only realized the value of the unique opportunities presented to them by the program, but the experience also provided them with more insight into scientific research. In fact, four students were given the unique opportunity to be involved with research that will be submitted to scientific journals for publication. Two students are co-authors on a paper that describes the use of magnetization transfer imaging to detect changes in the brain in an animal model of multiple sclerosis. Other students are co-authors on papers that study the thermodynamic differences of brain lipids in various species of fish using the Langmuir-Blodgett trough and use high performance liquid chromatography to detect lipid changes with demyelinating disease. Since even most undergraduate students do not get the opportunity to have their work published, this aspect of the Young Investigators' Program is particularly unique.

2) *Emphasize a multidisciplinary approach to problem solving.*

Students were impressed with the idea of a multidisciplinary approach, and fascinated with its implications. The responses made it clear that this emphasis was well-received.

3) *Provide a forum for young students to explore their scientific interests.*

Students were able to experience science in a manner much different than that of the high school experience. This difference was primarily found to be the approach taken by the mentors. Although the curriculum was intensive and the material difficult, the mentors made a particular effort to relate to the students on a personal level in an effort to make the environment more conducive to learning. By minimizing the typical student-teacher hierarchy, it was found that students were more relaxed and performed better both in and out of the lab.

4) *Encourage students to pursue scientific careers.*

A main goal of the program was to present an accurate picture of scientific research and to show the benefits associated with such a career. In addition to the curriculum described, students were also given tours of local industrial research facilities in an effort to demonstrate other types of available scientific careers. Although no students have yet finished college, 81.8% (9 out of 11) of the students who have moved on to college have science-related majors.

Although two of the students did not pursue science majors in college, personal contact with these individuals indicated that this was not due to negative experiences with the Young Investigators' Program, but rather a greater passion for the fine arts that they decided to pursue.

5) *Offer precollege students exposure to university-level work, in terms of both academics and research.*

Since the participants in the Young Investigators' Program are typically college bound, the curriculum was designed to ease the transition from high school to college. Parallels were continually drawn by the mentors to help the students understand the relevance of the projects to skills that they would need for a successful college experience. While students were required to complete research proposals in the context of their individual research projects, the writing process was taught consistent with what would be expected of college students.

In addition to these five main objectives of the program, students came up with some of their own ideas as to how the program was of benefit to them. Some of the skills that students felt they improved included teamwork, resourcefulness, problem solving, patience, and self-motivation.

Future Directions

The Young Investigators' Program is a continually evolving program. A major strength of the program has been its ability to adapt to the changing needs and interests of the student participants. Thus far, the trend of the program has been towards increased structure. From the more structured curriculum introduced in the second year to the more formal application process and point-based incentive system introduced in the third year, students were progressively more motivated, enthusiastic, and dependable. This is likely due to similarities to the academic setting to which high school students have long been accustomed.

In the future, it is anticipated that the Young Investigators' Program will be expanded to encompass more research groups and scientific disciplines. Community service work will also become an integral component of student participation. Because student projects primarily deal with debilitating medical conditions such as multiple sclerosis and AIDS, service to individuals with chronic disabilities will foster not only a deeper understanding of disease processes, but their effects on human life as well.

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