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Turning High School Students into MRS Authors and Presenters: The Magic of the Garcia Summer Scholars Program

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ABSTRACT

More than 50 high school students each year learn how to conduct science research at the Garcia Summer Scholars Program at Stony Brook University through hands-on, inquiry-based methods. Started in 1998, the program has already provided hundreds of students from diverse backgrounds a unique opportunity for outstanding scientific performance and achievement. In this paper, we present a brief overview of how the program operates as well as several case studies that display the effect of the Garcia Program on student accomplishment. The evidence provided demonstrates that the Garcia Program has had an overwhelmingly positive effect on its many student participants, regardless of their background or socio-economic status.

INTRODUCTION

The Garcia Summer Scholars Program at Stony Brook University is a research apprenticeship program that mentors each year more than 50 high school students from diverse ethnic and socio-economic backgrounds. Over the course of the six-to-eight-week program, the students learn to conduct university-level research in Materials Science and Engineering. Many students, because of their experiences in the Garcia Program, have gone on to win high school research competitions such as the Siemens Competition and the Intel International Science and Engineering Fair. Some have presented their projects at Materials Research Society Meeting poster sessions and at the American Physical Society; published in refereed journals; and have even acquired patents. In many cases, students in the program who come from poorly funded school districts are able to realize many more of these science and education-related achievements than their peers who do not participate in the program.

Literature on science education suggests that the environment provided by the Garcia Program for students is one in which students reach learning goals and become engaged with material. A 2003 study titled “The Laboratory in Science Education: Foundations for the Twenty-First Century,” asserts that laboratory activities have special potential for communication of important science concepts because these inquiry-based activities engage students in learning and require them to justify their conclusions with evidence [1]. The Garcia Program, which takes place in a university research facility and is run by faculty and graduate students who conduct the research being taught even when they are not working as mentors for the program, engages students in inquiry-based activities that are successful science education tools. Furthermore, to teach students how to conduct research in a hands-on manner, the mentorship in the Garcia Program is personal and supportive of individual students, ensuring each student’s engagement in and understanding of his/her project. A 2004 study titled

“Relationships Matter: Linking Teacher Support to Student Engagement and Achievement,” argues that this type of learning environment has a well-studied, positive influence on student academic performance and achievement [2]. With a large staff of faculty, graduate student mentors, undergraduate student mentors, and research experience for teachers (RET) positions filled by devoted high school teachers, students are provided with support from many educators interested in helping them learn to conduct science research and achieve their goals.

Here we describe how the Garcia program generates high student science achievement and present several case studies that demonstrate the success of the program in providing students from even disadvantaged backgrounds with the right environment for attaining outstanding academic goals.

DISCUSSION

When Rosalie’s [3] father first came to see her chemistry teacher at Parent-Teacher’s conference, he could only say three words in English: “College. Scholarship. Doctor.” And as the teacher waxed on in English about what a great student she was, he nodded but didn’t understand much of what was said since the only Spanish word the teacher knew was “gracias”.

Jacob, the son of Nigerian immigrants, was the star of the school production for two years in a row but his idol was Dr. Ben Carson, and his future goal was a career in medicine.

Jerry was bright but wasn’t putting effort into his Chemistry class. When his teacher asked him why, he said that he wanted to focus on playing his trumpet. It was explained to him that one does not exclude the other, and that a little effort in Chemistry would go a long way.

What do these students have in common? They are three of the over 30 students of Lawrence High School who conducted Materials Science Research at the Garcia Summer Scholars Program at Stony Brook University.

Lawrence High School has a 76% minority enrollment [4] and a diversity score of 0.70 (as compared to a score of 0.36 in the New York City Public School system) [5]. Its population of 949 students consists of >60% on free or subsidized lunch, and that percent is steadily climbing annually [6]. While the school has a great football team, its AP Chemistry class can only eke out about 10-14 students each year.

What the Garcia program did for these students was introduce them to the world of innovative Materials Science Research. Rosalie conducted investigations on hyaluronic acid and hydrogels; Jacob examined the effects of nanoparticles on dental pulp stem cells; and Jerry created a catalyst that improves the output power of hydrogen fuel cells. Rosalie graduated Barnard College, assisted by winning a Gates Millenium scholarship; Jacob graduated Yale University and is currently conducting Neuroscience research with the NIH while he applies to medical schools; and Jerry has just started his first year in the Vagelos Integrated Program in Energy Research (VIPER) program at the University of Pennsylvania, for students interested in energy research and engineering. He still plays the trumpet, but his “calling” has changed.

The Garcia Summer Scholars Program first began in 1998, when Dr. Miriam Rafailovich of the Materials Science and Engineering Department at Stony Brook University, decided to spend her summers by throwing open the doors of her labs to mentor high school students in research. What began with 12 students rapidly grew to more than 60 each summer, with more than 350 hopeful participants annually submitting their applications from all over the country and even overseas (Figure 1).

Figure 1. Garcia Summer Scholars participants of 2016 [7].

Selection is based on student transcripts, standardized test scores, and letters of recommendation. Dormitory facilities at the university are available for students unable to commute, and the program begins during the last week in June.

At the start, students are given three days of instruction on laboratory safety, after which they must pass a written test to be allowed to work in the labs. Then they are presented with a variety of daily lectures on current research topics given by those who are conducting the work. The students also participate in group experiments where they learn such techniques as spin casting polymer thin films and measuring their thicknesses with an ellipsometer.

As the initial days pass, the students, armed with their new knowledge and experience, begin to develop a particular area of interest of their own, and they are grouped with mentors according to their chosen fields. Within the groups, they are further divided into specific research experiments, either working alone or with one or two partners, and hence the real research begins.

Mentoring a large group of students like this requires a sizable support staff, and it is thanks to the more than 9 full-time faculty members, 21 graduate students, 3 high school teachers participating in the Research Experience for Teachers program, and 15 participants in the Research Experience for Undergraduates that these students receive such extraordinary mentoring. Still, labs sometimes get crowded, although the diversity of experiments does funnel students to travel to a variety of labs. Not always do things progress smoothly. At times mentors get overtaxed by the amount of needy high school students who require their help; or, they just yearn to focus once again on conducting their own graduate research for a while (Figure 2).

Figure 2. Graduate student mentorship

And, let's remember that the participants are still only high school students. For the first few weeks, mistakes abound. No matter how many times you tell them not to do so, the vacuum oven is left before it is fully pumped down to the required torr, resulting in the pump backing up and filling the oven with lubricating oil and necessitating three days of cleaning and repair. Even though they were taught never to place anything into a stock bottle of solvent, the ethanol is found to have a mysteriously submerged measuring pipette in it. Cell plates become contaminated; the ellipsometer bulb was not turned off after use and the bulb burned out; and lots of glassware accidentally plummet and shatter. It is enough to put even the most patient research scientist's teeth on edge.

But eventually, as August rolls around, the students become more lab-savvy and get a better bearing on the direction that their research is heading. And then the data starts rolling in with gusto. Students begin to work longer hours in the lab, trying to finish experiments before they must return home to California, South Carolina, Texas, or Taiwan. The formal end of the program is in mid-August and the dorm is closed, but many Garcia participants stay on by their new local friends so that they can continue their work. And those that live within commuting distance sometimes must travel three hours by railroad each way, just so that they can spend additional hours in the lab (Figure 3).

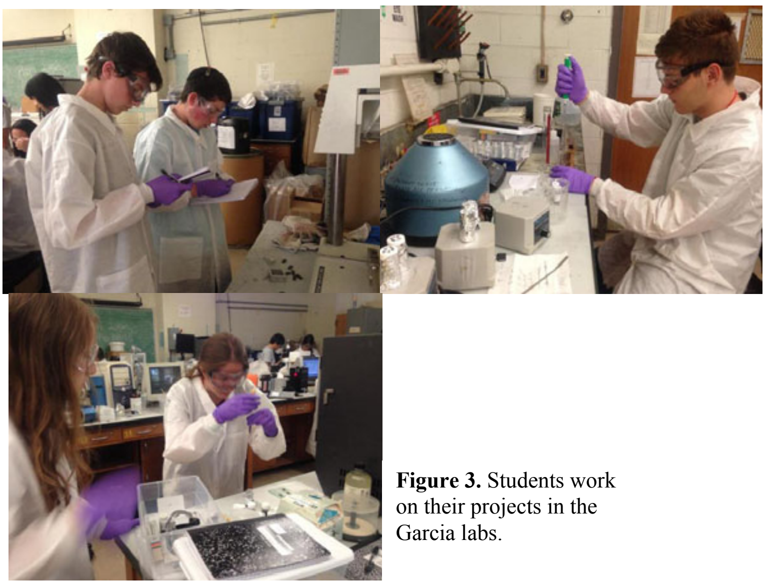

Figure 3. Students work on their projects in the Garcia labs.

A symposium of student research is held on the last day of the formal program. Each project is summarized on one PowerPoint slide that explains the experiment and results, which the student researchers present to an audience of students, parents, science teachers, high school principals, and Stony Brook faculty. A yearbook is compiled and distributed that not only contains the photos of all the participants and informal group pictures of the trips they took together, but abstracts of each project as well. Projects bearing names such as "Optimizing Electrode Catalyst Efficiency and DFT Modeling of CO Oxidation in Proton Exchange Membrane Fuel Cells"; "Assessing the Power Conversion Efficiency and Nanoscale Morphology of Photovoltaic Cells with High Molecular Weight Polystyrene Additives"; "Characterization of Injectable Enzymatically Cross-Linked Gelatin Based Hydrogels with Encapsulated Dental Pulp Stem Cells for Dental Pulp Tissue Regeneration"; and many more. The astounding thing is that these high schoolers can now easily and explicitly describe what is occurring in these experiments and the meaning of their results, and the information is imparted with the same enthusiasm as any 16-year old who recites the stats of his favorite baseball player. At the end of the symposium, a gala buffet lunch is served; T-shirts and other gifts are given to each participant, and hugs and cell phone numbers are exchanged.

But the mentoring does not end there. The students return home to compose 20-page research papers for the Siemens Competition; Intel (now Regeneron) Science Talent Search; and other science contests, and they are guided by Dr. Rafailovich and their mentors in the process. Approximately 17-25 Garcia students become Siemens Semifinalists, Regional Finalists, or National Finalists each year, and Dr. Rafailovich coaches them through every step of the competition, even traveling to Washington D.C. for the National Finals. Garcia participants also win major prizes in the Intel Science Talent Search; Intel International Science and Engineering Fair; Junior Science and Humanities Symposium, and many other competitions.

A few students have even achieved patents for their work. Some students write and submit papers to professional refereed publications and present their projects at the American Physical Society and the Materials Research Society Fall Symposium. (Nine Garcia students presented their research posters this year at the 2016 MRS Fall Symposium in Boston.) They are asked for their business cards; they are asked what graduate school they attend. And they smile and tell the truth- that they first must graduate high school.

Figure 4. Three Lawrence High School Garcia participants at the 2012 MRS Fall Symposium discuss their research with MRS members.

Three Garcia students from Lawrence High School (Figure 4) were standing in front of their research poster at the Materials Research Society Fall symposium and describing their experiments to onlookers. One scientist from abroad came and asked them several questions, which they answered with ease. He then asked them a question which they could not answer, and they stood and admitted that they didn't know how to respond. The scientist was surprised that they couldn't reply, which is when the students' mentor, who was off to the side observing it all, stepped in and informed him that they were still only in high school. "High school students!" he exclaimed. "I wish my graduate students would know as much as they do!"

It is not all work and no play. Dr. Rafailovich keeps in mind that summer should still mean fun for a teenager, so there are scheduled barbecues, softball games, a canoe trip, a fishing excursion, a museum trip. Students support each other in the lab and "hang out" with each other in the dorms after work, forming lasting friendships. They celebrate each other's successes and comfort each other's disappointments. One of this year's Lawrence students exclaimed at the end of the summer that it was the best summer of his life.

The long-lasting impression the program makes is recounted by the assessment of Mike, who participated in Garcia twelve years ago when he was a high school student from a very small school district on eastern Long Island. Mike is currently a Senior Process Engineer with Intel. He earned his PhD in Chemistry from Northwestern University and his BS in Chemistry from Duke University. He credits Garcia with having had a great influence in his choice of studies because of the strong research background he had acquired during his participation in the program. He says Garcia gave him "a foundation from an early age on how to recognize a problem and how to go about attacking it." When asked about how Garcia affected his overall high school experience, he said "Some of my best friends in high school, college, and afterwards, I met at Garcia. I met my first girlfriend there. I worked with amazingly talented and ambitious students. My high school did not have a rigorous science program and there were not many fellow students who shared my interests, so being around high schoolers with the same interests and ambitions was the best high school decision I ever made."

CONCLUSIONS

The Garcia Summer Scholars Program provides achievement pathways for aspiring high school student researchers, showing that success is not limited to those who come from well-endowed school districts or from specialty high schools that focus on mathematics and science. The Garcia Program provides equal opportunities for focused, motivated, science-oriented students, regardless of their socio-economic backgrounds; enabling research experiences that their own schools, with limited budgets, may not be able to offer. Bolstered by several studies on education methods, the learning environment developed by the Garcia Program over years of experience with science research education and apprenticeship has proved to be successful for its participants and has provided a lasting, positive experience for both students and mentors alike.

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At the date this manuscript was written, URLs or links referenced herein were deemed to be useful supplementary material to this manuscript. Neither the authors nor the Materials Research Society warrants or assumes liability for the content or availability of URLs referenced in this manuscript.

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