AC 2012-3417: YOUNG SCHOLARS PROGRAM: SUMMER RESEARCH OPPORTUNITIES FOR GIFTED AND TALENTED STUDENTS

Mr. Yair Joseph Mega P.E., Northeastern University

Yair Mega is a Ph.D. candidate at the Department of Electrical and Computer Engineering at Northeastern University, and a Research Fellow at the Cardiovascular Research Center at Massachusetts General Hospital. His area of research involves non-linear optics applications for bio-medical imaging. Mega has also worked as a program coordinator with the Young Scholars Program (YSP) at Northeastern University for the last two years. His involvement includes matching the technical contents of the research to students' background and interests. Mega holds an M.S. degree specializing in nano-lithography from the Department of Materials Science and Engineering at Tel-Aviv University, Israel, and a B.S. degree from the Department of Materials Science and Engineering at Ben-Gurion University in Negev, Israel.

Mrs. Claire Duggan, Northeastern University

Claire Duggan has a B.S. in political science from the University of Massachusetts and a M.P.A. in public administration from Northeastern University. She was appointed 2003-present Director for Programs and Operations, the Center for STEM Northeastern University; 1989-2003 Associate Director, CESAME/The Center for the Enhancement of Science and Mathematics Education, Northeastern University, and K-12 Outreach Coordinator, CenSSIS/ALERT, Northeastern University; and 1981-1989 Associate Director for Finance and Administration, Center for Electromagnetics Research (CER), Northeastern University. Publications/Papers: Reenergizing and Reengaging Students Interest through CAPSULE; A Novel and Evolutionary Method on Educating Teachers to Promote STEM Careers Jessica Chin, Abe Zeid, Claire Duggan, Sagar Kamarthi (IEEE ISEC 2011); and "Implementing the Capstone Experience Concept for Teacher Professional Development" Jessica Chin, Abe Zeid, Claire Duggan, Sagar Kamarthi (ASEE 2011). Relevant Presentations: "K-12 Partnerships" (Department of Homeland Security/Centers of Excellence Annual Meeting 2009); "Building and Sustaining K-12 Educational Partnerships" (NSF ERC 2007 - 2010 National Meetings); "Research Experience for Teachers: Integrating Research Skills into the classroom" (UNH 2nd Annual Nanotechnology Conference for Teachers April 2006); and "Educational Outreach Programs" (2005 MA STEM Summit). She was Co-principal Investigator/Program Director, Research Experience for Teachers (RET), development and implementation of the Research Experience for Teachers site at Northeastern University; Executive Director/Founder, Young Scholars Program, development and implementation of the Young Scholars Program, a summer research program for high school students; Co-executive Director, Exxon Mobil Bernard Harris Summer Science Camp, development and implementation of a residential camp for middle school students; Liaison, StepUP Imitative, coordinate Northeastern University's involvement with the StepUP initiative, a partnership effort between five universities and eleven Boston Public Schools; Project Director, IMPACT New England: A Regional Curriculum Implementation Effort, coordinated program development and implementation; Seminar Leader, Northeastern University School of Education, facilitated a group of students participating in the Introduction to Education course; Project Support Liaison, Teacher Innovation program, provided support to teachers/schools in the development and implementation of Teacher Innovation Programs (TIP), provided technical assistance to teachers through the proposal process, conducted proposal-writing workshops; Co-facilitator (2004), Boston East Pipeline Network; and Alumni, Lead Boston 2004 (The National Conference for Community and Justice). She won the 2006 Northeastern University Aspiration Award, and was recognized at the 2003 Northeastern University Reception honoring Principal Investigators that obtained funding in excess of $1 million over a five-year period.

Daniel Sullivan, Northeastern University

Daniel Sullivan has a B.S. in civil engineering and has worked for the Center for STEM Education since 2010.

Ms. Lauren Horn, Northeastern University
Dr. Charles A. Dimarzio, Northeastern University

Young Scholars Program – Summer Research Opportunities for Gifted and Talented Students

Yair Mega, Lauren Horn, Daniel Sullivan, Ivana Freitas, Charles DiMarzio and Claire Duggan.
Northeastern University at Boston, Massachusetts.

Abstract

Launched in 1989, the Young Scholars Program of Northeastern University (YSP) serves to address the growing national shortage of qualified U.S. citizens moving into STEM careers[1]. Over the years of operation of the program, increased attention and support for the matter has grown considerably partially due to recommendations made in the national report, *Rising Above The Gathering Storm*,[2] which noted the need for expanded experiential learning experiences in STEM for K-12 students. This paper depicts the methodology and the model used by YSP to successfully address this national need and increase the number of young people pursuing STEM career paths. The model developed at Northeastern University YSP has been refined to become a comprehensive learning experience for program participants and university faculty. YSP offers future scientists and engineers a unique paid opportunity for applied experience while still in high school, allowing students to explore STEM hands-on and expose them to a variety of careers available for STEM professionals. It also provides faculty and graduate students across the campus the opportunity to mentor the next generation of STEM professionals. Open to area applicants who have completed their sophomore or junior year in high school, the program encourages the participation of students from all income levels, genders and ethnicities while providing a stipend for the program's six-week duration. The YSP staff conducts post program evaluation and analysis to continuously improve on the program's content, lab assignment opportunities and to seek new ways to approach and interface with scholars in an increasingly interconnected world. In addition, YSP maintains a network of program alumni that help new candidates and alumni with their participation in Q&A sessions and conversations throughout the college application process. Our data, collected from last year's participants, shows high correlation between participating in YSP and choosing a STEM major and career.

Introduction

The Young Scholars Program was launched at Northeastern University in 1989 with funding from the National Science Foundation (NSF) in response to a national shortage of qualified U.S. citizens moving into STEM careers [1]. The first generation of this program ran from 1989-1997. In 2004, the program was reestablished with support from a private foundation.

In 2005, a report known as *Rising Above The Gathering Storm*[2] was prepared in response to a request by a bipartisan group of Senators and members of Congress who asked the National Academies to conduct a study of America's competitiveness in the evolving global marketplace. The report raised questions about what measures federal policymakers could take to enhance the science and technology enterprise so that the United States can successfully compete, prosper, and be secure in the global community of the 21st century and what strategies could be used to implement those actions[3]. The legislation that followed the report increased attention and support of the YSP program. Several newer studies building on the "Gathering Storm" report suggest

that even though improvement has been made, further action is required to correct our current situation. As globalization continues, success in the workforce is more and more based on experience and depth of knowledge [4].

Over the past 15 years, several studies [5-10] have investigated the effect that high school curricula has on the decision to pursue a post-secondary education (college and graduate school), area of concentration, the level of academic achievements and ultimately, wages. Some of these studies indicate that participation in and exposure to more advanced courses and materials in the early stages of education play a substantial role in the decision making process for choosing a college major and career path. More importantly, these studies suggest advanced work leads to a substantial economic return. Following this model, we observed that a program like YSP can very positively contribute to attracting more young talented individuals to STEM career paths.

One way to attract and retain students' interest in STEM fields and careers is to provide students with experiences that will shed light on the practical applications of science, or *learning by doing science* in ways similar to the work scientists actually do[13]. Almost every science and engineering program in the country puts a great deal of emphasis on this concept and therefore, have many lab courses that need be taken as a requirement for graduation from the program. Equally important to retaining students, especially for the transition from high school to college, is to support these students socially when they arrive at their university on their own for the first time. By having students feel more comfortable socially, they feel less isolated, which positively affects their "persistence to succeed academically." [14]

Despite increasing national test scores in the US, high-achieving students' interest in STEM careers is declining[12]. The recent study shows that fewer and fewer gifted and talented high school and undergraduate students are opting for STEM pathways. Of those who initially choose that path, fewer finish college with a STEM degree. This problem is not new. Another study[11] found that retention of STEM majors increased in the 1970s through late 1990s. However, despite some years' positive outcome of STEM retention rates, this trend was accompanied by declines, sometimes sharp, in retention among the highest performing students. This issue is also being approached by the YSP program. Since some of the students participating in the program still have at least one more year of high-school, a summer enrichment program like YSP can greatly increase the classroom learning experience by providing students insight into the development of STEM problems from concept to application. We have found that this experience has a positive influence on the attitudes of these young individuals towards pursuing STEM fields.

Unique Opportunity

There are many other enrichment programs for high school students across the country; however the uniqueness that the Northeastern University YSP has to offer is at the very heart of the program:

1. Demographic and socioeconomic diversity

Many of the most prestigious academic enrichment programs in our country charge a participation fee. Those fees, varying from $2,000-8,000, mean that most students from low socioeconomic backgrounds are financially unable to take advantage of these opportunities. Even students who might have the means to attend may decide the cost is too great compared to the benefits to warrant participation. It is also probable that students participating in these fee-based programs have already decided to pursue a STEM career path. For those students, these programs pave a road to success in making a candidate more desirable to top schools by improving their STEM skills and enriching their STEM knowledge; however, do not necessarily target those students who lack both overall exposure to STEM careers and access to STEM programs.

YSP performs the same functions as these fee-based programs, however instead of charging for participation, we offer a stipend. This stipend allows students, even from the lowest socioeconomic backgrounds, to attend and receive the same benefits as their more affluent peers, leveling the playing field. The weekly stipend is enough to cover the commuting expenses to campus and lunch, with a small amount left over, comparable to a minimum wage job. The stipend is designed to avoid attracting applicants who will only be participating because they want a summer job. In fact, there's no mention of the stipend on the program's website and students are unaware of it while applying, thus, attracting only those students who are sincerely interested in YSP for the unique research experience it offers

The program's staff make sure they accept a diverse group of young scholars. In the application process the candidates are asked to provide their school name, town, ethnicity, and total family income among other common demographic information like name, gender, age, school grades, etc. Diversity is a key to ensuring vibrant discussions with participants from all backgrounds.

Facilities

Northeastern University is well-known for combining classroom studies with experiential learning to allow practical applications to be an integral part of the learning process. The university is also at the forefront of research on many of society's most pressing STEM issues. YSP allows students to apply their base knowledge in the areas of science, math, engineering, and technology by providing them with cutting-edge tools and research assignments that are not normally available to high school students in the US. The exposure to experimental tools, methods and mentoring that isn't a part of our high school educational system deepens their understanding of concepts and prepares the young scholars for careers in these fields.

2. Research fields and lab assignments

Each year, a request for partnership is sent out to faculty from affiliated university centers and research programs, as well as any new faculty who have expressed an interest in K-12 outreach. The program is so well-received by faculty that typically, the program receives more research assignments than is available with current funding. Research assignments are selected based upon the quality of the project, evaluations from previous years (including participant feedback), and the interests of the current year's applicant pool. The participating faculty and their 2011 projects were within the disciplines shown below. Research assignments were predominantly in

the field of engineering, based upon interests of students and funding sources. Faculty participants from 2011 have all expressed an interest in continuing to work with the YSP program in 2012 and beyond.

2011 Research Projects

Chemical Engineering

Listen to Bacteria Talk

Civil and Environmental Engineering

Optimization of the Electrochemical Dechlorination of Trichloroethylene in Groundwater

Evaluating Water Quality at Potential Charles River Swimming Locations

Generation and Monitoring of Gas Bubbles in Sand Specimen to Prevent Ground Failure During Earthquakes

Evolution of Toxicity of Environmental Pollutants and Development of Biological Processes for Water Treatment

Electrical and Computer Engineering

Brain Computer Interface with Classification of Motor Imagery Signals

Foreground Object Detection and Tracking in Videos Using Statistical Background Subtraction
Vibration Energy Harvester Using Magnetic Material

Lung Imaging Using Optical Coherence Tomography

Mechanical & Industrial Engineering

Mechanical Engineering Design in the Laminar Flame Laboratory: Design of a Combustion Vessel Retracting System

Load-Bearing Capabilities of Ambulation Aids

Development of Wood-Plastic Composites

School of Pharmacy

Cellular Delivery Using Nano-Emulsions

Lab mentors are required to submit a full abstract of the proposed research assignment in addition to detailing specific research activities, required background knowledge and expectations of participants during the course of the summer program. Each year, new faculty interested in participating meet with program staff in addition to being encouraged to seek best practices from experienced faculty participants.

3. Field excursions

A variety of corporate and government site visits are conducted so students can see and speak with scientists and engineers in action. Destinations in 2011 included several well-known engineering companies, hospitals and research centers. One day each week is reserved for field trips. Additionally, social trips are organized by participants to be held after program time in which a majority of scholars choose to participate, further building the community.

4. Career/research exploration

Students participate in a weekly seminar series, with faculty speakers from across university disciplines. Topics covered in 2011 included: Cell Migration, Biomedical Optics and DOT, Historical Failures and Faulty Designs. Other presentations provided during the students' homeroom session include an Introduction to Engineering, with presentations from representatives of Chemical, Civil, Electrical and Computer, and Mechanical and Industrial Engineering departments.

5. Education and career counseling

A general overview of engineering education for undergraduate students presented by the Dean's Office of the College of Engineering and the Department of Cooperative Education acquaints students with the nuts and bolts of careers for scientists and engineers. Students are also provided beneficial information about searching for and applying to colleges from the university's Admissions Office in addition to the support provided from YSP staff. Students work on a college essay from the Common Application throughout the summer, receiving feedback from staff and their peers. By the end of the program each student completes one essay that he or she would be able to use during their college application process.

6. Experience college life on campus

YSP participants become acquainted with college life and undergraduate and graduate students, while having access to university recreational and educational facilities. Participants are exposed to university students at varied educational levels and are able to explore the campus as if they were students themselves. We have an urban campus with an array of resources that are available to all young scholars throughout the duration of the program. This immersion into college life allows them to become connected to the university fabric and comfortable with what their future in college might look like.

7. Online Resources

Students are required to maintain an electronic journal and laboratory notebook on Blackboard, an academic platform widely used by universities. This secure web site is used to provide program information, support information for STEM careers along with information on the college application process, as well as publicize upcoming STEM competitions and available scholarships. The site also paves the way for future electronic networking and support of program alumni.

8. Program outcome and achievements

As previously mentioned, the program staff collects input from program participants in the form of post program surveys, as well as surveys with program alumni several years after being in college or integrating into the workforce. Some of the key questions and responses that reflect the program's achievements are referenced in this section. Figure 1 shows the response to a two-part question targeting the effectiveness of the two main goals - attracting more students to choose STEM fields in college and later as a long term career. The response shows that 65% chose a career path as a result of participation in the program, and 94% are working today in the STEM industry. This indicates that approximately 29% had already had their minds set on a STEM career. This percentage is a very important number since it suggests that 71% of students in high school are unsure about college majors at this early stage, and they can very much be influenced if they are given the right opportunity. However as a disclaimer, we should mention that this is not a research paper and therefore we can only say that the results showed are captured by our limited-scope surveys. We do believe, however, that this is a question that invites further research and investigation.

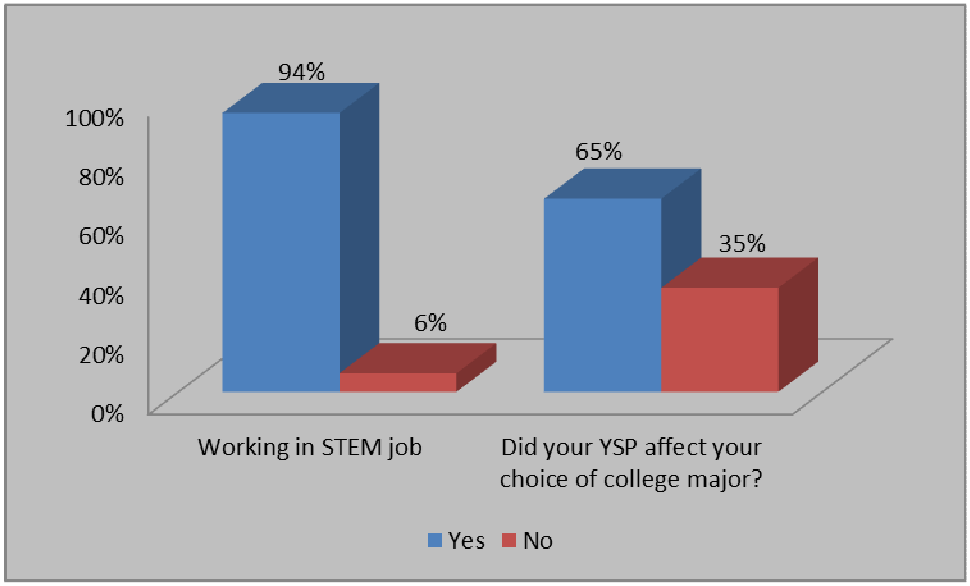

Figure 1. Early years of the program alumni survey results

Another important source of input we receive is through a participant survey at the end of the program. In this case we are also breaking down the learning experience feedback into smaller pieces that can help us focus on the components that are making the program most effective.

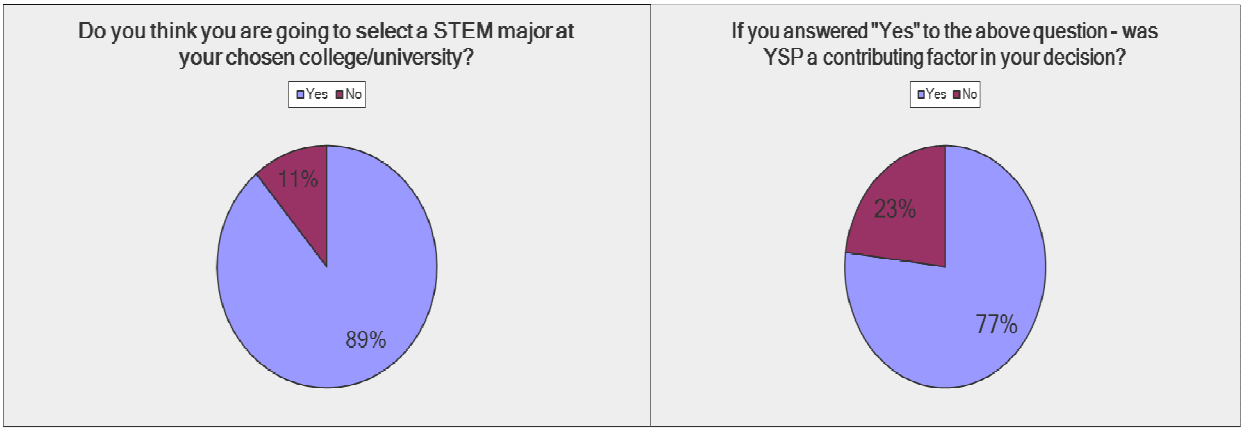

Figure 2. Influence of current program on major selection in college

Figure 2 shows the response to the survey questions regarding the influence of the program on the students to choose a STEM major in college. It is important to keep these results in perspective by comparing them to the general population of students in the US choosing STEM majors. For that purpose, we compared our results to those provided by National Center for Education Statistics[15]. We did not include the data here instead we are bringing here highlighted information relevant to our program and discussion , however the reader is encouraged to view some of the results to get a better grasp of the severity of the need for STEM professionals in our society. The data clearly shows a significant growth in business professionals. Currently business' share is 22% of all majors, while all STEM fields combined are only 15%. Also, tracing the behavior from the early seventies shows that business grew from 14% to its current level, while STEM increased from 19% in the early seventies to 22% in the mid-eighties followed by a the steep drop to its current level of only 15%.

Figures 3 and 4 present some selected questions showing the outcome of the programs' objectives. Increasing the awareness to STEM career pathways and preparation for college together are something the program is trying to do hand in hand to introduce the students to a STEM major in college.

Figure 5 was displayed here to present the students' satisfaction of several different aspects of the program. This describes in our effort to create the environment and the infrastructure for networking beyond the six weeks of the program.

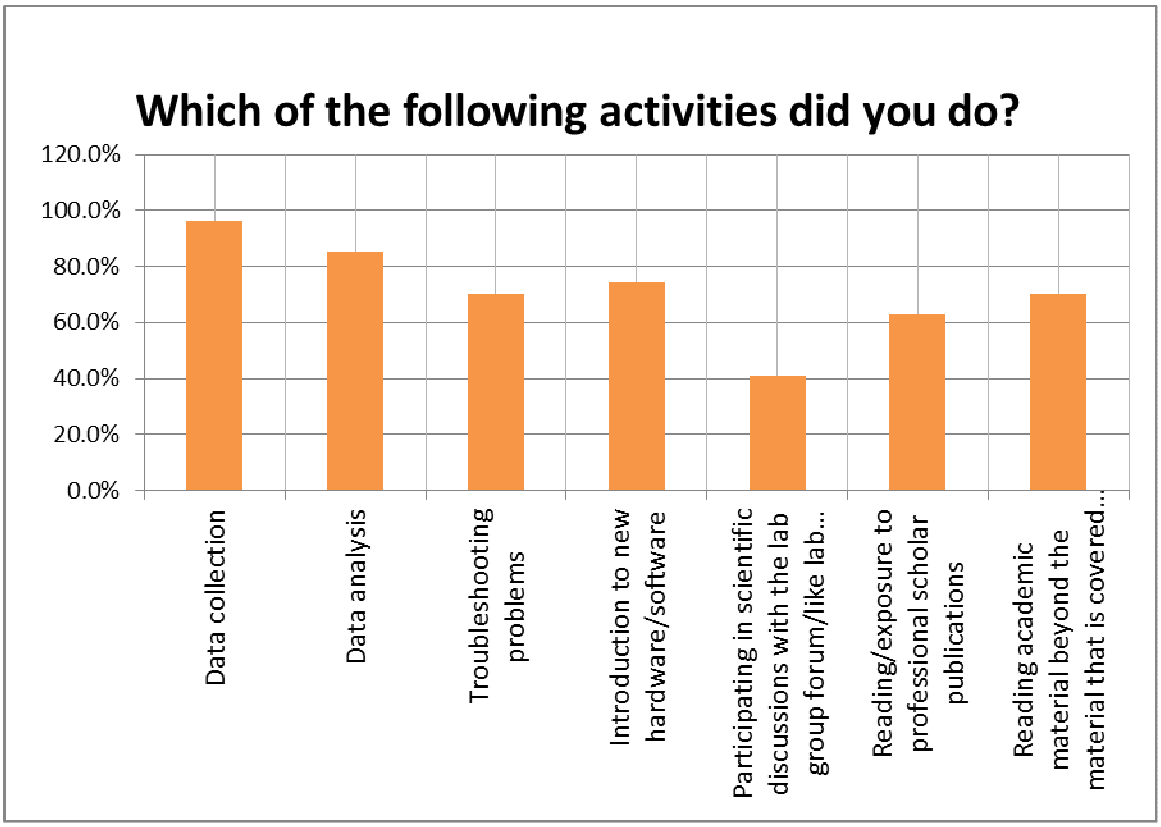

Figure 3. Scientific Activities Performed in the Labs

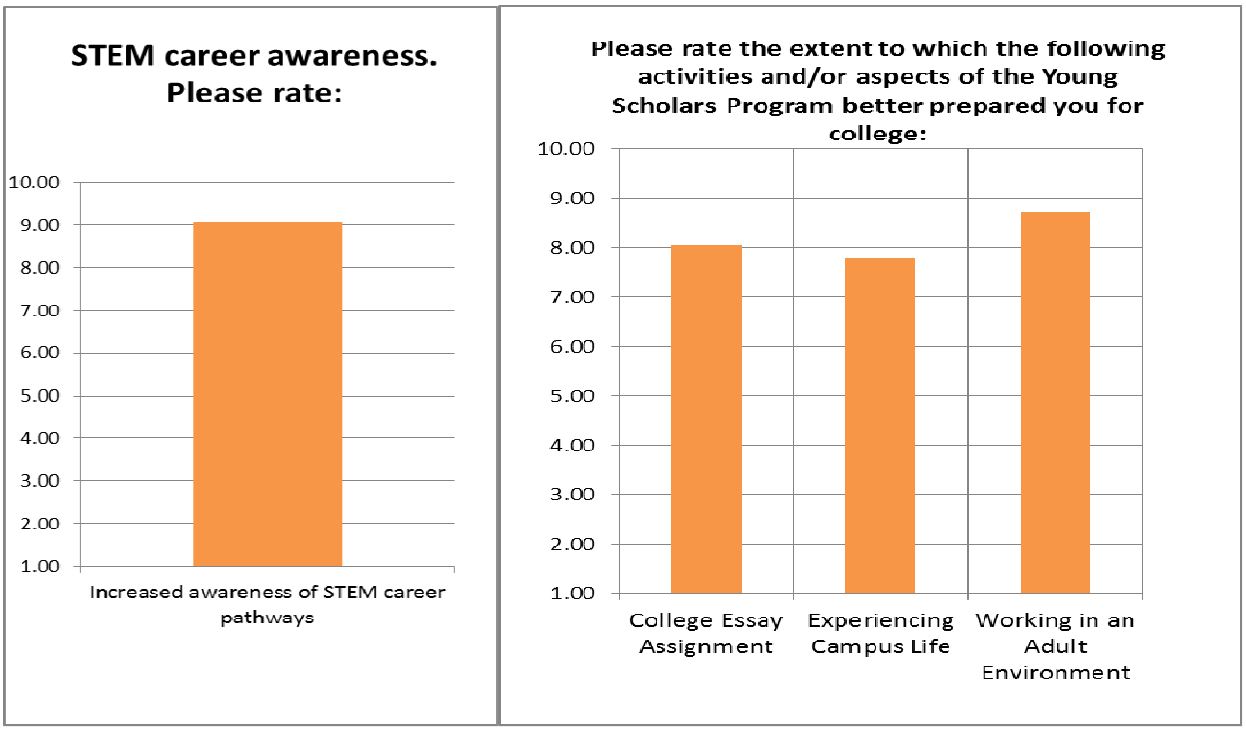

Figure 4. (Left) Students' Awareness in STEM Careers and (Right) Preparation for College

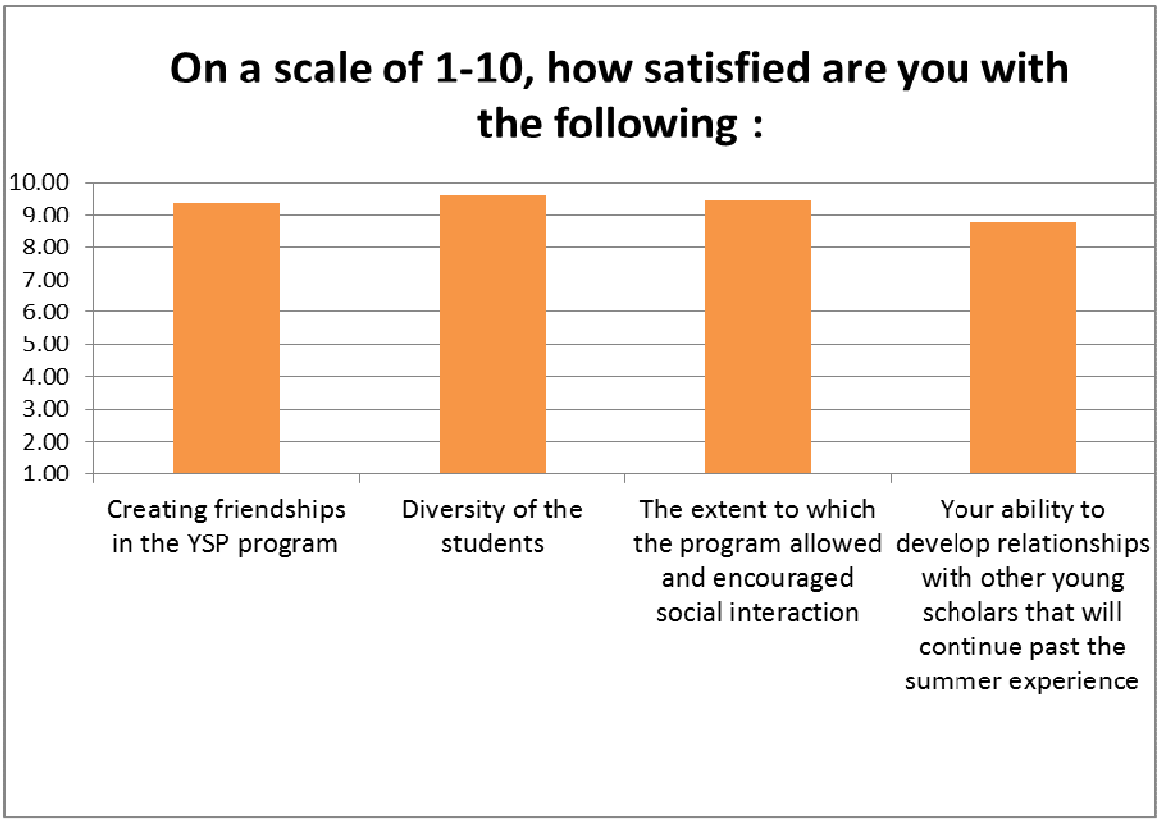

Figure 5. Students' Input of the Different Aspects of the Program

9. Networking and community building

One of the core objectives of YSP is to maintain connection to and continue support of the program alumni. The STEM community that YSP has established over its history enables continued networking and support opportunities even after the students graduate from the six-week program. In addition to establishing relationships between YSP participants, students are introduced to and given the chance to establish ties with other university students, faculty, and past YSP participants. These relationships continue to be a driving force behind the success of the program; by creating a nurturing research environment, the students become comfortable with the networking and interpersonal skills involved in STEM careers.

Networking during the program is accomplished through brown bag lunches, field trips, social activities, and homeroom activities. The group sizes for the YSP programs are small and conducive to networking and social interaction. The brown bag lunch events are a way for students to investigate other research projects, and the students and faculty associated with the various lines of work. Career exploration seminar series introduce the students to other faculty and graduate student research on a variety of subjects.

The program staff keep alumni connected and up to date with current offerings through a number of social media platforms including LinkedIn, Facebook, and Twitter in addition to the outreach blog that is updated with current research and social/networking events. In addition to the social

media programs, the alumni are contacted directly through email and mail in order to inform the past participants about events of interest. YSP alumni are also contacted with requests to participate in current-year YSP events in order to show current participants the possible career paths and opportunities available to them.

a. College alumni network

The program seeks to provide current YSP students an opportunity to build relationships with university students and faculty in addition to fellow participants. By providing the participants with a tangible research setting, students are able to gain appreciation of the experience, and achieve a high level of comfort in networking and team relations. Working in a team setting allows the students the opportunity to gain real project experience in a workforce setting; over 70% of the research was conducted in a team situation, which creates a nurturing social community for the students. The program also helped students feel more prepared for future work in a similar lab and team environment. Feedbacks suggested the introduction to an adult workplace has contributed to their experience as reflected by figure 6.

In figure 7, taken from last year's survey feedback, participants also noted that they were almost 90% satisfied with their ability to develop relationships with other YSP participants that will continue past the summer experience. The program encourages and enables social interaction between other participants and also faculty and university students at a rate greater than 90%.

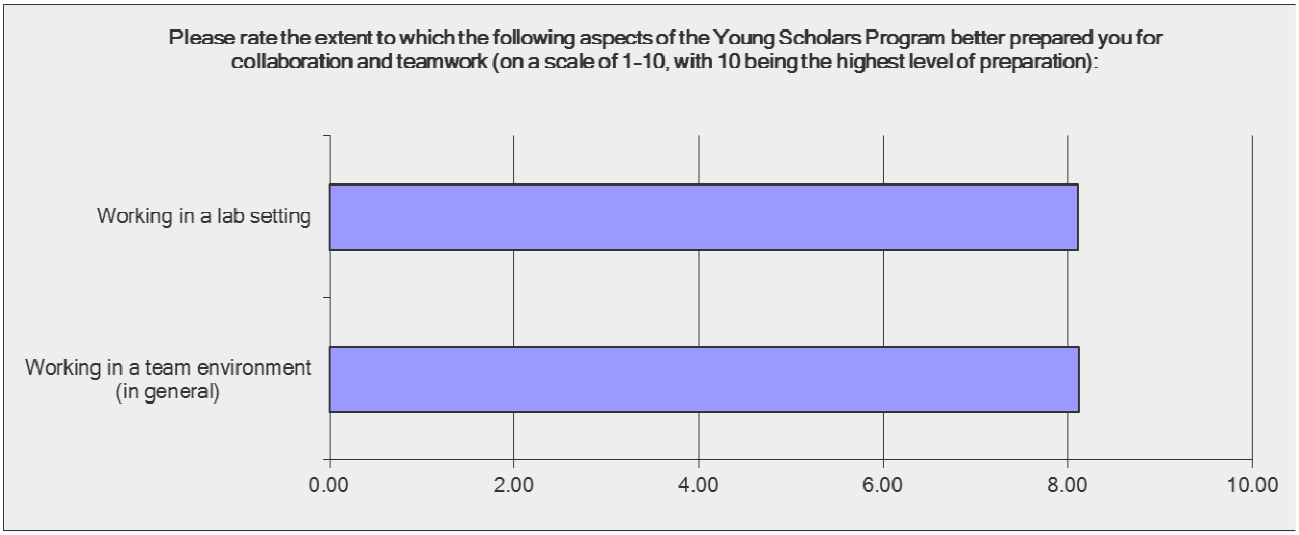

Figure 6. Working in an mature environment workplace

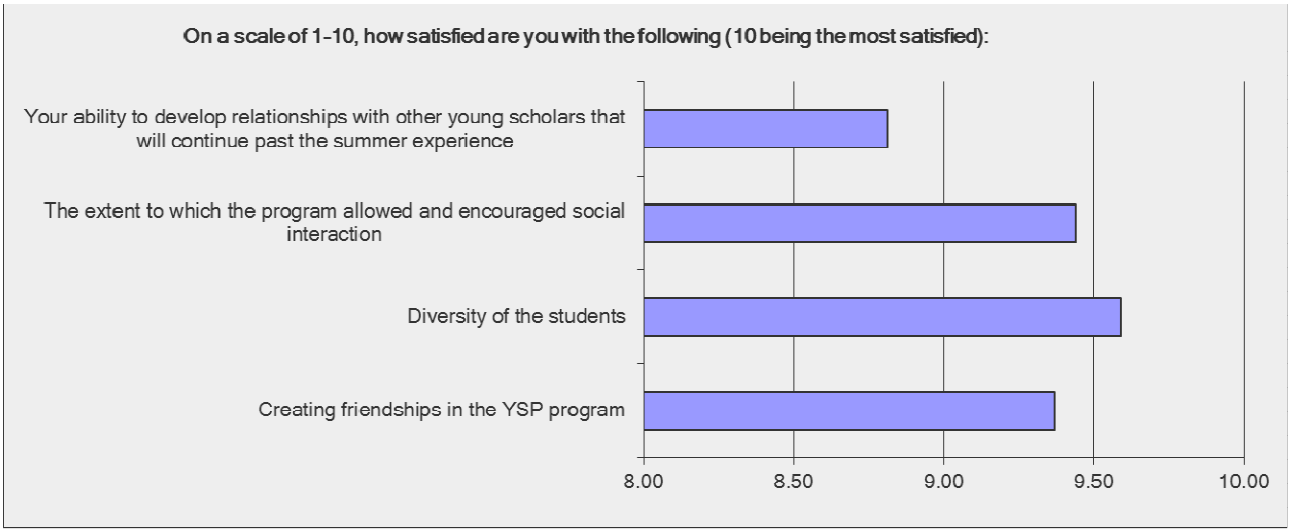

Figure 7. Student's feedback on satisfaction from the program

b. Industry alumni network

Graduates of YSP are often more than willing to participate in establishing and maintaining strong ties to industry and STEM professions. Graduates from the beginning of the program in the early 90's have helped provide feedback and continued involvement that allows the program to continually improve. Over 80% of 2008 alumni surveyed indicated that they were interested in connecting with the current YSP students. Alumni are invited to participate in presentations, field trip events, and webinars during the YSP summer program. The involvement of past YSP participants gives current students an invaluable support system by presenting examples of potential career paths and connections for future networking functions.

Discussion

The Young Scholars Program at Northeastern University was originally established to address the growing shortage of STEM professionals, which are essential for the U.S.to maintain its advantage and compete in the global economy. YSP addresses this issue by identifying students at a fairly early stage, their high school years, and encouraging them to pursue a STEM career path, in college and later in life.

This can be achieved by our model, identifying a STEM discipline a student might be interested in and providing him/her with early hands-on experience, in our case during our summer program. Once the student is interested and confident he/she can handle a career in a STEM discipline, students might feel more comfortable to continue in this path in his/her future career. Creating a supportive environment is also very crucial to the success of keeping a student on the path to a career in one of the STEM fields. YSP therefore maintains a supporting network of its alumni and reaches out to them to support and inspire current students. Using these methods YSP has been very successful with encouraging the choosing of a STEM major as a career path.

It is very difficult to accurately and clearly estimate the contribution of the program to the choices of the career paths made by our alumni, and conclude exactly what weight our program had on each participant's career path. However, the statistical results from our surveys compared to the national data provided by the National Center for Education Statistics, indicate that the degree with which our alumni move on to scientific professions in colleges, universities and later in life, is more than four times larger than that of the general population in the U.S. This fact, in addition to results obtained from personal questionnaires of our alumni stating that 65% believe they chose a STEM career directly due to their participation in the program; indicate that YSP achieves its intended results.

References

1. Gardner, D. P. (1983). A Nation at Risk: The Imperative for Educational Reform. An Open Letter to the American People. A Report to the Nation and the Secretary of Education. Washington D. C.: Department of Education. National Commission on Excellence in Education.
2. NAS/NAE/IOM, Rising above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future, National Academies Press, 2007. The initial report release was in 2005, with the final, edited book issued in 2007.
3. Letters from Senators Jeff Bingaman and Lamar Alexander, dated May 27, 2005, and Congressmen Sherwood Boehlert and Bart Gordon, to NAS President Bruce Alberts.
4. Augustine, N., Barrett, C., Cassell, G., Grasmick, N., Holliday, C., Hackson, S., Jones, A., Levin, R., Mote, D., Murray, C., O'Donnell, P., Raymond, L., Richardson, R., Vagelos, P., Vest, C., Whitesides, G., & Zare, R. (2010). Rising above the gathering storm, revisited: Rapidly approaching category 5. Washington, DC: National Academies Press.
5. Altonji, Joseph, Erica Blum, and Costis Meghir. "Heterogeneity in Human Capital Investments: High School Curriculum, College Major, and Careers", 2011.
6. Arcidiacono P, Hotz VJ, Kang S. Modeling college major choices using elicited measures of expectations and counterfactuals. IZA Disc. Pap. 4738.
7. Berger MC. 1988. Predicted future earnings and choice of college major. Ind. & Labor Relat. Rev.41(3):418–29
8. Bertrand M, Hanna R, Mullainathan S. 2010. Affirmative action in education: evidence from engineering college admissions. J. Pub. Econ. 94(1-2):16–29
9. Betts JR. 1996. What do students know about wages? Evidence from a survey of undergraduates. J.Hum. Resour. 31(1):27–56
10. Eide E, Waehrer G. 1998. The role of the option value of college attendance in college major choice. Econ. Educ. Rev. 17(1):73–82.Lowell, B. L., Salzman, H., Bernstein, H., & Henderson, E. (2009).
11. Steady as she goes: Three generations of students through the science and engineering pipeline. Paper presented at the annual meeting of the Association for Public Policy Management, November 7, 2009, Washington, D.C.
12. Bøe, M. V., Henriksen, E. K., Lyons, T., & Schreiner, C. (2011). Participation in science and technology: Young people's achievement-related choices in late modern societies. Studies in Science Education, 47(1), 37–71.
13. National Research Council, "How Students Learn Science in the Classroom", 0309-0890-6, 2005
14. Dumas-Hines (2001) Promoting diversity: recommendations for recruitment and retention of minorities in higher education, College Student Journal / Sept, 2001
15. http://nces.ed.gov/programs/digest/d10/tables/dt10_282.asp?referrer=list