ASPiRe, a Ten-Week Summer One-to-One Mentoring Program and its Impact on Undergraduate Student Learning and Confidence

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Abstract

The DeMatteis School of Engineering and Applied Science at Hofstra University offers a 10-week summer program where students are paired with faculty to engage in a research or design project. The student is paid a weekly stipend of $400 while being mentored one-to-one by a full-time faculty member. Approximately 29 students took part in this program during the summer of 2019, culminating in a presentation to their peers and faculty mentors, and members of the Dean's Advisory Board for the school.

It is hypothesized that the process and completion of the research or design project through the program positively impacted the students' confidence and self-efficacy. To determine if the hypothesis is true, the students were assessed through a simple survey, the results of which are presented. In addition, two of the 29 students were asked to reflect on three areas of learning. Their responses are presented as case studies.

Introduction

Engineering schools with predominantly undergraduate enrollments traditionally emphasize research opportunities for upper level undergraduates working in conjunction with faculty members. At such institutions, the level of faculty research is often congruent with what a highly motivated rising senior can contribute to in a meaningful way. Consequently, accommodation is often made through offering independent study courses taken during the academic year for credit, or focused summer research stints of variable length, or even a combination of the two, to enable these experiences for students, especially those who may be thinking of going to graduate school, where research will be a major component of their formal studies.

At the Fred DeMatteis School of Engineering and Applied Science (SEAS), both these approaches were employed for many years, with select students benefitting by both the knowledge accrued and the prestige of having their names appear on publications as co-authors with the faculty supervising their research. Then, in 2014 and 2015, a benefactor provided some funding for several students conducting research in bioengineering projects. The opportunity was attractive enough to these students to deflect them from summer internships or other employment options. Seeing its success in a small cohort, the school administration decided in 2016 to formalize the research experience, once fundraising among major donors (principally members of the school's advisory board) guaranteed that a budget would be available to underwrite this new model. It announced the creation of what is now called the Advanced Summer Program in Research (ASPiRe for short), in which students would sign a contract to work for ten weeks during the summer and be paid for their services. The first year saw twelve students from the various degree programs working with nine faculty, while earning stipends of $3000. By 2019, the numbers had grown significantly, with 29 students being paid $4000 and working under the direction of seventeen faculty members, representing an almost 60% participation level among the school's full-time faculty. The DeMatteis School is now in receipt of pledged financial support guaranteeing the program's solvency for at least the next four years.

In addition to the scholarly work produced, helping both faculty and students professionally, the program also ensured greater utilization of laboratories during what was previously a relatively slack time between the end of one academic year and the start of the next. By making available the skilled labor of highly talented students, the program also is producing a noticeable shift in faculty research areas toward topics that dovetail well with programs that emphasize undergraduate education.

The summer of 2019 marked the fourth year of the official program, and the sixth of any paid summer research experience. Table 1 shows the growth of the number of participants by major and gender.

		Number of Participants by Major									
Year	Total	1	2	3	4	5	6	7	8	9	M/F
2014	3	3									3/0
2015	6	4	1	1							4/2
2016	12	3	6	2	1						6/6
2017	20	7	4	1	1	2	5				16/4
2018	24	7	5	2	4	1	3	2			17/7
2019	29	6	5	3	1	3	7	2	1	1	22/7

Table 1: Major Legend: 1 = Bioengineering, 2 = Mechanical Engineering, 3 = Civil Engineering, 4 = Electrical Engineering, 5 = Computer Engineering, 6 = Computer Science, 7 = Industrial Engineering, 8 = Bioelectrical Engineering, 9 = Biomechanical Engineering

Literature Review

Upon reading the introduction, the first thought may be, “How does this program differ from an REU (Research Experiences for Undergraduates)?” [4]

ASPiRe and REU are similar programs but do differ in some fundamental respects, e.g., undergraduate students supported by NSF/REU funds must be U.S. citizens, U.S. nationals, or permanent residents of the United States, or its possessions, and a REU Site may be at either a U.S. or foreign location. While the REU programs are funded by taxpayer dollars, ASPiRe is funded entirely by private donations and there are no requirements that participants be U.S. citizens, U.S. nationals, or permanent residents of the United States. [4]

A significant fraction of the student participants at an REU Site must come from outside the host institution, or organization, and at least half of the student participants must be recruited from academic institutions where research opportunities in STEM are limited (including two-year colleges). The ASPiRe Program has no such requirements. The approval process for REU is considerably more complex than the ASPiRe program and can require the submission of a proposed budget, letter of interest, essay, resume and references.

ASPiRe is a ten-week, full time, intensive program for students of the university that are interested in pursuing a research project related to their major, that requires the students to work full-time in the Fred DeMatteis School of Engineering and Applied Science (SEAS) laboratories under the guidance of Hofstra faculty peer mentors. Furthermore, students in the ASPiRe program are required to make formal presentations of their research at the end of the ten-week period to the SEAS faculty. Research topics are determined by the project’s mentor. Because participation by faculty and students is based solely on a mutual decision to work on a research project that can be largely completed over a ten-week period, with funding guaranteed by the school, the ASPiRe roster of projects is more likely to run across the entire spectrum of faculty program specializations than is a typical REU program. Often the latter is limited to a smaller subset of faculty that buy-in to summer undergraduate research.

One may also wonder whether a program of this nature is beneficial to both the faculty and to the students.

Prince, Felder, and Brent (2007) answered this question when they performed an analysis on existing and potential synergies [5] reporting that for the instructor, “The likelihood that research productivity actually benefits teaching is extremely small...the two, for all practical purposes, are essentially unrelated. (Feldman, 1987)” For the student, “Attending a college whose faculty is heavily research-oriented increases student dissatisfaction and impacts negatively on most measures of cognitive and affective development. Attending a college that is strongly oriented toward student development shows the opposite pattern of effects. (Astin, 1994)” In the end, simply proposing that "...we maybe should accept the conclusion that teaching and research (however conceived) are unrelated and move on to ask how we should enhance this relation (of course assuming that we wish to do so). (Hattie and March, 2002). The DeMatteis School wishes to do so.

Prince, Felder, and Brent (2007) proposed three strategies for strengthening the research-teaching nexus: (1) bringing research into the classroom; (2) involving students in research projects; and (3) broadening the model for academic scholarship. [5] The ASPiRe program implements the second strategy in a way that is unique compared to existing programs such as the NSF Research Experience for Undergraduates (REU) program [4], the University of Michigan Undergraduate Research Opportunity Program [1], and the Massachusetts Institute of Technology Undergraduate Research Opportunity Program. [3]

Their analysis found that "Engaging students in research projects correlates positively with the students' attainment of the bachelor's degree, commitment to the goal of making a theoretical contribution to science, and self-reported growth in preparation for graduate, or professional school. He also found positive correlations between research involvement and a broad range of self-reported growth measures and satisfaction with many aspects of an educational experience. (Astin, 1994)" They further reported that students, and faculty, overwhelmingly find it to be a positive experience. [5]

To assess that the ASPiRe program creates a similar positive impact, a Likert Survey was created to assess self-efficacy and confidence. Several surveys, such as the Longitudinal Assessment of Engineering Self-Efficacy [LAESE] and the Pittsburgh Freshman Engineering Attitude Survey [PFEAS] were researched to establish preliminary questions to assess self-efficacy and confidence. [2] The former was the primary influence for selecting the five Likert Survey questions. [6]

Methodology

Students completing their first, second, third, and fourth (but not yet graduating) years were encouraged to apply to the program during the beginning of the spring semester. Program attendees performed their research or design project under the direction and guidance of faculty mentors and were encouraged to pursue a research project that directly correlated to their undergraduate field of study.

Under the guidance of the faculty mentor, students worked on research projects either by themselves, with a colleague, or with two colleagues. Seventeen faculty participated in Summer 2019, with some mentoring two students and one mentoring three students. The projects lasted ten weeks culminating in a symposium where all students presented their work.

A simple survey was created to collect demographic data, assess their perceived confidence and self-efficacy as a result of participation in the program, and to spark reflection on the program. A link to the survey was emailed to all 2019 participants four months after the completion of the program. Two participants were asked to reflect more on their learning experiences.

Results

The 2019 cohort consisted of 29 students representing nine of the engineering and computer science disciplines. A simple t-test procedure in SAS 9.4 on the overall GPA of the participants with gender as the variable, was performed. An F value of 1.27 with a large p value ($p<0.8166$) revealed an equality of variances. The pooled t-value was -0.48 with $p<0.6385$. Because of the large p-value we "fail to reject" the null hypothesis and do not have strong reason to conclude that the GPA means for the female participants ($M = 3.3586$, $SD = 0.4325$) and the male participants ($M = 3.4568$, $SD = 0.4883$) are different. The negative difference of -0.48 indicates that the male participants had slightly higher overall GPA.

Fourteen students, six females and eight males, responded to the survey. Five students worked by themselves on a project, four students worked with one other colleague, and five students worked with two other colleagues. Two students (1 female, 1 male) were between their first and second year, five students (3 females, 2 males) were between their second and third year, four students (2 females, 2 males) were between their third and fourth year, and three students (3 males) were between their fourth year and graduation at the university.

Students were asked to assess their perception of the difficulty of the research or design project. Using a scale of Very Easy = 1, Easy = 2, Neutral = 3, Difficult = 4, and Very Difficult = 5, the perceived difficulty was 3.64 (See Figure 1.) with 100% of the students finding the activity difficult, or neutral.

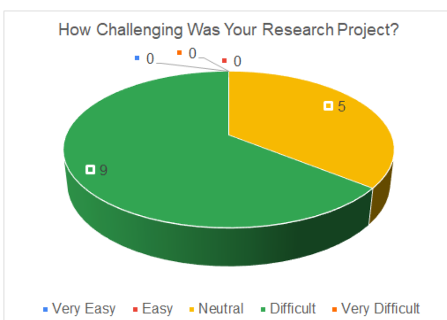

Figure 1: Perceived difficulty = 3.64

Students' confidence and self-efficacy were assessed using a Likert scale of Strongly Disagree, Disagree, Slightly Disagree, Slightly Agree, Agree, and Strongly Agree. (See Figure 2.) Students felt confident that they had chosen the correct major, will do well in their major during the current academic year, were comfortable approaching a faculty member, and will graduate with a degree in their major. The responses for "I am well prepared for post-graduation plans" were more evenly distributed. One 3rd-4th year student and one 4th-graduation student chose "slightly disagree" indicating that perhaps participating in such a program during earlier academic years would have proven helpful in determining a career path.

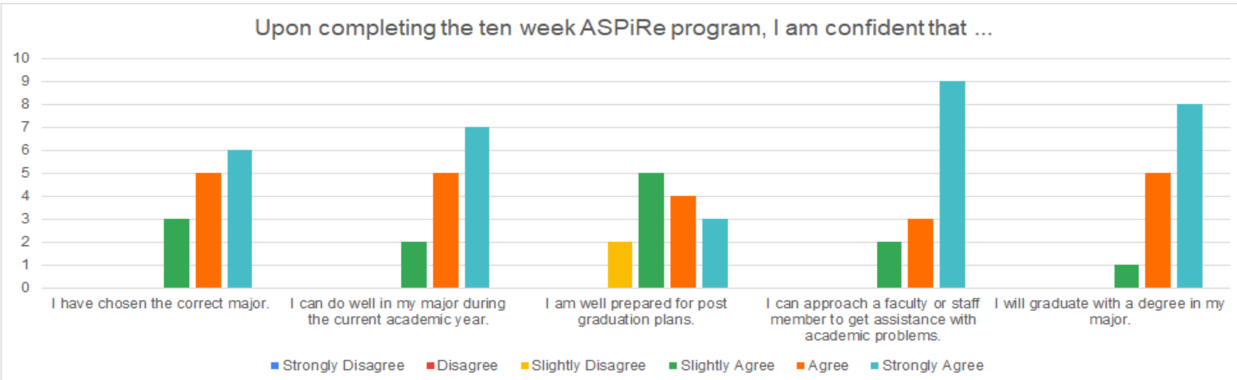

Figure 2

In the survey, students were given three prompts to reflect on their experience. A simple word frequency query in NVIVO 12 pro on each prompt produced the respective word clouds. The top 10 most frequent words (with stemmed words) greater than four characters were used to create the word cloud.

First Prompt: Did your work during the summer program provide direction for your future career path? In what ways? All but two students responded positively that it helped to "figure out my interest in the field", "further solidify my interest in human factors and ergonomics", and "show me that I am interested in research", etc. The two students responded with, "It didn't provide me a new direction, just tools to use for whichever direction I choose," and "I don't yet feel confident in the direction my career path will take. The program did give me a chance to evaluate whether I wanted to carry on in the particular subfield I researched in."

Figure 3: Word Cloud for First Prompt

Second Prompt: What was most beneficial to completing your work? The answers varied but one of the common themes was time. "Lab meetings every week where we presented our findings and proposed next steps and got to consult with our mentor helped prepare for the symposium as well as problem solve research blocks." Another student commented, "Support from professors." Others benefited from being forced to problem solve differently. "The most beneficial aspect of completing my work was allowing me to acquire a new way of thinking and approaching problems and coming up and implementing appropriate solutions."

Figure 4: Word Cloud for Second Prompt

Third Prompt: Did you gain a greater understanding of the major area connected with your research project? All but two students responded positively with one student stating, "Very much so. I also have more confidence in the subject and can speak to professionals in both the industry and in the research field in regards to my research with more ease and understanding, as well as hold a conversation and exchange ideas about my research."

Figure 5: Word Cloud for Third Prompt

Case Studies

Two students were asked to provide more reflection to assess the impact of learning. Each student was asked to consider three main areas of learning and reflect on where their knowledge stood at the start of the program, and how it evolved to the end of the program.

First Student

A senior male computer science major, mentored by a male electrical engineering faculty member engaged in a wound closure project. The student, formerly a business major, was introduced to, and learned, core technologies CUDA-C, OpenCV, and PCL. All were outside of his comfort zone, and skill level, at the start of the program.

Area 1: Professional Learning

"The best way to learn how to do something is to just do it. Prior to working with my mentor, most of my software development experiences revolved around classroom projects and some small personal projects. In conventional computer science classrooms, most assignments and projects are limited in terms of size, length and level of difficulty. The reason is simple, there is a limited amount of time for such hands on projects and experiences in the classrooms. The normal amount of time for these projects range from a couple of weeks for small projects to larger projects which last for a whole semester. With shorter amounts of time, these smaller projects become "easier" projects, because of the fact that less time can be spent on investigating the problem or topic. For a computer scientist, the ability to investigate and explore the problem or topic is a huge part of learning and growing. It means stepping up the game from developing small sub-functions, to seeing the bigger picture and developing software with many sub-functions that work together. My mentor showed me the problem and the goal that we were trying to solve and achieve. We have been tackling this particular issue nonstop. It has been like going from playing little league baseball to playing in the big leagues! The experience of working by myself on a large scale and realistic project has opened many doors for me as a student and a soon to be professional. Few of these learning experiences include being able to work tirelessly to solve an issue or problem until I come up with the answer. The satisfaction of seeing the software work after spending many hours on it, is truly unmatched. All the effort that went into the finished product was very much worth it and left me with a feeling of satisfaction with the end result. This experience has been most valuable and an area of interest when referring to my resume during interviews."

Area 2: Technical Learning

"This experience has also broadened my view in the computer science and engineering fields. I had very little experience with computer vision, CUDA parallel programming and edge detections. The project started off with the direction of using techniques of edge detection on computer vision to detect the edges of the wounds. When it became apparent that 2 dimension techniques may not be enough to discover the fully enclosed wound edges, we decided to explore ways of detecting in

3 dimensions using point cloud library (PCL). This provided me with the experience of developing a solution from the ground up and it opened my eyes as a software developer.
Now I have the vision for many interesting applications that I see being useful in the future. It definitely has sparked my creativity and imagination. As a matter of fact, I came up with two personal side projects due to being inspired by this project."

Area 3: Academic Learning
"This program has also opened my eyes for a potential involvement with further PhD research. One of the greatest things about working with smart and experienced people is that human intelligence is contagious. My mentor, along with the Dean and another faculty mentor, guided me and made me realize that further research in PhD programs can be very interesting. The fact that the team working on the project is also directly associated with the project idea, made the structure of the development cycle much clearer and easier. This is also one of the advantages of doing PhD research. Their experience in researching and publishing papers helped me gain a lot of knowledge regarding publications. With my mentor's guidance, I am currently working towards publishing my research."

Second Student
A sophomore female civil engineering major, mentored by a female mechanical engineering faculty member, engaged in a design project to create a platform where students could efficiently and safely test fabricated pumps. The student engaged in three iterations of the design process, creating three prototypes. There were many firsts such as learning about new materials, applying knowledge learned in statics to the design, understanding each step of the design cycle, documenting the process, and creating a presentation poster.

Area 1: The Design Cycle
"Before I started my summer project I didn't have much experience with the Engineering Design Process. I learned about it in class; what it was and what the steps were, but never applied it to a project. Since completing my project I have a better understanding of the process and how useful it is to designing almost anything.

The first step I took was to go more in depth into what the different steps of the process actually were and how to apply them. The Design Cycle consists of 5 steps: Ask, Imagine, Plan, Create, Improve. I began with the "Ask" step which was basically the problem of how to create a better testing station for the students to use. I proceeded to brainstorm ideas for the "Imagine" step and then created some sketches for the "Plan" step. Once I was satisfied with my design I moved onto the "Create" and actually built a prototype. Next was the "Improve" step which was used the most as it helped me modify my project through each prototype step going from mock-up to the first prototype and to the final one. When the first prototype was completed, I went back to the "Ask" step and evaluated what needed to be improved for the final prototype by systematically moving from there to “Imagine”, “Plan”, and finally “Create”.

When working on a project I naturally start with coming up with ideas and drawing out what they might look like. What made this experience different is the design cycle gave me defined steps that broke the process up which definitely helped me focus my attention on what needed to be improved and prevented me from fixating on one step. I also realized while going through the steps that this process can be used for both the overall problem, such as building a water pump testing station, or to focus on a specific issue, such as improving the way the drawers moved. The Design cycle will definitely be used on projects I have in the future, such as my senior design project, but also to guide my fabrication process in whatever I may work on.”

<u>Area 2: Technical Skills</u>
“Throughout this project I learned many fabrication techniques encompassing how to use different materials and some physical fabrication tips. Cardboard was discovered to be a very good prototype material since it is easy to work with and readily available. It allowed me to test if the design I came up with would properly function before committing to the actual material. The second material was acrylic which was used for the majority of the testing station. I learned how to use it as this was the first time working extensively with the material. A specific adhesive is used to join the pieces so I learned how to use that and how to properly clamp the pieces so they attach correctly.

AutoCAD was used to create 3D models of my two prototypes. I had taken a course on it during the semester right before working on this project so I drew mostly on my knowledge from that class, but I did learn more specific skills such as how to import files of a specific hinge from McMaster-Carr.com. I also learned by error that I should create the prototypes in AutoCAD first to ensure the dimensions of pieces I cut match up properly. I forgot to take into account the thickness of the material when I would mark my pieces of acrylic and the two pieces would be slightly off. If I had referred to my AutoCAD drawing first, I would have noticed the discrepancy in dimensions and corrected it before cutting the material.

For future projects, I plan on starting with a cardboard mockup since it provides a low cost option to testing out ideas before starting with other material that may be expensive or in low supply. I also like working with acrylic, partly because I am so familiar with it, but also because it comes in a multitude of colors, thicknesses, and opacities which provides many design options. AutoCAD will also be used first before any cuts are made to ensure all the dimensions are correct.”

<u>Area 3: Testing</u>
“I fabricated a pump and had to learn how to properly prime it. I ended up using a squirt bottle filled with water that I squeezed into the long tube. I got rid of stubborn air bubbles by raising the tube to a higher height and then raising the other side so the bubbles would “drain”. In relation to

testing I had to design the station so that the students were able to easily test their pump. I had to take into account that multiple people were going to be using this station and not everyone thinks like I do so I came up with a standardized system for the students. I created a stand that the pump fits into so there is no question about which way the pump is oriented when the students go to test. This area was a learning process for me to gain a specific skill as well as learning to think about how other people will interact with whatever design I create."

Conclusion

The ASPiRe program is unique because it engages students and faculty, in the present case almost four dozen people total, from one school within the university, utilizing the school's resources, and creating an active learning community during the summer.

The perceived difficulty of the projects leaned towards "difficult" which is perhaps why participating in the ASPiRe program had a positive impact on student confidence. As a result of participating, most felt that they had chosen the correct major, could do well in their major during the current academic year, and will graduate with a degree in their major. Students also gained confidence to approach a faculty, or staff member, to get assistance with academic problems. This is important because students often perceive faculty to be "godlike" when indeed, they are not. Removing the fear factor associated with this barrier, while still retaining a healthy amount of respect for experience and knowledge, is a delicate balance. If a program such as this can make faculty more approachable, then it would be worthwhile to assess a mini-version of the program offered to first-year students during a five-week intersession, and see if it improves retention. The DeMatteis School is building a program called W-SPiCE to fulfill this need.

Both students in the case studies were impacted by the program, perceiving their project as "difficult." Student 1 is now pursuing graduate work in computer science after graduating with a business degree. Student 2 was able to fill gaps, or reinforce her education, as well as transition from a dualistic thinker to a realistic thinker. She also answered "strongly agree" to the question, "I will graduate with a degree in my major." This further strengthens the case for offering this program to students earlier in their academic career in order to improve retention.

When looking at the results of the NVIVO 12 pro coding it became apparent that a lot of the words were very similar to words that were in the survey question. This could be due to students simply reiterating the question in their answer. However, the word research came up and was the largest which correlates to being the most used word in the survey responses. This may be due to the students responding in a fashion such as "The research I completed over the summer helped me figure out what I want to do in the future". In addition, students may have wanted to be more specific in their response by using the word "research" instead of the more general word "work", as used in the question. Most of the projects were research projects, as opposed to design projects, so that may also have contributed to the common use of the word "research".

Future work will also include assessing the 2020 program participants and mentors immediately after the program ends; using existing Likert surveys to assess confidence, and retention of the students. The word clouds appear to show that students are just likely to reuse words from the prompt. Therefore, better prompts for the future assessments will be defined.

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