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## Engineering Student Perceptions of Combined Faculty and Peer Academic Performance

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### Abstract

There has been a nationwide effort to increase the number, caliber, and diversity of the science, technology, engineering, and mathematics (STEM) workforce. Research on student development shows that while there is a need, providing financial aid alone is not a sufficient factor for academic success of low-income academically talented college students. Thus, Hostos Community College has recently created the NSF-funded Hostos Engineering Academic Talent (HEAT) Scholarship Program which offers its scholars financial support and experience with a combined mentoring model where students work with faculty and peers during the academic year. This research then systematically investigated the impact of a combined faculty- and peer-mentorship approach with a population not yet studied, undergraduate STEM students at minority-serving community colleges. Preliminary data indicates that the combined mentoring approach has positive effects on scholar's academic performance and STEM identity. The findings are expected to be generalizable to other populations, and hence provide an opportunity to expand the combined mentorship model to other STEM programs at a variety of institutions whose students could benefit from its implementation.

### Introduction

Hostos Community College (HCC) has recently created the NSF-funded Hostos Engineering Academic Talent (HEAT) Scholarship Program designed to increase the number of low-income academically talented students who persevere and graduate with associate and baccalaureate degrees in engineering. In addition to providing financial support, HEAT offers its Scholars exposure to a combined mentoring model where students work with faculty and peers during the year as part of their academic experience in the program.

While there is a wealth of literature on the factors that contribute to college student success, the positive impact of mentorship in science education on student retention and graduation (Loue, 2010) made it well suited to be integrated into the HEAT Program. Specifically, mentoring has been shown to improve academic achievement, student engagement, awareness of support services, retention, graduation, and access to professional networks (Smith & Lucena, 2016; DePass & Chubin, n.d.; Executive Office of the President, 2014; Taylor-Smith & Adolfo-Bermeo, 2009; Crisp & Cruz, 2009). Since a central component of HEAT is its relatively unique body of students, undergraduate STEM students at minority-serving community colleges, this is an opportunity to study the impact of mentoring in a population that has yet to have been thoroughly investigated.

A closer look at literature on mentoring in and out of academia indicates that there are many challenges with this type of research (Crisp & Cruz, 2009; Allen, Eby, O'Brien, & Lentz, 2008). A primary concern is the lack of a clear definition for the concept of "mentoring." Jacobi (1991) first outlined three characteristics of mentoring based on an analysis of the literature. These characteristics were later updated (Crisp & Cruz, 2009) to include: 1) a focus on growth and accomplishment of an individual with any of several forms of assistance; 2) broad forms of support, such as career development, role modeling, and psychological support; and 3) relationships that are personal and reciprocal. The combined faculty and peer mentorship model included in HEAT makes use of these defining elements and thus the research may contribute to the body of work in this area.

Similarly, the research on faculty-mentorship models reveals a dearth of clarity on the conceptualization of this approach, which is empirically validated. One of the few empirical studies that does, however, showed that mentoring progressed through a series of four stages over the course of several years (Kram, 1983). This work was extended and conceptualized mentorship via a content analysis of interviews with mentors to include "psychosocial" and "career" functions (Kram, 1985; Kram & Isabella 1985). This conceptualization of mentorship was further studied by Paglis, Green & Bauer, 2006 who added "research collaboration" to the list of functions. These functions served as the conceptual framework for the faculty-mentoring model in the HEAT Program.

There is also a lack of precision in the conceptualization of student-led mentorship models. One of the more developed approaches however includes the "near-peer" mentorship model first reported by Jett, Anderson & Yourick, 2005 that was designed specifically for undergraduates and secondary students studying in Science, Technology, Engineering and Mathematics (STEM). Study of the "near-peer" approach noted that this model differs from other student-led mentoring by 1) an emphasis on the mentee's ability to both acquire and share knowledge; 2) a focus on selecting students from traditionally underrepresented populations; and 3) encouraging mentees to explore topics of interest via research and teaching (Tenenbaum, Anderson, Jett & Yourick, 2014). This structure served as the conceptual framework for the student-led mentoring in the HEAT Program.

Another concern with the research on mentoring is a failure to distinguish between different forms of mentoring and the absence of studies on combined mentoring models. While most research has focused on mentoring of college undergraduates by faculty advisors, the role of mentor can be fulfilled by, among others, staff, senior students, peers, friends, and family. To date, no study has looked at a combined faculty- and peer-mentoring model. Since HEAT makes use of both faculty-mentoring and student-led mentoring models, this is a unique opportunity to study the impact of two forms of mentoring as a combined approach.

A final concern about research on mentoring is how nearly all of the investigative work has been conducted in 4-year institutions. It has been observed that community colleges have been almost completely excluded from this research (Crisp, 2009). Thus, as HEAT takes

place at a two-year institution, this provides an opportunity to significantly extend the literature on the impact of mentorship for a population that has yet to be thoroughly considered.

While mentoring has been shown to have a positive effect on students, research on the combined impact of faculty and peer mentoring on community college student's academic success is still limited. Here, via HEAT, is an examination of the impact of a combined faculty and student-led mentoring model on the academic success of 10 HEAT Scholars. This research studies whether a combined intervention of faculty mentoring and peer mentoring has a positive effect on the Grade Point Average (GPA), and retention and graduate/transfer rates for the students enrolled in this program (Campbell & Campbell 1997). Furthermore, surveys were used to assess if the combined mentorship model has a positive effect on HEAT Scholars' academic, professional and personal growth as well as their STEM identity. The findings are expected to be generalizable to other populations both inside and outside of HCC, and thus provide an opportunity to expand the HEAT mentorship model to other STEM programs at a variety of institutions whose students could benefit from its implementation.

### The Study

#### HEAT Scholars

HEAT Scholars were low-income academically talent students with demonstrated financial need and were required to maintain a minimum overall GPA of 3.0, and a minimum College Math and Science GPA of 3.0 with no STEM courses grades below "B-" to remain enrolled in the HEAT Program. The 10 scholars in this study were majoring in Chemical (2), Civil (3), Electrical (3), Environmental (1) and Mechanical (1) Engineering as part of the Hostos Joint Dual Engineering Degree Program with The City College of New York's Grove School of Engineering (CCNY's GSoE). Out of the 10 HEAT Scholars, 50% were women, 60% Black or African American, 30% Hispanic and 10% Asian (see Table 1).

Table 1. HEAT Scholars Profile\*

| Characteristics                         | Number |
|-----------------------------------------|--------|
| <b>HEAT Scholars</b>                    | 10     |
| <b>Race / Ethnicity<sup>&amp;</sup></b> |        |
| Black or African-American               | 6      |
| Hispanic                                | 3      |
| Asian                                   | 1      |
| <b>Gender</b>                           |        |
| Female                                  | 5      |
| Male                                    | 5      |
| <b>Academic Standing</b>                |        |
| Upper Freshman                          | 2      |
| Lower Sophomore                         | 7      |
| Upper Sophomore                         | 1      |
| <b>Expected Major</b>                   |        |
| A.S./B.E. Chemical Engineering          | 2      |
| A.S./B.E. Civil Engineering             | 3      |
| A.S./B.E. Electrical Engineering        | 3      |
| A.S./B.E. Environmental Engineering     | 1      |
| A.S./B.E. Mechanical Engineering        | 1      |

\*Source: Data retrieve from CUNYfirst. &Scholars self-reported their demographic information on a technical program survey.

## Combined Mentoring

Presented below is an outline of the combined faculty- and peer-mentoring model in the HEAT Program and the evaluation methodology used to assess the combined intervention on HEAT Scholars' academic performance and development.

### Faculty Mentoring

Three STEM faculty served as mentors, two of whom were each assigned three scholars and one faculty mentor was assigned four scholars. Mentorship assignments were determined by considering student and faculty feedback that was collected before the start of the academic year about whom they wish to work with and ease of scheduling. Scholars who had no preference were randomly assigned to a faculty mentor accordingly. The faculty-led mentorship meetings were scheduled biweekly throughout the academic year with sessions that lasted up to 45 minutes. The informally structured meetings typically took place in the faculty's office where they could discuss program, academic, professional, and personal matters. In the early spring during which this study took place, the university was forced to close its buildings due to the COVID-19 pandemic. Mentoring sessions continued however, shifting to telephone and online conference software as meeting spaces. The specifics of each conversation were kept confidential. While faculty were not trained on mentorship directly, they were provided guidance on the characteristics of successful mentoring as outlined by Crisp and Cruz, 2009, and the empirically validated functions of faculty mentorship identified by Paglis, Green & Bauer, 2006, which include elements of psychosocial, career, academic, and research development. Each mentoring session was centered on three main pillars: Academic Issues such as classes, course schedule, school projects/papers/exercises, and study habits; Professional Development considerations that may include job, conference, and grant opportunities, and interview techniques; and Personal Matters such as life experiences shared by student and life experiences shared by the mentor.

### Peer Mentoring

Six peers started as mentors, but one was unable to complete the program due to workload and scheduling conflicts. Each peer mentor was assigned one or two scholars. Mentorship assignments were based on feedback collected from students and peers prior to the academic year, shared research interests and majors, and scheduling. Peer mentors were selected from the HCC Black Male Initiative (BMI) Together wE Achieve More (TEAM) Program. Among the goals of this program is to train and provide peer mentorship to science and engineering students. All peer mentors completed a peer-mentor training course at the beginning of the academic year that was aligned with the HEAT peer-mentorship model. The conceptual framework of student-led mentoring in the HEAT Program is based on the "near-peer" mentorship model,<sup>13</sup> as highlighted above.<sup>14</sup> These mentorship meetings were held biweekly throughout the academic year on campus in breakout areas within a larger STEM student room, and ran for no more than one hour. The breakout areas afforded a degree of privacy for the meetings. As it happened with the faculty mentoring however, peer mentoring shifted to telephone and online conference software during the early spring semester when this study took place due to university building closure because of the COVID-19 pandemic.

### Evaluation

Consistent with Campbell and Campbell, 1997 who explored the effects of faculty mentoring on the academic success of minority students, success was assessed by examining changes in Grade Point Average (GPA), rate of retention, and graduate/transfer outcomes. Additionally, HEAT Scholars' perception of the mentoring experience was also examined. End-of-semester satisfaction surveys were used to assess the degree to which the mentoring had an effect on students' academic, professional and personal growth.

### Results

Preliminary data from surveys indicates, in the Scholars own words, that the combined mentoring approach has had positive effects on their academic, professional, and personal growth. Some of these reflections are shared in Table 2. Overall, the survey responses suggest that the greater impact of the sessions were related to academic issues and professional development more so than personal issues. The conversations regarding personal issues were intertwined with the other two mentorship pillars, academic issues, and professional development. As the mentorship progressed, the faculty-scholar mentorship relationship grew positively, and most of the scholars reached out to their mentors even if no mentorship session was scheduled. The trust level of their relationship enhanced as the scholars were feeling supported by their mentors and comfortable to talk to them.

Regarding the peer-lead mentorship sessions, while they were also scheduled to occur twice a month, sessions later in the academic year happened on average once a month and were more spontaneous since most of the scholars and their peer mentors shared the same STEM room used for workshops, research, mentoring and tutoring. In general, the STEM faculty and peer mentors felt like the sessions were productive and were looking forward the next ones. Likewise, the scholars agreed that the mentorship sessions were constructive and were eager to the next ones. However, some scholars believed meeting once a month was enough instead of biweekly.

Table 2. HEAT Scholar's Reflections via End-of-Semester Surveys

| Faculty Mentorship                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• "My faculty mentor gave me the best advice on what my next steps should be when I was having trouble."</li> <li>• "Mentorship sessions helped obtain the skills and tools to survive this challenging semester."</li> <li>• "Started the semester poorly, but faculty mentorship helped me realized my faults. Though it was difficult to get backed up, but I will do better."</li> <li>• "Because mentorship helped academically and also with personal situations."</li> <li>• "Speaking with my professor was what got my mindset ready to carry out the semester."</li> </ul>                                                              |
| Peer Mentorship                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <ul style="list-style-type: none"> <li>• "Without a peer mentor, I was not able to do well for the course work. They helped me a lot, for example, every Thursday they helped me with physics and math."</li> <li>• "My peer mentorship sessions were valuable guides of how to successfully work my way through the semester."</li> <li>• "My peer mentor was very integral in my transition at City College."</li> <li>• "I am looking forward to become a mentor and share the key that helped me in my path."</li> <li>• "my selection is that peer mentorship guide ma [sic] a lot throughout this semester it was hard but they help, encourage me and i [sic] did it."</li> </ul> |

The HEAT Scholar's reflections listed in Table 2 suggest that they believe the faculty and peer mentorship experience helped in their academic, professional, and personal growth as well as the development of their STEM identity. They have started to dream big and want to succeed in engineering.

A preliminary quantitative analysis also illustrates the positive effect of combined mentorship on rates of retention, graduation, transfer from two- to four-year institutions and GPA. The HEAT Program retention rate during its first year has been 100%. As of Summer 2020, all 10 Scholars remain in the HEAT Program with 50% earning their Associate in Science degree in Engineering. One Scholar transferred to CCNY's GSoE in the Spring 2020 semester and the remaining four are scheduled to transfer to CCNY's GSoE in Fall 2020. Thus, 50% will be transferring to a 4-year institution and the remaining 50% will continue pursuing their Associate in Science degree in Engineering. Some Scholars have also shown interest in transferring to other universities as two Scholars have been accepted to Cornell University to continue their baccalaureate degrees in engineering: the first scholar who transferred to CCNY's GSoE and another one who is about to finish his associate in science degree at HCC.

Figure 1

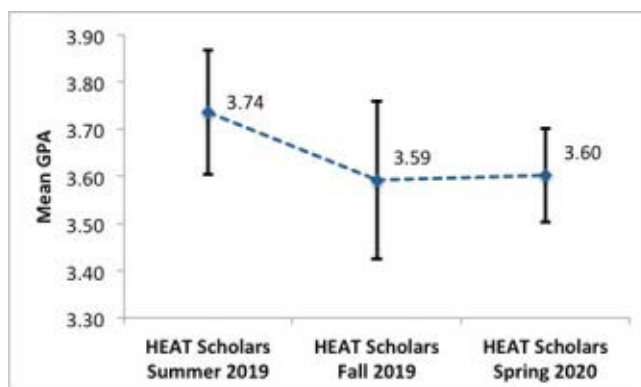


Figure 1 shows the HEAT Scholars' mean GPAs and standard deviations at the end of the Summer 2019 semester, at the end of the Fall 2019 semester and at the end of the Spring 2020 semester. Error bars represent the standard deviations.

As a cohort, Figure 1 illustrates how HEAT Scholars have maintained their GPA since beginning the program. They started with a mean GPA of  $3.74 \pm 0.26$  in the Fall 2019 semester, then obtained a GPA of  $3.59 \pm 0.33$  at the end of Fall 2019 semester, and finalized with a GPA of  $3.60 \pm 0.20$  at the end of Spring 2020 semester. None of these differences were statistically significant (one-way ANOVA  $F(2,27) = 0.877$ ,  $p = 0.427$ ). It is worth highlighting that these Scholars' mean GPA includes their core engineering major courses. Thus, maintaining their mean GPAs as a cohort represents success due to the challenging courses they were taking during this period and the obstacles they faced during the transition from in-person to distance learning mode due to COVID-19 pandemic. In addition, as seen in

Figure 2, the HEAT Scholars' mean GPA at the end of the Spring 2020 semester ( $GPA = 3.60 \pm 0.20$ ) is significantly higher compared to the match-paired group of students with similar majors, class standing, course enrollment and course history ( $GPA = 3.15 \pm 0.63$ ),  $t(20) = 2.166$ ,  $p = 0.021$ . This preliminary finding suggests that combined mentorship might have a significant impact on raw outcomes in courses.

Figure 2

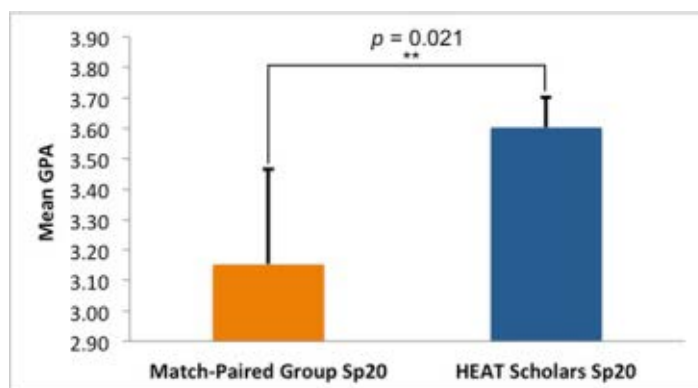


Figure 2 shows a comparison between HEAT Scholars' and the Match-Paired Group's GPAs at the end of the Spring 2020 semester. p-value  $< 0.05$  (\*\*) was determined with one-tailed t-test. Error bars represent the standard deviations.

## Conclusion

Community colleges play a crucial role in enhancing and diversifying the STEM pipeline and contribute to meet the high demand for a skilled STEM workforce in the United States (National Research Council and National Academy of Engineering, 2012). The preliminary study presented here suggests that the combined faculty- and peer-mentoring model could assist in this effort. The HEAT Scholars have expressed in their own words the positive effect of this mentorship experience on their academic and professional growth as well as their STEM identity. Their GPAs during the combined mentorship experience have remained statistically consistent with previous semesters even as they were taking more difficult courses in their engineering majors and faced with the sudden change to distance learning during the middle of the Spring 2020 semester due to the COVID-19 pandemic. Similarly, HEAT Scholars' mean GPA during the semester of the combined mentorship experience was statistically greater than a group of students who were matched according to major, class standing, course enrollment, and course history and did not have the opportunity to participate in the mentorship as described.

While these early findings from a single (and profoundly atypical) semester are encouraging, there are a number of factors to be considered as this research moves forward. Looking at HEAT Scholars' progress over time in an environment that reflects the more traditional college experience will be critical to understanding the impact of the combined mentorship model. Additionally, the HEAT Program is projected to serve 30 Scholars by the end of the five-year project duration. As more students are exposed to the combined mentorship model, the increased sample size will allow us to study the robustness of these findings and to unpack the variables that contribute to what was observed. Understanding what elements of the HEAT mentorship experience are having the greatest impact, and exploring the development of Scholars' STEM identity over an extended period of time are among the most important.

As HCC serves a student population that is more than 80% minorities and 67% women, HEAT as a model of intervention could help to expand the STEM pipeline and prepare more underrepresented and female students for engineering careers. It is expected that the HEAT mentorship model will be generalizable to other STEM programs at a variety of institutions whose students could benefit from its implementation.

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