Approaches in addressing access and success among female engineering students at the 2-year college level

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Abstract

In 2016 Georgia State University, a large public urban research university in the southeast U.S., consolidated with Georgia Perimeter College, the state’s largest two-year access institution, creating Georgia’s largest university serving over 58,000 students across six campuses located the Atlanta-metro area. The “new” Georgia State University is among the most diverse in the nation, and annually graduates more African American students than any other higher education institution. The university is comprised of eleven colleges, inclusive of Perimeter College which is now a college within the larger university, and awards associate’s degrees. It is within Perimeter College that students can take the first two years of engineering coursework that can either lead to an A.S. degree or be used for transfer to a four-year engineering degree program. On average there are approximately 900 students enrolled in the engineering pathway, where 28 percent are first-generation, 53 percent are Pell-eligible, and approximately 59 percent are from populations traditionally underrepresented in STEM. While minority engineering student enrollment continues to grow at a steady pace, enrollment among female students has remained flat at 18 percent over the last three years. Consequently, the uniqueness of this work presents ways in which Georgia State University, Perimeter College is working to support its female engineering students. More specifically, the paper presents ways in which the college is proactively working to address issues of access and success through three strategic approaches: 1) the formation of new female-led student clubs aimed at encouraging a growth mindset in engineering; 2) the creation of academic-based collaborative learning spaces which support synergistic activities between faculty and students; and, 3) student engagement in the form of wraparound services based in co-curricular programming. It is through these efforts that the authors hope to further the discourse among engineering educators on how to improve access and the success of female engineering students especially within the first two years of the college experience.

Strategic Approach I: Female-led Student Clubs

Background

Over 30 years ago, world renowned Stanford psychologist, Dr. Carol Dweck and her colleagues became interested in students’ attitudes about failure. What they noticed was that some students were able to rebound from failure while other students were not, even when the setbacks were relatively small [1]. As a result of studying the behavior of several thousand children, she determined that how we view and inhabit is a fundamental part of our personality [1]. She coined the term mindset, which is described as the underlying beliefs that people have about learning and intelligence; and, further determined that one could have a fixed or growth mindset [1]. A fixed mindset is defined as, “people beliefs in their basic qualities, like intelligence or talent [2]”. Whereas a growth mindset is defined as “basic abilities that can be developed over time through hard work and dedication [2]”. Figure 1 provides a graphical depiction of fixed and growth mindsets [1].
In 2017, the University System of Georgia, which comprises twenty-six higher education institutions from across the state and which acts as the governing body to which Georgia State University belongs, embarked on the implementation of the Momentum Year [3]. The Momentum Year is a suite of strategies designed to help students at institutions within the University System achieve their educational goals, including successful degree completion and on-time graduation, with an intentional focus on the first year [4]. Strategies of the Momentum Year include [4]:

- **Academic Focus Area** – grouping programs together so that students can pursue coursework at the beginning of their academic matriculation, but that can be more broadly applied across a wide variety of majors which helps students to avoid earning unnecessary credits as they narrow their program choice.
- **Fifteen to Finish** – encouraging students to take a course load of 15 or more credit hours, which helps to reduce debt and time to graduation.
- **Academic mindset** – finding ways to support student growth and help build resiliency even if they experience setbacks.

There has been significant literature surrounding the topic of student retention in higher education which also includes female persistence rates in STEM degree programs [5], [6], [7]. While gains have been made in increasing the number of females earning STEM degrees, it has been estimated that over 40 percent leave their engineering degree programs or if an engineering degree is earned, they never work in the field [8], [9]. This can be exacerbated in the two-year college space where only 40 percent of students enrolled, earn a degree or certificate within six years of enrollment and where many of these students are part-time, thereby increasing their time to degree and loan debt [10]. It should be noted that in recent years Georgia State University has made significant strides and increased the persistence rate of students from 58 percent to 70 percent [11]. However, these significant gains do not translate to the most vulnerable populations in STEM including those who are traditionally underrepresented, first-generation college, and particularly women. Recent data show that from year 1 to year 2, the attrition rate of female students in engineering and in computer science for the college is 60 percent.
Consequently, there is still significant work to be done in looking at the persistence of female engineering students and finding ways to turn these numbers around.

This section describes one strategic approach that is being implemented focused on the Momentum Year activity of **academic mindset** in the context of improving persistence of female engineering students. The formation of the female-led club, Women in Technology (WIT) was designed with the intention of helping to create a sense of belongingness while also helping female engineering students to “see themselves as engineers.” While the authors recognize that this strategic approach is not unique or novel to increasing retention rates of females in engineering, the uniqueness of this approach comes in that it is being implemented in the 2-year college space where student life activities, although important in creating connectedness and belonging, often take a back seat.

**WIT Club Formation and Programming**

The Women in Technology (WIT) student club was formed with eleven students and one faculty advisor at Perimeter College (the Alpharetta Campus) in November 2018, with a primary focus on fostering female students’ engagement in advanced technologies and real-world industry level projects while also helping them to develop an academic mindset. The Alpharetta Campus was intentionally chosen because more than 700 technology companies are based within close proximity to the campus.

The club had several gatherings ranging from on-campus meetings with students and professionals to site visits at local corporations and consulting firms. With these activities and involvements, club members gained the opportunity to interact with industry professionals for networking purposes and enhanced their understanding of the existing and upcoming technologies. Another significant advantage of this approach has been for female students to talk and speak in front of other individuals, which helps to build up their confidence and self-initiations. One interesting point to note that was initially when the club was formed, the faculty advisor did most of the work inclusive of planning and reaching out to professionals for technical talks and site visits. However, as students’ self-confidence increased, it was noticed that students became more proactive in bringing technology-related discussions for brainstorming to the meetings. Anecdotally, the advisor saw how the combination of those advancements, began to shape the overall direction of the club in that students began receiving more support, help, and attention from industry professionals and it is working to empower the female students through internship and job opportunities, educational sponsorship supports, and fellowships.

WIT club programming is specifically designed to enable students to further understand the importance of hard work, creativity, teamwork, and career planning. Programming includes:

- **Mentoring.** Students work with professional technical mentors who provide guidance inclusive of resume workshops which are designed to help club members highlight their strengths and demonstrate a potential for making contributions to projects with various employers.

- **Having sessions specifically on local work opportunities and research experiences for undergraduates (REU).** Mentors as well as other technical professionals and faculty provide students with updated information on local opportunities, in which they can
apply for or engage which help to shape the technical future. NSF-funded REUs are extremely competitive and even more difficult for two-year students to obtain due to the requirements of advanced-level course work. However, research has shown that these experiences not only impact student retention but also influence students’ decision to persist in and pursue STEM careers [12], [13], [14]. The WIT club works with students on this level of engagement which again helps club members see themselves as engineers with the intent of growing their mindset and skill level.

- **Focusing on leadership.** With different positions such as president, vice president, and secretary roles, students not only gain the value of understanding how to conduct the business of the club, but also have the opportunity to hone their leadership skills as they plan and program for different activities as well as task implementations and management.

- **Promoting the “We Culture”.** The “We Culture” is defined by encouraging women in any technology field to stay the course and support one another. More specifically, it is further elaborated upon and discussed with students that as women we need to support one another; acknowledge each other’s contributions; and mentor the next generation of girls and encourage strategic thinking. These club sessions focused on helping members create their own narratives by finding ways to empower a voice of their own. Self-efficacy, academic mindset, strategic thinking, and the importance of networking are often topics for discussion. Through these efforts, we hope that our female students can come to believe that their thoughts can happen and that they can make their dreams of becoming an engineer a reality. Our future work in this area includes working with local area schools by arranging visits where girls can visit the campus, gain exposure to college and the engineering pathway, as well as work with the leadership of those schools on exposure to technology and computer programming.

Although in its infancy of just over one-year old, the WIT club has grown to over twenty-two members and has become a place for female engineering students to find a sense of belonging, empowerment, and connectedness. It is our hope to continue this work and collect quantitative data that we see anecdotally. To this end, the next section presents the formation of the STEM Centers, which were created as academic-based collaborative learning spaces designed to support synergistic activities, inclusive of club meetings. As the two-year teaching arm of the institution, all students are commuter students and thereby need a space to meet, collaborate, and gain exposure.

**Strategic Approach II: STEM Centers**

**Background**

STEM Centers were created at three of the Perimeter College campuses (Clarkston, Decatur, and Newton) with an objective to improve student access and success among STEM pathway students and those enrolled in STEM-related courses. The centers were designed to create academic-based collaborative learning spaces where students could gather, work on projects, and receive peer and faculty-based instruction. More specifically, the spaces were created as a result of student requests for a “space” where they could meet other STEM pathway students and form informal study groups. As commuter students, these students face limited contact opportunities
with faculty, staff, and peers outside the classroom environment. Unlike residential students, commuter students rarely have the opportunity to observe faculty involved in non-classroom activities, make connections with peers in classes other than those in which they are enrolled, or socialize with other students encouraging them to become integrated into the campus community. Research has shown that these informal connections have been linked to academic performance and persistence [15]. Therefore, the goal in the creation of the STEM Centers was to strategically align itself with the institution’s mission of strengthening student success as well as increasing persistence rates of STEM pathway students and those enrolled in STEM-related coursework. The next section presents the programming and activities of the STEM Centers.

**Programming**

*Faculty-led Instruction Program*

The Faculty-led Instruction program was designed to provide students with access to faculty outside the classroom environment, thereby encouraging students to engage in informal mentoring and making connections with faculty in an “anxiety-reduced, non-consequential” environment. Faculty members could work with a student individually or students in a group setting on class material or on co-curricular projects. Some of these co-curricular projects resulted in research projects which benefited both faculty member - increased professional activities reported and student - increased applications and acceptance to NSF-funded Research Experience for Undergraduates at top universities from around the country (i.e., Texas Tech, Georgia Tech, Boston University, etc.).

*STEM-related Workshops*

On Fridays, the center was dedicated to hosting STEM-related workshops. At Perimeter College, classes meet Mondays through Thursdays, which allowed Fridays to be utilized for co-curricular programming. Students had the opportunity to attend a STEM-related workshop hosted by various faculty members and/or guest presenters. The workshops were designed to introduce students to current topics in STEM-related areas.

*Group Study*

Students enrolled in STEM-related courses could reserve space in the Center for the purpose of group study. Group study consisted of small teams that focused on specific topics or course material. Teams were typically unique in nature and were informally formed based on the backgrounds and abilities of its members. Through informal inquiries, this was found to be the most requested usage of the space.

*PLUS Program*

The PLUS (Peer-led Undergraduate Study) Program provided peer-led tutoring for students who were enrolled in beginner-level courses with a specific emphasis on STEM pathway students and STEM-related courses. Tutoring sessions were led by advanced students who had done well in the courses in which they were tutoring and who had chosen as a pathway a STEM discipline.
The PLUS program primarily focused on introductory chemistry courses as these courses had high DFW rates (approximately 46.3 percent) and were considered “gatekeeping” courses. Additionally, tutoring occurred in pre-calculus and calculus math courses as well as calculus-based physics courses.

On average tutors engaged approximately 300 students per semester and data collected from those students who attended peer tutoring passed the classes at a rate of 69 percent and labs at 90 percent with a C or better (data was not collected from all students enrolled in the classes but instead focused on those attending the tutoring sessions). As it related to the math and physics courses, data showed that many students were attending the tutorial sessions not to improve the grade in the course in which they were currently enrolled, but as a refresher for concepts on prerequisite material (79 percent) and (65 percent) respectively.

Supplemental Instruction

In addition to the PLUS program, the center also engaged students in supplemental instruction (SI). SI was developed by Deanna Martin at the University of Missouri-Kansas City in 1972 as an academic support model that utilized peer-assisted study sessions to improve student persistence and success in courses that had been targeted as being difficult and inhibiting student progress [16]. Georgia State University has become a noted leader in SI touting that students who consistently participate in SI receive, on average, a half or a whole letter grade higher than students enrolled in the same course that do not attend SI [17]. However, this work was primarily targeted in the four-year degree space at the institution. Therefore, considering the success of this work it was decided that in addition to the PLUS program, SI would also be utilized, and the STEM Centers provided an excellent space for implementation. In the Centers, SI sessions were regularly scheduled as informal review sessions in which students learned how to integrate course content and study skills while working together. The sessions were led by “SI leaders.” SI leaders were advanced students at Perimeter College (typically those who had completed the first-year of courses in a STEM pathway) who had previously done well in the courses and who would attend all class lectures, take notes, and act as model students.

High School Visitation Day

One of the most successful activities held in the STEM Centers was the STEM High School Visitation Day (STEM HSVD). STEM HSVD was an outreach program that worked with Title I high schools from the surrounding area to introduce students to Perimeter College and STEM. HSVD allowed students to sit in one college class that they would normally take during their matriculation. Also as part of their visit, they were introduced to each of the STEM programs; received information on the admissions process from an admissions counselor; and toured one of the campuses. Between 2014 and 2016, this NSF in part-funded program engaged approximately 300 students, with 59 percent being female. Over the duration of the grant (2012 – 2016) more than 400 students were surveyed and data revealed that before the HSVD program, only 26 percent stated that they intended to pursue post-secondary education and of the 26 percent, 44 percent were considering a STEM discipline. After the event, 52 percent stated that they would enroll in a post-secondary institution and of the 52 percent, 82 percent were
considering a STEM discipline [18]. One note of pride that one of the first HSVD females who attended the program is now a biology doctoral student at Massachusetts Institute of Technology.

WiSE Home

As previously stated, the STEM Centers were created as a result of student requests for a “space” where they could meet other STEM pathway students and form informal study groups. One organic outcome that was not originally part of programming in the STEM Center at the Clarkston Campus was that the Women in STEM Experience (WiSE) club began using the center to meet, conduct workshops, and host community-related events targeted toward increasing the number of girls interested in STEM (i.e., Black Girls Who Code). While the authors could not have predicted that this would be one of the ways in which students wanted to use the center, it seems like a natural fit and has become “home for the WiSE club” at Clarkston campus.

In summary since their inception, the STEM Centers have become a part of the STEM landscape at each of their campuses. They are academic-based collaborative learning spaces, where students can engage one another and faculty. At one of the campuses, between fall 2017 and fall 2019, 3631 students visited the center with primary purposes of group study (1526) followed by faculty-led instruction (1155). These centers, along with the formation of WIT provide an excellent opportunity for female students to engage beyond the classroom experience. The next section provides an additional strategic approach aimed at improving student success and the persistence of females in the engineering pathway.

Strategic Approach III: The MESA Program

Background

One of the country’s most innovative and successful programs, Mathematics, Engineering, Science Achievement (MESA) provides support for educationally disadvantaged students so they can excel in math and science and graduate with baccalaureate degrees in science, engineering, computer science, and other math-based fields [19]. The MESA program was initially launched in 2006 on Perimeter College’s Clarkston Campus and was supported by MESA USA and Hewlett-Packard. Since 2012, the MESA program has been supported in part by the University System of Georgia STEM Initiative and Perimeter College. MESA scholars benefit from wraparound services like Academic Excellence Workshops (AEW); academic advising/counseling; assistance with the transfer process to a 4-year institution; career advising; summer research/internship opportunities; and linkages with student and professional organizations. Benefiting from these activities, these at-risk students earn high GPA’s and graduate/transfer at a higher rate than their non-participating counterparts.

The MESA Difference – Academic Excellence Workshops and Dedicated Center

Academic Excellence Workshop (AEW) structure was initially developed by Dr. Uri Treisman [20]. Dr. Treisman developed the workshop structure at UC Berkeley after closely examining the difference in performance between Asian and African American/Hispanic students in calculus [20]. By immersing himself in the lives of both groups, Dr. Treisman observed that the Asian
students had integrated their academic and social lives and studying together was an integral component of their day [20]. In contrast, the African American and Hispanic students were more often academic loners. Since the initial introduction of AEWs into academic programming, many schools have adopted the workshops and have seen an increase in the success rates of not only their minority students, but their STEM student population as a whole [20].

AEWs are group learning experiences that provide students with the opportunity to work collaboratively in a positive environment to achieve a high level of subject mastery. AEWs are unique because they not only involve students who lead the workshops but also faculty liaisons that develop the material which parallels the topics covered in class. The workshops focus on advanced group-learning methods for technical concept mastery. The AEW is designed to give students the opportunity to enhance their learning experience for a particular course. The student facilitator for an AEW is trained to develop exercises that foster debate on key elements that have generally given students difficulty and hindered the learning process. As a result of this interaction the students gain both a sense of connectedness and the development of their own learning community.

The MESA Difference - MESA Center

The MESA Center is an academic-based center designed to help MESA Scholars excel in STEM by providing access to technology and opportunities for peer support and information-sharing. The MESA Center is strategically placed among STEM faculty offices on the Clarkston Campus where the engineering faculty have their offices. This allows faculty to assist with AEWs and promotes faculty-student interaction beyond the classroom. Students utilizing the Center have access to:

- STEM-related workshops
- State-of-the art software and printing
- Group study
- Peer-tutoring
- AEWs

MESA Scholars

The focus of MESA is to provide support and wraparound services for first generation and/or students who have been traditionally under-represented in STEM disciplines. Figure 2 shows the diverse student body of MESA Scholars for AY 2011 – AY 2017. These numbers mirror the general student body in which approximately 67 percent of students enrolled self-report as being from a minority group. Similarly, figure 3 shows the number of female and male participants. While this figure shows that there is disproportionately a larger number of male MESA scholars as compared to female MESA scholars, what it does not show is the persistence of the female MESA scholars who remain in a STEM pathway is approximately 62 percent.
Conclusion

In summary, the aim of this paper was to present three strategic approaches that Georgia State University, Perimeter College is taking to improve the access and success of all students in STEM pathways, but specifically females who have chosen engineering. While the authors acknowledge that the approaches by themselves are not unique and are available to all students, but when taken together provide additional resources and space for female students studying engineering especially within their first two years of matriculation. More work needs to be done in this area with quantitative data being married to the anecdotal data presented, which is the anticipation of the authors as the female-led club is only one year old and the STEM Centers are just four years old and programming and personnel are becoming stable and consistent. It is the hope of the authors that the introduction of the strategic approaches presented provide a discourse among engineering educators who are especially interested in the topic of how to address access and success among female engineering students at the 2-year college level.
References


