CREATING AN EQUITABLE LEARNING ENVIRONMENT

Taryn M. Bayles and Claudia J. Morrell
University of Pittsburgh and Morrell Consulting

The need to engage underrepresented students (as well as traditionally represented students) in engineering and other science, technology, and mathematics disciplines remains high, yet the strategies implemented to attract, recruit, and retain underrepresented students into rigorous engineering programs have yielded few results over the past decade.[1] An important reason for the low enrollment and high attrition among underrepresented students (at four-year institutions) is their sense of isolation, invisibility, discrimination, and not belonging.[2] A lack of empathy experienced from peers can manifest in interactions and may be perceived as callous, unemotional, or even aggressive[3] and may be the source of a student's resulting actions to withdraw. Research has documented through both qualitative and quantitative studies over decades that students process their experiences as a lack of empathy or caring, or as some weakness or failing on their part.[4,5] The resulting blame for "failing" is seldom attributed to the existing social and institutional hierarchies of power that are too often invisible to those that are in the dominant culture and class.[4, p.103] While it is seldom the intention of faculty to create learning experiences that are discouraging, nevertheless, research has documented there is a culture in engineering that proscribes a way of thinking and doing that provides advantages to students who have grown up in the dominant culture and are familiar with and have access to the networks and social and cultural capital.[4] From single case studies to the meta-analysis of more than 100 studies, researchers and practitioners have attempted to understand the conditions for creating an educational experience in which traditionally underrepresented students can thrive in percentages equal to their percent of the population. This paper offers another approach from grassroots practitioners that supports prior thinking available in the literature and also is based on experiential learning and understanding from the field. The result is a recognition that we must create environments where all students are accepted, valued, and empowered to achieve academic success and also a recognition of the importance of graduating greater numbers of diverse students who understand the importance of and are capable of demonstrating empathy to their colleagues in education and the workforce.[6,7] So where do we as faculty and program providers go wrong, and how do we change the experience of students in engineering courses and programs?

A national report developed by Morrell and Parker[8] identified three requirements for creating an *equitable learning environment* that provides an experience of empathy (or caring) for students in their classrooms. The authors contend that building an educational environment that is inclusive, culturally responsive, and caring provides a pedagogy that encourages multiple student perspectives, values, and beliefs be shared openly and safely in a respectful environment. Students who are aware of and benefit from an equitable learning environment in engineering education are more likely to enroll, engage fully in their learning, and be retained

Taryn Bayles *is a teaching track professor, and vice chair of Undergraduate Education in the Chemical & Petroleum Engineering Department at the University of Pittsburgh. She has spent part of her career working in process engineering, computer modeling & control, process design & testing, and engineering management with Exxon, Westinghouse, Phillips Petroleum, Sandia National Labs, and PETC. She has also spent more than 20 years teaching chemical engineering at the UNR, Pitt, UMCP, and UMBC. Her research focuses on engineering education and outreach and has received more than $6.7M of NSF funding; the goal of this research is to increase awareness of and interest in pursuing engineering as a career, as well as to understand what factors help students be successful once they have chosen engineering as a major.*

Claudia Morrell*'s decades of work have focused on understanding and enacting efforts to increase access and educational equity for women and other underrepresented groups to quality education in science, technology, engineering, and mathematics. She has both a national and international reputation and proven history of success using research-based models and tested practices to improve student outcomes for both secondary and post-secondary education. In the United States, Ms. Morrell has recently provided consulting for the Baltimore County Public Schools in Maryland; the U.S. Department of Education; the Pennsylvania Department of Education; the Allison Group (an evaluation organization); Johns Hopkins University School of Education; and the University of Pittsburgh Swanson School of Engineering; among others.*

through graduation, particularly among students from underrepresented groups. While important work by the National Research Council[9] and others identifies conditions for learning, this work takes a novel approach of identifying the qualities of the classroom environment and culture from the underrepresented student's perspective based on the experiences of practitioners in the field. The hypothesis presented here is that students do not enroll or remain enrolled if they do not feel they are welcome, belong, or can be successful, even if academically capable. Morrell and Parker's national report identified supportive research for this theory, but also hosted three separate focus groups representing nationally recognized STEM-student-serving agencies, faculty and non-profit leaders serving underrepresented populations, and STEM business leaders representing their workforce development efforts. In each case, the participants validated that the essential question for all students (and particularly underrepresented students) in STEM is: "How does entering and participating in the classroom make the student feel?" Given that today's educational experience is based on a patriarchal, white culture, particularly for traditional STEM fields, how does education counter the systemic biases that remain to make sure all students feel welcomed and empowered? How do we make sure females and minorities are resilient enough to face the cultural biases that remain to their academic achievement in engineering and other STEM fields? In chemical engineering, enrollment and completion of females and underrepresented groups has seen some progress in some higher-education programs and less so in others. This framework applied to the work of Bayles and Morrell in chemical engineering (as well as in broader formal and informal STEM programs and courses) suggests there is not one silver bullet or a 10-step solution for increasing the under-enrollment and completion of traditionally underrepresented students. Instead, chemical engineering faculty are provided another tool for creating visibility related to the classroom experience for their consideration.

Morrell and Parker identified and validated with the focus groups and the literature the necessary conditions to create an equitable learning environment. Every element places the responsibility of the creation of the environment on the educator and classroom leader or facilitator. Students bring with them their experiences, cultural understanding, beliefs, and values. It is the classroom leader's responsibility to understand or learn these qualities about their students and shape the classroom environment to effectively meet the needs of the students.

- ***Inclusive:*** *Educators are aware of and responsive to the ways that students may be marginalized by our current education system and seek to address them, including their own implicit bias. Micromessaging,[7] micro-inequities, micro-aggressions, and micro-affirmations are central to our communication and are often conveyed without awareness or intention, but have impact nonetheless.*
- ***Normalizing:*** *Educators take seriously and are mindful of the multiple perspectives, values, experiences, and beliefs of their students and create daily opportunities for a diversity of community contributions and collaboration, such that the educational experiences feel "normal" to all students. The classroom culture and environment shifts to meet the needs of the students and does not expect students to conform to current educational practices as a default position. Examples where this has been done include providing a private room for refugee Muslim males that need to pray throughout the day, selecting literature that presents earth science from the perspective of Native Americans, and providing workarounds for lifting heavy truck tires for females in automotive technology classes.*
- ***Empowering:*** *Classrooms are student-centered where students have access to and responsibility for their own learning and self-assessment, and are provided opportunities for free inquiry, and can safely and respectfully challenge authority when necessary.*

A fourth element central to the concept of empowering students (and that was formerly part of that definition) has since been separated to add clarity to the theoretical framework.

- ***Relevant:*** *Students experience learning relevant to their lives, participate in collaborative learning, and are able to learn essential knowledge through direct applications to community and cultural experiences.[10]*

These theoretical constructs provide extensive opportunities for multidisciplinary discussions, clarifying definitions, rigorous measurement, and extensive research. Over the last 15 years, the authors have developed and taught a wide variety of programs (many sponsored by the NSF) to help introduce K-12 students and their teachers to engineering. In addition, at the university level, the authors implemented learning and support programs to facilitate student success. In each proposal to the NSF and other funders, a series of activities was recommended based on research that had demonstrated programmatic success (such as the use of role models, mentors, or hands-on activities). While an understanding why certain activities were effective (or not) has not been the focus of the authors' practice, a lifetime of shared effort and research into multiple practices has led to the recognition that there are consistent qualities required for creating an equitable learning environment. In turn, the four elements identified as necessary to create an equitable learning environment, when in place, have led to increased enrollment and completion rates for traditionally underrepresented students by gender and race. The rigorous research needed to test this hypothesis has yet to be done. However, reverse engineering of highly successful programs indicates that this theoretical framework is on the right track. What is needed is for students to experience a sense of welcome by faculty and peers (inclusion), a program that aligns to their cultural identity (normalcy), a belief in their own ability to create successful academic outcomes (empowerment), and an interest in the subject matter derived from and connected to their personal, family, and community experiences (relevant). While this framework was not part of the authors' original broad thinking at the time, a careful review of their programs to date has revealed these four factors have consistently been components in all program success. When students have felt excluded, out-of-place, or powerless, the authors hypothesize that personal vulnerabilities have emerged around the students' self-identity and personal comfort leading to a belief that no matter how capable they were, they were not "engineer material." This belief is then manifest in their response to disengage from consideration of the program or field and a lack of interest in enrollment, studying, and completion as they believe they "do not belong" or "are not welcomed."

The authors hypothesize that educators can expand success in our efforts to recruit and retain diverse students in engineering by looking for the larger qualities that are necessary to create an equitable and caring learning experience. By understanding important indicators in caring for our students, educators can recognize fully why different mentoring programs succeed or fail, why some role models have a huge impact and others do not, or why some engineering programs have large numbers of women and some remain male-dominated. The remainder of this paper provides examples of programs—which the authors developed and provided while they were both at the University of Maryland Baltimore County—and analyzes the key factors that made them successful. Due to space limitations, many programs are only briefly described, however the authors believe that they also provided significant impact.

SECONDARY INFORMAL EDUCATION

Informal education has often been used as a means for creating a welcoming environment for students to experience education through fun, less-constrained environments.[11] For attracting girls and other underrepresented groups to engineering, the authors have developed and delivered a number of programs that in hindsight incorporated all four criteria required for establishing equitable learning environments. In each case, these programs lead to a positive learning experience and outcomes for the attendees.

1. ***Computer Mania Day***[12-14] *was begun in 1995 in Howard County, Maryland, by a group of academics and business leaders concerned about the lack of female technical workers in the Maryland area. In 2003 it was hosted as a signature event by the Center for Women and Information Technology (CWIT) at the University of Maryland Baltimore County (UMBC). Middle school girls in Maryland were surveyed during the initial development about the type of computer learning environment that would appeal most to them and to suggest names for such a program. The responses shaped Computer Mania Day: a free program held on a Saturday in May targeting girls for participation (and also open to boys who wanted to attend) and consisting of many hands-on science and technology sessions (conducted by successful young women with expertise in various areas of technology) with rock music playing, door prizes, and party gifts.*
2. *The* ***ESTEEM*** *program (Enhancing Science and Technology Education and Exploration Mentoring, ESI – 0422703) was an informal education program that ran from 2004 through 2007 and incorporated a 22-week after-school program and a four-week summer immersion experience for middle school students and their teachers to introduce IT learning experiences with college and professional role models. ESTEEM targeted girls for participation (to ensure 50% enrollment), although it was open to both boys and girls, and provided education in engineering and IT to encourage the students' interest and involvement in elective technical classes, as well as support students' pursuit of engineering and IT careers.*

The ESTEEM program participants (Figure 1, next page), of whom 50% were girls, were recruited from six local middle schools that were identified as having a larger percentage of students from lower-income families. The students, in two, two-week sessions, carried out the activities described in the curriculum, under the leadership of the UMBC graduate assistants, CWIT fellows (female chemical engineering, information technology, or computer science undergraduates), and classroom consultants. During the weekly sessions, students participated in icebreakers and completed hands-on activities relating to the following topics: simple machines, cameras, digital photography and storytelling, telephone technologies, animation, lava lamps, simple machines refreshers, bridge design, flashlights, hands-on-optics, bubble making, ESTEEM reflections, career exploration, and a toy design challenge. The program provided students with an introduction to the engineering design process, lessons on the inner workings of computers (where students were allowed to disassemble and assemble computer parts), and a series of Personal Development Sessions, where students learned about leadership development and networking skills through presentations.

At the conclusion of the academic year, students developed and delivered presentations in an event called A Taste of ESTEEM. In these presentations, ESTEEM students presented reflections and hands-on demonstrations with an accompanying science fair display board based on their experiences in ESTEEM to parents, community partners, and classroom consultants. Lastly, a compelling digital story using a PowerPoint/Video format was shown sharing the success and retelling students' positive accolades of the ESTEEM program. Post-program questionnaires were distributed to students and parents in May, at the culmination of the after-school program.

Figure 1. *ESTEEM particpants.*

During years one and two, ESTEEM served 186 students, with duplication between camp and after-school participants. Pre- and post-program questionnaires were obtained and analyzed and disaggregated by gender, covering personal, career, and technical skills, as well as their perceived change in attitudes and abilities.

Female data showed statistically significant changes for the following responses: my ability to program, my ability to create a website, my ability to build kits, my ability to use tools, my ability to create a project using digital photography and digital editing, and my understanding of careers in technology and engineering. In only two weeks, female attendees showed a statistically significant increase in the response to the item "I have an understanding of who I am (my talents and interests)." While many items did not show a statistically significant increase in the results between the pre-program mean score and post-program mean score, for most items there was an increase in the scores.

Why were these informal education programs seemingly successful? They created a powerful learning environment that was equitable in meeting the needs of the diverse student attendees (Table 1).

TABLE 1
Informal Education Programs' Equitable Learning Indicators

Inclusion	• Targeted underrepresented students from public schools around the state
	• Used marketing of diverse images by gender, race, ethnicity, income, and accessibility
	• Intentionally targeted communication to ensure diverse students felt invited, welcomed, and included
Normalizing	• Speakers, role models, and presenters represented a balance of males and females representing multiple races/ethnicities
	• Presenters were "cool"; easily interacted with the students
Empowering	• From activities to giveaways to speakers, everything was about the students' interest, engagement, confidence-building, and self-efficacy
Relevant	• Activities targeted issues relevant to students' lives
	• Local service learning projects and engineering design challenges connected to technology students had in their home or school

SECONDARY FORMAL EDUCATION

3. ***STEP*** *Outreach Program[15] (STEM Talent Expansion Program, DUE – 0230148)[16] was funded through an NSF STEP program that focused on creating an interest among high school students in science, technology, engineering, or mathematics (STEM) fields.*

Specifically, as part of a required chemical engineering Transport Phenomena II course, undergraduate students were required to go to a local high school and teach a class with the goal of increasing the high school students' awareness of the importance of mathematics, physics, chemistry, and biology to the field of engineering. Teams of three to four undergraduate students delivered a presentation, provided hands-on activities for the high school students, and provided an evaluation to be completed by the class and the teacher. The project provided the college students with an opportunity to be creative, to share their experiences with high school students, to be role models, and to introduce the high school students to technical areas and careers that they might not have considered. During the presentation, the high school students were made aware of the various paths and diverse coursework that the college students had taken in order to study engineering and what they planned to do upon graduation. The college students also discussed what skills they learned in high school that had been helpful in their college education and during their summer research experiences and internships. Hands-on activities tied concepts that the high school students have learned to what the college students learned in their advanced college courses. The college students were then required to explain how the activities related to practical industrial applications.

T-tests were used to separately analyze statistical significance of means for each section of a student-teacher questionnaire and a high school student questionnaire. The majority of the student teachers rated the program as "effective" or "very effective" in increasing students' awareness in (1) connections between math/science to engineering, (2) careers not previously considered, and (3) various paths available in STEM. Each of these areas was statistically significant. Hands-on activities were rated more positively than just having the undergraduates share their experiences. The student teachers rated that the secondary students (1) were more encouraged to pursue a STEM field, (2) were able to comprehend the concepts presented, and (3) had a better appreciate of math/science. The findings were statistically significant.

The high school students related how beneficial several activities were for them. Consistent with the student teachers' (college students) perceptions, hands-on activities were related as being the most beneficial by the high school students. In describing the college students' learning experience, the student teachers rated this component, with statistical significance, more beneficial than exposure to STEM related professionals. The real-world application of the activities was also significantly beneficial.

The college students were also assessed using the STEM Program Attitude Assessment, a 24-item assessment of their interest in STEM; details of this assessment and validation have been previously presented.[16] In addition, the college students were also evaluated by the high school students, the high school teachers, and the college instructor.[15] This outreach program has extended well beyond the NSF funding, and has been part of author Bayles' classes for the last 15 years, and now includes K-12 students and impacts more than 1,000 secondary students annually. The equitable learning indicators for the secondary formal education program can be found in Table 2.

K-12 Teacher Professional Development

In addition to providing opportunities for secondary and post-secondary students to learn about engineering in a welcoming and supportive environment, curricula were also developed and implemented for secondary students through mathematics, science, and technology education courses. Key to the following initiatives was the provision of Professional Development (PD) workshops for the teachers who used the curriculum. In the PD, an equitable learning environment was created so that the teachers could experience and re-create it in their own classrooms. When considering the impact of these programs on our increased enrollments, we believe that it was significant that most of these programs were developed and led by chemical engineering faculty, and that chemical engineering undergraduate and graduate students served as role models to help facilitate.

4. ***Introduction to Engineering through Mathematics*** *(EEC – 0212101).[17] Program goals were to (1) develop curriculum kits that target different fields of engineering that can be used in algebra classes, (2) provide summer workshops for in-service mathematics teachers and undergraduate engineering teaching fellows, (3) develop an undergraduate engineering teaching fellows program (information regarding the selection and training of students is provided in the reference), to provide hands-on instructional classroom support for algebra teachers to help them integrate the curricula into their courses, (4) maintain student interest in engineering at schools through the development and institutionalization of an after-school engineering program, and (5) to increase the involvement of females and other underrepresented groups in engineering by providing female and minority engineering role models in the classroom and developing curricula that encourage interest and participation by all groups.*

TABLE 2
Formal Education Program Equitable Learning Indicators

Inclusion	• Served students from public schools around the state to attract undergraduates who are interested in education and service
	• Intended to make non-traditional college students feel valued, empowered, and respected
Normalizing	• College student presenters were a balance of males and females representing multiple races/ethnicities
	• Presenters were "cool"; easily interacted with the students
Empowering	• All elements focused on the secondary and post-secondary students' interest and engagement to build interest, confidence, and self-efficacy in STEM
Relevant	• Activities targeted issues relevant to the students' lives as documented by current research on service learning
	• Engineering design challenges served as foundation of activities even before the concept was formalized in the literature as is common today

5. ***INSPIRES*** *(INcreasing Student Participation, Interest, and Recruitment in Engineering and Science, ESIE – 0352504; DRL – 0822286). Program was developed to create a curriculum that incorporates hands-on activities, online interactive animations, mathematical design simulation, and inquiry-based learning with "real-world" engineering design exercises. The curriculum targets the Next Generation Science Standards and aligns to the Framework for K-12 Science Education. The first grant included curriculum development of four modules[18] and two-day PD for teachers, and the second grant included an additional module and collaboration with secondary education faculty to provide extensive PD comprised of the comparisons of two-day, four-day and three-week PD.[19]*

TABLE 3
Teacher Professional Development Equitable Learning Indicators

Inclusion	• The curriculum was developed to target the inclusion of URM students by gender and race
	• Relevant activities and design projects were provided to teachers to take back to their classrooms
	• The faculty leader created a friendly environment with intentional messaging to model welcome, interest, and caring of all attendees
	• Student teaching fellows were coached to be respectful, friendly, and professional of all audience members and to develop their empathy skills
Normalizing	• The teachers, role models, and presenters were mostly female
	• Women were trained to easily interact with adolescent boys and girls
	• Applications targeted multiple interests
	• Teaching fellows were also young females and/or URM students who served as excellent role models
Empowering	• The curriculum provided teachers with materials and pedagogical practices
	• Hands-on learning and problem-based activities grounded in math, science, and engineering
	• Student teaching fellows provided activities that would challenge the students and allow the teachers to be successful with their application, increasing student self-efficacy
Relevant	• The activities represented real-world challenges with applications to the students' everyday lives

The curriculum was initially developed as an alternative for schools who were unable to implement Project Lead The Way (PLTW) into their schools due to cost. The curriculum provides low-cost engineering design project-based learning which can be used in technology education classes as well as in biology, allied health, chemistry, and physics classes.

To date, the curriculum has been used by more than 200 science and technology teachers impacting more than 5,000 students in the mid-Atlantic region. The online component of the curriculum allows for pre- and post-testing of science and engineering concepts, and it has shown that the curriculum enables students to achieve statistically significant learning gains in both science and engineering (regardless of the length of the PD). When comparing the various PD, students who had teachers from the three-week PD performed better than those who had teachers with the shorter PD in the scientific principles evaluations (but showed no statistically different learning gains in engineering).

6. ***TEAACH*** *(Teachers and Engineers for Academic ACHievement) program was co-developed by Bayles through funding and support from Northrop Grumman and was designed to help middle school STEM teachers to integrate engineering concepts into their classrooms. The objectives of the program, now in its twelfth year, are to (1) assist mathematics, science, and technology education teachers in integrating engineering concepts and applications into the classroom, (2) acquaint educators with various engineering disciplines in a high-tech environment, (3) promote engineering as a challenging, multi-dimensional, and exciting career choice, (4) expose teachers to best-practice demonstrations, experiments, and classroom applications, and (5) encourage networking among teachers and Northrop Grumman engineers. As a result of this workshop, the teachers have requested undergraduate students from the STEP Outreach Program to come to present and provide hands-on activities for their classrooms.*

Table 3 provides the elements the authors identified as essential to the success of these programs for the teachers and their students.

UNIVERSITY INITIATIVES

The following programs were university initiatives, designed to recruit, support, and retain female and underrepresented students in career pathways from secondary education to community colleges through to university. Many of these programs were supported by the National Science Foundation and required an external evaluator, and for most of our programs (including many mentioned above) the external evaluator was Dr. Mark Peyrot, director of Loyola College Center for Social and Community Research. He and his team developed and validated the survey instruments (which can be found in the cited references) and summarized the program outcomes.

7. *The* ***Center for Women in Technology (CWIT)*** *<http://cwit.umbc.edu/> is a merit-based scholarship*

program for talented undergraduates intending to major in: computer science; information systems; and chemical, computer, and mechanical engineering. The program targeted females, although it awarded scholarships to both males and females, with the goal of addressing UMBC's low enrollment of females in their engineering, information technology, and computer science programs, by building a supportive cohort of males and females.

8. ***CSEMS** (Computer Science, Engineering, and Mathematics Scholarships), **SITE** (Scholarships in Information Technology and Engineering), and **T-SITE** (Transfer Scholars in Information Technology and Engineering) (DUE – 0220628, DUE – 0630952, DUE – 1154300, respectively). These three programs provided scholarship money, a one-week summer bridge, and programming support throughout the year for students majoring in STEM fields. Articulation of community college transfer students was part of these programs.*

Over the five years of the CSEMS project, a total of 70 students received scholarships, augmented by supplemental academic and student support services. Support services were provided beginning in the students' freshman year and included peer and faculty mentoring, faculty advisement, tutoring, and a one-week summer bridge (that included team building, career exploration opportunities related to CSEM fields, and informal learning experiences to increase interest in CSEMs). CSEMS exceeded its objectives:

- *Three-quarters of the 70 participants were retained in a CSEM major;*
- *40% graduated and obtained employment in a CSEM field;*
- *More than 11 % graduated and pursued a graduate degree in a CSEM major;*
- *Although 14.3% of the students transferred to a non-CSEM major, of those, 60% transferred to a STEM major and all of these students have either graduated or were on track to graduate when the project ended.*

The Scholarships in IT & Engineering (SITE) project was administered by CWIT. A total of 30 students were awarded the SITE Scholarships. Half were women or underrepresented minorities. SITE scholars participated in the new Scholar Retreat, monthly family meetings, Women in Technology events, leadership and services events, and career activities such as industry site visits and career fairs. CWIT staff closely tracked student progress and provided holistic advising through regular one-on-one meetings. Over the course of the project, SITE scholars maintained an average cumulative GPA of 3.45. Twenty-four scholars graduated, and three have enrolled in graduate school. The combination of scholarships funds and programming support resulted in retention and graduation rates far above the norm for women, transfer students, and underrepresented minorities in these majors. In May of 2011, an end-of-year assessment survey was administered to all CWIT and SITE scholars and a focus group was conducted with graduating seniors. SITE scholars overwhelmingly agreed that faculty and peer mentoring contributed to their academic success and ability to solve problems and overcome challenges that they encountered.

Since 2012, the T-SITE program has successfully served 32 transfer students from Maryland community colleges within the CWIT community at UMBC. As of May 2017, 84% of the T-SITE scholars in the first three cohorts have achieved the following:

- *graduated within three years of their matriculation,*
- *been retained at 100% in a computing or engineering major, and*
- *have participated at a rate of more than 68% in REUs, internships, and professional positions at locations such as University of Arizona, University of Pittsburgh, Northrop Grumman, Travelers, Carrier, the National Security Agency, and Harris Corporation.*

These results far exceed the average metrics of STEM transfer students nationally, which report a total of 69% of associate's degree students who entered STEM fields had left within six years—half of these individuals by switching to a non-STEM field and the rest by exiting college before earning a degree or certificate.[20]

9. ***STEP** (STEM Talent Expansion Program DUE – 0230148)[16] identified the relative effectiveness of a two-week summer bridge program, a mentoring program, a minimal stipend, and an internship program on student enrollment and retention in STEM programs. This program partnered with a local community college to increase the number of students receiving degrees in STEM areas. In addition the program established the first internship program at a community college in the state.*

10. ***Introduction to Engineering Design**[21] is a freshman engineering course that was completely revised from an engineering design on paper to a hands-on engineering design course, which required student teams to design, build, test, and evaluate product performance. Even though this course was for chemical, mechanical, and computer engineering students, it was taught by a chemical engineering faculty member and the majority of the teaching fellows were undergraduate chemical engineering students (*i.e.*, junior and senior undergraduate engineering students who had taken Introduction to Engineering Design and applied to the Teaching Fellow program). Once selected, they participated in a two-day training program and weekly meetings with the instructor over the course of the semester.*

11. ***Transfer Student Success Course**[22] is a one-credit*

course designed to assist in the successful transition of transfer students from their previous community college or university to our institution. It focuses on developing and understanding the skills needed and the academic expectations to achieve success at an honors university and is taken simultaneously with our material and energy balance course.

One of the goals of the success course was to provide additional contact time for the transfer students in a smaller setting, so that they would feel more comfortable interacting with the instructor and in study groups. The students also noted the additional content help and the guidance of the peer mentor (who was a transfer student and who had taken the course the previous year). Over the last five years, our material and energy balance course has included 30-50% transfer students. During this same time period, our chemical engineering department student population is 30-45% underrepresented and about the same percentage female. Students who have taken the student success course have earned ABC grades versus DWF grades with similar percentages as the freshman admits (ABC to DWF ratios were anywhere from 2 to 1 to 7 to 1 ratios).[22] However, the transfer students without the transfer success course are almost twice as likely to earn DFW grades (vs. ABC grades) in the material and energy balance course. As expected, success in the material and energy balance course correlates directly with the department graduation and retention rates. As supported by the literature, it is believed that the success in the material and energy balance course has less to do with the content of the transfer success course, but has more to do with the sense of community[23-26] that these transfer students experience with their peers, the course instructor, and the peer mentor.

TABLE 4
University Initiatives Equitable Learning Environment Indicators

Inclusion	• Students invited to participate from across the country and from local schools and community colleges
	• Students were provided diverse messages of welcome to ensure the students felt valued and respected
	• Implicit bias was recognized and addressed
Normalizing	• Females (and males) were connected to other like-minded students through study groups, business and faculty mentors, and service-learning opportunities
	• Intentional efforts were made to create an experience of comfort, friendship, and support in a traditionally white male environment
Empowering	• Engineering faculty challenged students to work independently and in groups in freshman engineering design projects to achieve at the highest levels
	• Empowerment builds self-confidence and self-efficacy leading to resilience in the program and engineering professions
	• Upperclassmen provided support to sophomores and freshmen
Relevant	• Faculty delivered courses using the engineering design process to address engineering design challenges that incorporate real-world problems

Table 4 provides the equitable learning indicators for the university initiatives that contributed to the success and retention of our students.

Working collaboratively as a chemical engineering faculty member and the executive director for CWIT, the two authors transformed the lives of many of the students and the culture of the campus programs. For instance, over the programs' time period, the chemical engineering enrollments at the institution more than quadrupled, during which the female population ranged between 25-48% female and the underrepresented minority students ranged between 20-47% (predominantly African-American). Perhaps most importantly, though, was the graduation of significantly more female and African-American students in engineering, leading to small but important changes in the culture of the engineering profession.

The engineering academy still has a long way to go in both understanding and valuing the work of creating a climate and culture of inclusion, normalcy, empowerment, and relevancy for underrepresented students. Another analysis might be to look at unsuccessful programs using the four criteria as a lens for understanding why they failed, but space constraints do not provide that opportunity here. For faculty and administrators, the goal of this paper is to encourage greater dialogue in departments and on campuses. Unfortunately, an increase in hate crimes on campuses has increased tension rather than decreased it. Ignoring this reality for students, particularly those targeted, only increases the likelihood that they will drop out. Each faculty member has the opportunity to look at her or his own programs and courses (successful and failed) and ask, "Did I provide an equitable learning environment for all of my students based on these four criteria?"

REFERENCES

1. Castello, C.B., *Increasing Opportunities for Low-income Women and Student Parents in Science, Technology, Engineering, and Math at Community Colleges*, Washington DC Institute of Women's Policy Research (2012)
2. Reyes, M., "Unique Challenges for Women of Color in STEM Transferring from Community Colleges to Universities," *Harvard Educational Review,* **81**(2) 241 (2011)
3. Reniers, R.L., R. Corcoran, R. Drake, N.M. Shryane, and B.A Vollm, "The QCAE: A Questionnaire of Cognitive and Affective Empathy," *J. Personality Assessment*, **93**(1), 84 (2011) Retrieved Dec. 5, 2016, from <http://dx.doi.org/10.1080/00223891.2010.528484>
4. Foor, C.E., S.E. Walden, and D.A Trytten, " 'I wish that I belonged more in this whole engineering group:' Achieving Individual Diversity," *J. Eng. Ed.*, **96**(2), 103 (2007)
5. Ong, M., C. Wright, L. Espinosa, and G. Orfield, "Inside the Double

Bind: A Synthesis of Empirical Research on Undergraduate and Graduate Women of Color in Science, Technology, Engineering and Mathematics," *Harvard Educational Review*, **81**(2), 172 (2011)
6. Godfrey, E., and L. Parker, "Mapping the Cultural landscape in Engineering Education," *J. Eng. Ed.*, **99**(1), 5 (2010)
7. Parker, C., C. Morrell, C. Morrell, and L. Chang, "Shifting Understanding of Community College Faculty Members: Results of Equity-Focused Professional Development Experience," *New Forum Press*, **30**(3), 41 (2016)
8. Morrell, C., and C. Parker, "The Education Equation: A New Model for Improving STEM Workforce Outcomes through Academic Equity," Congressional Briefing, Sept. 25, 2015. <http://www.napequity.org/solving-education-equation/> (2015)
9. Cole, R.W., Ed., *Educating Everybody's Children: Diverse Teaching Strategies for Diverse Learners*, ASCD, 2008, pp. 13-14
10. Scales, P.C., E.C. Roehlkepartain, M. Neal, J.C. Kielsmeier, and P.L. Benson, "Reducing Academic Achievement Gaps: The Role of Community Service and Service Learning," *J. Experiential Education*, **29**, 38 (2006)
11. Bransford, J.D., A.L. Brown, and R.R. Cocking, Eds., "How People Learn: Brain, Mind, Experience, School," Executive Summary (2008) <https://www.lmtsd.org/cms/lib/PA01000427/Centricity/Domain/91/HowPeopleLearn.pdf>
12. Morrell, C.M., A.M. Spence, T.M. Bayles, and W. Shewbridge, "You Can Be Anything – Women and Technology Video," paper # 809 published in the *Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition*
13. Morrell, C.M., S. Cotton, A. Sparks, and A. Spurgas, "Computer Mania Day: An Effective Intervention for Increasing Youth's Interest in Technology," A Report to the Maryland Commission for Women, (2004)
14. Sanders, J., C. Morrell, and C. Morrell, "Evaluation of Computer Mania Day for Girls," Report to the Multinational Development of Women in Technology (2009)
15. Ross, J.M., and T.M. Bayles, "Incorporating High School Outreach into Chemical Engineering Courses," *Chem. Eng. Ed.*, **37**(3), 184 (2003)
16. Bayles, T.M., C.M. Morrell, and A.M. Spence, "Science, Technology, Engineering and Mathematics Talent Expansion Program, An Analysis of a Pilot Program," Paper #2006-1900 published in the *Proceedings of the 2006 American Society for Engineering Education Annual Conference & Exposition*
17. Spence, A.M., T.M. Bayles, and C.M. Morrell, "Engineering Applications in the Early Algebra Classroom," paper #1432 published in the *Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition*
18. Ross, J.M., T.M. Bayles, and J.E. Singer, *The INSPIRES Curriculum, The Go-to Guide for Engineering Curricula Grades 9-12*, C. Sneider (Ed.), Thousand Oaks, CA: Corwin Press, 2015, pp. 19-30
19. Reeves, R.M., T.M. Bayles, and J.M. Ross, "A Novel Approach to Professional Development," Paper AC-2010-1952, published in the *Proceedings of the 2010 American Society for Engineering Education Annual Conference & Exposition*
20. Chen, X., and M. Soldner, "STEM Attrition: College Students' Paths Into and Out of STEM Fields, Statistical Analysis Report," US Department of Education, Institute of Education Sciences, National Center for Education Statistics (November 2013)
21. Bayles, T.M., "Project Based Learning Design Projects for Introduction to Engineering Design Courses," Paper #1381 published in the *Proceedings of the 2005 ASEE Annual Conference & Exposition*
22. Bayles, T.M., "A Chemical Engineering Success Course for Transfer Students," published in the *Proceedings of the 2016 American Society for Engineering Education Annual Conference & Exposition*
23. Sheppard, S., S. Gilmartin, H.L. Chen, K. Donaldson, G. Lichtenstein, O. Eris, M. Lande, and G. Toye, "Exploring the Engineering Student Experience: Findings from the Academic Pathways of People Learning Engineering Surveys (APPLES)," Center for the Advancement of Engineering Education, Technical Report CAEE-TR-10-01, (2010)
24. Wu, P., "Increasing College Opportunity for Low-Income Students," <https://www.whitehouse.gov/sites/default/files/docs/white_house_report_on_increasing_college_opportunity_for_low-income_students.pdf>
25. Yoder, B.L, "Going the Distance Best Practices and Strategies for Retaining Engineering, Engineering Technology and Computing Students," <https://www.asee.org/retention-project>, ASEE (2012)
26. Corbett, C., and C. Hill, "Solving the Equation The Variables for Women's Success in Engineering and Computing," <http://www.aauw.org/research/solving-the-equation/>, AAUW (2015) ❒