NSF S-STEM: Transfer Success Co-Design for Engineering Disciplines (TranSCEnD)

Dr. Rachel McCord, University of Tennessee, Knoxville

Rachel McCord is a Lecturer and Research Assistant Professor in the Engineering Fundamentals Division at the University of Tennessee in Knoxville. She received her Ph.D. in Engineering Education from Virginia Tech. Her research interests include the impact of metacognitive and self-regulated learning development on engineering student success, particularly in the first year.

Dr. David J. Keffer, University of Tennessee, Knoxville

David Keffer received his B.S. in Chemical Engineering from the University of Florida and his Ph.D. in Chemical Engineering from the University of Minnesota. Since 1998, he has been a member of the faculty in the College of Engineering at the University of Tennessee, where he is currently professor and associate head in the Materials Science & Engineering Department. Prof. Keffer is a multiscale materials modeler, using computational simulations to develop structure-property relationships in nanostructured materials. He was awarded a Fulbright Distinguished Lectureship to teach at Yonsei University in Seoul, Korea in 2010-2011.

Dr. Jennifer Retherford P.E., University of Tennessee, Knoxville

Dr. Retherford is an alumna of the University of Nebraska, Omaha, and received her graduate degrees from Vanderbilt University. She currently teaches a variety of courses supporting the department of Civil & Environmental Engineering at the University of Tennessee. Among many structural engineering courses, Dr. Retherford also manages the Senior Design Project course for all undergraduate seniors.

Chris Wetteland, University of Tennessee, Knoxville

Prof. Mary Skidmore Kocak

Mr. Travis Griffin, University of Tennessee, Knoxville

Mr. Travis Griffin was the Fred D. Brown Jr. Director of Engineering Diversity Programs at the University of Tennessee, Knoxville. Mr. Griffin comes to the university from Oklahoma State University where he served as the coordinator for the Multicultural Engineering Program. In this role, Mr. Griffin focused on recruiting, advising and retaining students for the College of Engineering, Architecture and Technology. He also developed, implemented and managed special programs targeted to underrepresented groups and a multicultural awareness program for the college.

Mr. Griffin received his bachelor’s degree in software engineering from Mississippi State University in 2004 and his master’s degree in higher education from USM in 2005. He is an active member, leader and advisor within the National Society of Black Engineers (NSBE) and National Association of Multicultural Engineering Program Advocates and has received numerous recognitions and honors including the NSBE Alumni Extension (AE) National Leadership 2006 award and the Region 3 NSBE AE Dedication 2006 award.
NSF S-STEM: TranSCEnD: Transfer Success Co-Design in Engineering Disciplines

Abstract
Beginning with the graduating high school class of 2015, the Tennessee Promise program provides "last-dollar" scholarships and mentoring programs focused on increasing the number of students at any of the state's 13 community colleges, 27 colleges of applied technology, or other eligible institution offering an associate's degree. In its inaugural class, about 58,000 students (90% of Tennessee's senior class) applied for Tennessee Promise. Thus, the faculty and administration at the University of Tennessee anticipate that transfer students are likely an increasingly important fraction of the student body. In the Tickle College of Engineering, transfer student enrollment has increased at an average rate of 10% per year over the last five years. Transfer students face a unique set of challenges, which differ from those who begin their first year at a university as freshmen. The challenges are both academic--adapting to the reduction in individual attention with university coursework--and social--lacking a well-defined peer-cohort with whom the adjustment to university life can be shared. In engineering, transfer students also statistically represent a different demographic population than the student body of entering freshmen (the fraction of first-generation college students is double (32% compared to 15%) among transfer students, which can potentially bring cultural challenges as well. These challenges manifest in an unfortunate fact: currently the fraction of engineering transfer students who do not graduate within 5 years is nearly double (29% to 15%) that of traditional engineering students who have an analogous two years of college behind them. Finally, existing programs for financial aid are disproportionately distributed to students who enter the university system as freshmen relative to transfer students. The objective of the TranSCEnD program at the University of Tennessee is to increase the retention of engineering transfer students to a level comparable to engineering students, who entered the Tickle College of Engineering as freshmen. A program which spans a five-year process--two years at the community college, a summer bridge program, and three years at University of Tennessee--is proposed. Activities include faculty exchange between institutions, student skills seminars, sustained mentoring, intra-cohort peer learning, and inter-cohort peer-teaching. The individual elements of the program as well as the synergistic integration of elements have been chosen to balance two influences: (1) a program designed with theoretical influence from Tinto’s Theory of Voluntary Student Departure, and (2) a practical acknowledgment of demonstrated success at the University of Tennessee. This paper will provide a summary of the TranSCEnD program as well as provide an update on current activities from the grant team.

Introduction
Beginning with the graduating high school class of 2015, the Tennessee Promise program provides “last-dollar” scholarships and mentoring programs focused on increasing the number of students at any of the state’s 13 community colleges, 27 colleges of applied technology, or other eligible institution offering an associate’s degree. Upon receiving the two-year associate’s degree, for many students, the next step is to transfer to a four-year institution. For young Tennesseans who aspire to become engineers, the University of Tennessee, Knoxville (UTK) is a natural choice, as it is the State Land Grant University and its Tickle College of Engineering (TCE) offers twelve bachelor’s degrees from eight departments of study.
The leadership in the TCE at UTK has identified as a strategic priority: the need to internally develop programs to better facilitate the success of a growing number of transfer students. Over the past five years, the number of transfer student admitted to the TCE has increased by more than 10% annually on average, rising from 97 students in academic year 2011-12 to 159 students in 2016-17. Similarly, engineering participation at local community colleges such as Pellissippi Community College (PSCC) has also grown, with 175 students starting in the engineering curriculum in 2010-2011 to 240 students starting in 2015-2016.

Transfer students face a unique set of challenges, which differ from those who begin their first year at a university as freshmen. The challenges are both academic—adapting to the reduction in individual attention with university coursework—and social—lacking a well-defined peer-cohort with whom the adjustment to university life can be shared. Transfer students also statistically represent a different demographic population than the student body of entering freshmen, which can potentially bring cultural challenges as well.

Certainly the TCE (and UTK as a whole) have in place a variety of support systems and programs to optimize the success of the general student body. There is also an office specifically designed to serve transfer students broadly. This project intends to create a complementary program that specifically serves transfer students in the TCE. The TranSCEnD program invokes the concept of Co-Design, in which all stakeholders are actively involved in the design process to help ensure the results meet their needs and is usable. In this case, TCE administrators, tenured faculty, lecturers and staff, with explicit input from local community college partners, have developed a process to enhance the transition of students from a community college to UTK TCE. The process spans the student experience from the community college, continues through a summer transitional workshop, and persists through graduation at UTK. Financial support is offered to eligible students through the funds provided by the S-STEM program. The process is meant to remain flexible since the needs and situations will vary greatly from one transfer student to another.

Two departments, the Civil and Environmental Engineering (CEE) and Materials Science and Engineering (MSE) will initially participate in TranSCEnD. They have an explicit interest in the success of the TranSCEnD program, as part of an effort to increase undergraduate enrollment in their respective departments; in other words, these departments want to leverage the opportunity created by the Tennessee Promise program to actively recruit qualified transfer students. Introductory courses (Introduction to Materials Science in MSE and Structural Mechanics in CEE) will be offered during the summer before transfer at UTK. Each course is linked to a bridge project that combines elements of civil engineering and materials science in an interdisciplinary, team-based design of an alternative energy system. In the first semester at UTK, a Student Skills for Success (SSS) seminar course will continue both the science of the project as well as reinforce academic habits for success. TranSCEnD will become a cohort-spanning community as senior participants become team leaders in the transition project and seminar.

The TranSCEnD program will adhere to best-practices stemming from both educational theory and hands-on experience at UTK. The pedagogical results will be carefully assessed, evaluated and disseminated.

Project Rationale
There are many ways in which students can pursue the goal of earning a four year degree in engineering. Traditionally, students enroll in courses and earn a degree attending the same four-year institution. While this method is appropriate for many students, other paths are becoming increasingly popular. An alternative path is through the use of two year institutions as a mechanism for the completion of a four year degree. Today, many students are choosing to begin their college career at community colleges and transfer to a four year institution after a period of time to complete their degree. The benefits of starting at a community college include a lower initial cost for tuition when compared to a four year institution, closer proximity to home, smaller class sizes, and lower admission standards for those students not able to meet the requirements of a four year institution. With the Tennessee Promise scholarship now offering to cover the remaining tuition and fees requirements not covered by other state funding to complete a student’s first two years of school through community college, the option to start at a two year institution is becoming increasingly popular in our state. As such, two year community colleges are beginning to be a highly utilized option for students pursuing engineering degrees in the state of Tennessee.

While new funding sources such as Tennessee Promise provide mechanisms for lowering monetary barriers for students in the first two years of college, there are still significant barriers to overcome in helping students to successfully transition and complete an engineering degree at a four-year institution. These barriers include continued financial limitations after the completion of the Tennessee Promise scholarship, academic and transfer readiness, and academic and social integration to the four-year institution (Engle & Tinto, 2008).

Financial, Academic, and Social Barriers

While scholarships like Tennessee Promise help to alleviate some of the financial burdens of students during the first two years of school at a community college, after this aid is expended, transfer students, on average, have a much higher rate of financial need than incoming freshmen to UTK. Institutional data shows a significant financial need for many students transferring to the four year institution that could be alleviated with scholarship support after transfer.

Apart from financial barriers, transfer students also face numerous academic barriers both before and after transfer to a four year institution, especially those pursuing a technical science related degree, as this type of degree pursuit is cited as a challenge to four year student success after transfer [1, 2]. Many students enter two year institutions because of issues in academic preparation from high school, thus requiring them to take remedial courses to prepare for the coursework associated with a four year degree. Students who choose to transfer before completing these remedial courses are at a further disadvantage [3]. The need for remedial coursework thus shows a lack of academic preparation, which can hinder successful transfer [3]. Successful completion of the remedial courses is shown to improve the likelihood of transfer and four year degree completion [4]. Also, students that move on to take more challenging courses, stay continuously enrolled, transfer earlier, [4] and complete a higher number of hours [5] are all shown to have higher rates of success once the transfer process has taken place.

When making the decision to transfer, students who enter a four year institution with a higher incoming GPA [1, 2, 6-9], enter with a higher number of credit hours [6, 10] and have aspirations for a higher degree above a four year degree [8, 9] tend to be more successful in the
completion of their four year degree. ‘Transfer-shock’ refers to the immediate dip in GPA of those transferring to four year institutions. Transfer shock is typically attributed to students with unrealistic expectations for performance between the two and four year institutions. Part of the origin of unrealistic expectations is captured in Figure 1(d), which shows that the fraction of engineering students (at UTK from 2013-2016) who are the first in their family to attend some college (irrespective of graduation) is double among transfer students compared to students who entered as freshman. Consequently, transfer students disproportionately lack the family knowledge resource necessary to form realistic expectations. Researchers have shown that students successfully navigate through transfer shock when they are more transfer ready. Transfer readiness is impacted by counseling, advice from students and faculty, and an understanding of the academic requirements of the new institution [11].

Another prominent factor impacting students’ success in four year completion after transfer is integration into the social aspects of the new institution. This social integration includes participation in clubs, organizations, and events of different cultures. Students who were more integrated into the social atmosphere of the institution cited higher levels of satisfaction and more likely to persist to graduation [12]. There are numerous models for investigating mechanisms for retention in undergraduate education, but none may be more popular or widely used than that of Tinto’s Model of Voluntary Student Departure [13], shown in Figure 2.
In Tinto’s model, a student’s choice to stay or leave higher education is informed by several layers of information and experiences. First, student’s choices are impacted by a series of pre-entry attributes they bring with them at the beginning of their higher education experience. These include family background, skills and abilities, and prior schooling. As noted previously, many barriers to success for transfer students are included in this first layer of categories, including academic preparedness, demographic categories, and family experiences with higher education, such as status as a first generation college student [14]. Students bring goals and commitments into their higher education experience. These goals and commitments are then impacted by the institutional experiences they have at their higher education institution. These experiences are formal and informal and impact what Tinto calls Academic Integration and Social Integration. After goals and commitments are impacted or transformed, students will make a decision to stay or leave their academic pursuits. Tinto’s Model of Voluntary Student Departure has been successfully used across multiple higher education contexts, and more specifically, in engineering [15-17]. While Tinto’s model has widely been adopted to investigate the success of traditional undergraduate students in higher education, many researchers believe that Tinto’s model, as shown in Figure 2, falls short in fully defining success for more non-traditional students, like those who start their career at a two-year institution [18]. Instead, these researchers believe that a revision to the Institutional Experiences and Integration portion of the model should be made by creating a single Integration category called Socio-Academic Integration [18-21], as shown in Figure 3.

There are several cited reasons for the shift in retention model. First, students who choose to enter a two-year community college first tend to find their social satisfaction through means other than the social aspects of higher education. These students tend to find social satisfaction in family, civic organizations, and places of worship rather than in the social environment provided at a four-year institution [19, 20]. Second, students in community colleges who participated in more activities related to their majors where they found...
community, especially those involved in STEM majors, and performed better academically [21]. These students cited a better social and academic fit to the institution (both community college and four-year institution) than those that participated in activities but did not find a sense of community in those activities.

TranSCEnD builds on evidence-based strategies for mitigating many of the pre and post transfer barriers cited in order to increase successful transfer and completion of a four-year degree of transfer students in the UTK Tickle College of Engineering. TranSCEnD will focus on the development and leveraging of both financial and socio-academic support services offered at both the PSCC and UTK campus in order to increase retention rates.

TranSCEnD will:
- Offer academic scholarships to academically talented transfer students pursuing an undergraduate engineering degree at UTK to finish the remaining portion of their four-year degree at UTK, reducing the financial hardships associated with transferring to a four year institution
- Provide a socio-academic connection from the UTK pre-transfer program to the community college community via:
  - Recruiting and information seminars on-site performed by TCE engineering faculty
  - On-campus (UTK) faculty led tours of engineering research labs
  - Cohorted summer bridge project and engineering courses during summer of transfer
  - Provide a socio-academic connection from the post-transfer process through graduation via:
    - Cohorted academic success seminar focusing on the academic needs of transfer students
    - Cohorted engineering seminar to stay connected to cohort members and faculty
    - Highly encouraged participation in a high impact practice by year 4
    - Required participation as mentor for incoming TranSCEnD student cohorts, which also fulfills the requirements of TN Promise community service.

**Student Selection**

*Engineering Transfer Students.* The TranSCEnD scholarships will be distributed exclusively to transfer students in the college of engineering. While we hope to focus on a cohort in the two initial departments, CEE and MSE, all transfer students in TCE will be considered to meet this requirement. We propose to recruit a cohort of 20 students for each year of the NSF award, totaling 100 students impacted over the 5 year award to UTK. Selection into the cohorts will occur during the students’ second year at the community college and required cohort activities will officially commence during the summer before transfer to UTK. Recruitment into the TranSCEnD cohorts will be determined on the basis of (1) the academic qualifications, (2) financial needs of the student, (3) and participation in initial TranSCEnD activities. While PSCC currently provides 48% of TCE engineering transfers, the TranSCEnD program will consider students transferring from any school.

*Academic Eligibility.* The central Registrar’s Office maintains its own standards for admission into the university. In the case of PSCC, there are established articulation
agreements for transfer students. The TCE administration maintains additional standards for admission into the college of engineering at both the freshman and transfer level. For the purposes of the TranSCEnD program, the initial minimum academic qualification for a TranSCEnD scholarship is that the student meets the existing UTK and TCE requirements for admission to the college of engineering. Admissions to TCE are based on a Success Prediction Indicator (SPI), calculated by adding a student’s ACT score to 10 times their core high school GPA. A SPI score of 60 and a math ACT score of 25 are minimum admissions requirements for TCE, which are more stringent than the current University admissions requirements. Performance grades in engineering courses taken at PSCC will also be considered for academic eligibility. Subsequent academic qualification will require that the students maintain a 3.0 GPA. Students who fall below this GPA will be placed on probationary status and will lose their eligibility with another semester in which the GPA for courses taken during that semester is less than 3.0.

Financial Eligibility. The financial eligibility criterion for receiving a TranSCEnD scholarship is based exclusively on the FAFTA data collected by the university centrally. Student need is a function of Cost of Attendance (COA), Expected Family Contribution (EFC), and other sources of scholarships and grants (ESG) and is calculated as:

\[ \text{Student Need} = \text{COA} - \text{EFC} - \text{ESG} \]

Any engineering transfer student who does not have all of their student needs met will be considered financially eligible for a TranSCEnD scholarship. In some cases, the TranSCEnD scholarship could be used to meet a “last dollar” contribution to students who would otherwise drop out without that level of support. However, in the majority of the cases, the scholarship will cover a portion of the remaining student need. To meet our target of impacting 20 students per year, an average award of $6,000/year is anticipated. A maximum award of $9,000/year will be set. In no case will TranSCEnD scholarships be used to exceed the student need.

Initial TranSCEnD Participation. Initial activities including TCE faculty seminars presented on-site at community colleges, and lab experiences at TCE will be offered for students willing and able to travel to campus. Participation in these activities will be considered as a factor for selection into the TranSCEnD Program. Students unable to attend on-campus lab activities will be given additional opportunities to perform an offsite research project to confirm interest.

Student Selection. A student selection committee, chaired by the PI, will be formulated. Annually, the Associate Dean of Academic and Student Affairs in the TCE, Parang, will distribute to the committee a list of all eligible incoming and current transfer students who have met the academic and financial eligibility requirements. Parang already performs an analogous service for a soon to expire S-STEM grant at UTK (# 1258417 in Section A). This information will contain current GPA as well as current Student need, departmental information, and participation in preliminary TranSCEnD activities. A committee, composed of the PI, four co-PIs, Kocak and Parang, will jointly identify the scholarship recipients and the amount of each scholarship.

S-STEM Support Programs
Programmatic support for the TranSCEnD program will include a variety of events, coursework, group projects, and advising to both encourage students to participate in the program as well as aid in their success. These programmatic pieces align with the high impact practices identified by the AAC&U [22] and are structured throughout the academic career of the transfer student. They are designed to meet the socio-academic needs of the community college transfer student [19]. Offerings to students are high-lighted in the call-out box above. Additional detail in terms of how each element is integrated into a showcase timeline is provided in Figure 4 below. Also shown in Figure 4 is a schematic describing how the TranSCEnD scholarship would complement the Tennessee Promise scholarship, which is applicable only at community colleges. In the state of Tennessee, a second common scholarship is the Hope Scholarship, which is funded by the Tennessee state lottery. The Hope Scholarship is a four-year, merit-based and covers 80% of the cost at either a community college or a state university. A Hope Scholarship can transfer with a student from the community college to UTK. However, a transfer student with a Hope Scholarship may require additional financial support (potentially through a TranSCEnD scholarship) for two reasons. First, the tuition at UTK is higher than that at a community college. Second, historically, relatively few engineering students, especially transfer students, finish in the four-year life of the Hope Scholarship. Therefore, financial aid in the fifth year is often required. For these reasons, schematics for students on both the Tennessee Promise and Hope scholarships are shown in Figure 4.
**Year 1: Onsite Faculty Seminars**

As a way to generate interest in UT K Tickle College of Engineering disciplines, faculty members will travel to community colleges state wide to perform an onsite laboratory demonstrations, and promote academics and research capabilities of individual departments. This *high impact practice* resembles a first year seminar focused on introducing students to different disciplinary areas of engineering. To aid in this demonstration, the MSE department has a Mobile Materials Science Lab (MMSL) where students have the opportunity to make 3D printer filament, print tensile samples, and perform mechanical properties measurements in the period of an afternoon. Additionally, the seminars will provide interested transfer students with information about academic disciplines, career options, research opportunities, transfer procedures, and information on the TranSCEnD program. The seminars will provide a faculty contact for those students interested in pursuing the program further.

**Year 2: Laboratory Experiences of UT Engineering Departments**

Hands-on laboratory tours have proven to be effective tools for introducing students to the respective departments. This *high impact practice* is an initial introduction to engineering research and serves as a potential generator of interest in undergraduate research. In MSE, hour-long tours have been developed and led by both students and faculty to give prospective students a more in depth exposure to tools and topics covered in MSE: this includes operation of a scanning electron microscope (SEM), performing mechanical testing, and 3D printing. In combination with the laboratory tour, the departments host undergraduate student poster sessions. The poster sessions highlight undergraduate research and projects conducted in coursework. This is an opportunity for potential TranSCEnD students to learn how undergraduate and independent research is conducted in the MSE department. Posters sessions have been an effective mechanism for giving potential students time to interact with undergraduates in the department, and learn first-hand how research is incorporated into the major. When possible, students in the TranSCEnD program will be asked to perform these hands on demonstrations as part of the tours.

**Summer: Introductory Coursework**

As part of their TranSCEnD scholarship, students will have an opportunity (not required for acceptance, but encouraged) to participate in summer introductory departmental coursework. As previously stated, transfer students who complete more credit hours [5] as well as higher level coursework [4] have a higher likelihood of graduating with a degree. Introductory classes will aid TranSCEnD students by fulfilling departmental coursework and prerequisites, developing a peer group for students who may be off-cycle or in between academic years, and providing insight into what engineering disciplines may be of interest. There are numerous benefits to cohort learning in different educational environments, including the opportunity for peer learning [23], providing a structure for teamwork and collaboration [24], and developing a family-like atmosphere where students take the responsibility to care for one another [25]. Introductory coursework taught from MSE will include *Introduction to Materials Science and Engineering* (MSE 201) and from CEE *Structural Mechanics* (CEE 262). MSE 201 is a required course for 5 of the 7 engineering majors at UT.
Summer: Team Building Project

A major focus of the TranSCEnD experience is a summer program where students voluntarily participate in a multidisciplinary capstone group project. The high impact capstone project will incorporate aspects of materials science and civil, environmental, mechanical, and electrical engineering to build a solar thermal heating system or both an off grid/grid-tied solar electric system; the projects will alternate every other year. The projects will supplement the summer lecture coursework with a hands-on experience that will give the students opportunity to cement a series of experiences to develop a strong cohort for moving through the academic programs.

Students who participate in the group project will get a chance to work together to build a completely functioning alternative energy system related to hot water heating or electrical generation. The projects will specifically expose students to the fundamental materials science involved in these systems, as well as the infrastructure considerations required for mounting. The solar thermal project will expose students to energy and energy policy, materials selection, heat flow and transfer, pumping systems, plumbing and soldering, electronics, data acquisition, presentations and report writing. The photovoltaic project will introduce students to energy and energy policy, materials selection, electronic materials, basic electronics and electrical systems, batteries, data acquisition, and presentations and report writing. Both projects are directly related to future opportunities in the solar industry, which is one of the fastest growing technical job markets (National Solar Jobs Census). Furthermore, it is possible that some transfer students can use prior job skills (construction, plumbing, electrical, and HVAC) as a platform for gaining perspective in the science and engineering topics, as well as developing leadership roles. This effort will be led by TranSCEnD team member, Chris Wetteland, an MSE faculty member and licensed solar installer.

Years 3-5: Dedicated Advising.

The Tickle College of Engineering at UT is fortunate to be able to place a dedicated advisor into each of its departments. Dedicated advising efforts will be able track the needs of transfer students and be able to address and anticipate solutions on an individual basis. Transfer students will be required to receive advising twice as often (each semester rather than once per year) relative to other engineering students.
Figure 5. Schematic detailing activities of faculty and students participating in the TranSCEnD program. One component of the program is cohort development and service learning, which is accomplished both within a transfer class (intra-cohort), as well between classes (inter-cohort).

Year 3: Student Success Skills Seminar Series
Transfer students entering UT are required to take a First Year Studies course (FYS 101). The goal of FYS is to help students transition—personally, socially, and academically—to life at UT. First year seminar courses focusing on academic skill development have been shown to impact connectedness and social integration on a campus [22]. Effectively making these transitions in the first year is crucial to success at UT, graduation, and future achievement. As part of a dedicated FYS 101, students will get an opportunity to develop the summer project for the following TranSCEnD cohort, thus providing a means for a mentor-mentee relationship between cohorts of TranSCEnD students and engaging students in another high impact practice: service learning. See Figure 5.

Year 4: Intra-Cohort Peer Teaching/Learning
An overall theme of the TranSCEnD Program is to maximize opportunities for students to develop and sustain a cohort for support and collaboration; this may be particularly true for transfer students who may have careers, skills, and experience which separate them from traditional undergraduate students. However, it is anticipated that discounted tuition for community college schools may result in transfer students who share more similarities to typical undergraduate population. During year 4, the TranSCEnD cohort will meet biweekly with TranSCEnD team members to check in on academic progress and discuss topics of interest related to future success. A previous UTK S-STEM award (1258417) noted that students felt constant check-ins with program staff and faculty were a primary reason for their success in the program. Furthermore, upper level students will be invited back for the summer program to gain exposure in an additional project as well as provide leadership and peer-mentoring to incoming students.

Year 5 to Completion: Inter-Cohort Peer Teaching/Learning
While the benefits of the intra-cohort experience provide a support mechanism for transfer students, it is also critical to encourage TranSCEnD students to pursue relationships and experiences outside of the cohort in order to integrate into the academic environment of the university. During the student success skills seminar, TranSCEnD students will be introduced to different academic programs beneficial to future careers in engineering. These academic programs include undergraduate research, co-ops and internships, significant participation in engineering student societies, and significant participation in engineering project groups, such as the Steel Bridge competition and Material Advantage. UTK’s TCE has a robust Office of Professional Practice that supports student internships and co-op experiences among 490 employers across the country. Overall, 40% of undergraduate engineering students in TCE participate in either a co-op or internship experience. UTK also has a robust undergraduate research program supported by the Office of Undergraduate Research, where TCE is an active participant. TCE supports 22 engineering focused student organizations and 4 engineering honors societies. TranSCEnD will work with the Office of Professional Practice, the Office of Undergraduate Research, and the engineering student societies to offer information and support on how to participate in
these programs. Participation in at least one of the programs or in service learning (Figure 5) will be strongly encouraged for support in the final years of the TranSCEnD students’ undergraduate careers.

Acknowledgements
This material is based upon work supported by the National Science Foundation under Grant No. 1742130.

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