Board 84: The 2TO4 Project - Facilitated Transition from 2-Year to 4-Year Engineering Studies (WIP)

Dr. Kenneth A Connor, Rensselaer Polytechnic Institute

Kenneth Connor is an emeritus professor in the Department of Electrical, Computer, and Systems Engineering (ECSE) at Rensselaer Polytechnic Institute (RPI) where he taught courses on electromagnetics, electronics and instrumentation, plasma physics, electric power, and general engineering. His research involves plasma physics, electromagnetics, photonics, biomedical sensors, engineering education, diversity in the engineering workforce, and technology enhanced learning. He learned problem solving from his father (who ran a gray iron foundry), his mother (a nurse) and grandparents (dairy farmers). He has had the great good fortune to always work with amazing people, most recently the members and leadership of the Inclusive Engineering Consortium (IEC) from HBCU, HSI, and TCU ECE programs and the faculty, staff and students of the Lighting Enabled Systems and Applications (LESA) ERC, where he was Education Director until his retirement in 2018. He was RPI ECSE Department Head from 2001 to 2008 and served on the board of the ECE Department Heads Association (ECEDHA) from 2003 to 2008. He is a Life Fellow of the IEEE.

Dr. Bruk T. Berhane, Florida International University

Dr. Bruk T. Berhane received his bachelor's degree in electrical engineering from the University of Maryland in 2003. He holds an M.S. in engineering management from the George Washington University and a Ph.D. in minority and urban education from the University of Maryland. In 2003, Bruk was hired by the Johns Hopkins University Applied Physics Laboratory (JHUAPL), where he worked on nanotechnology and microsystems. In 2005 he left JHUAPL for a fellowship with the National Academies and researched methods of increasing the number of women in engineering. Later that year, he briefly served as a mathematics instructor in Baltimore City High Schools.

From 2005 through 2018, Dr. Berhane directed engineering recruitment and scholarship programs for the University of Maryland. He oversaw an increase in the admission of students of color and women during his tenure and supported initiatives that reduce the time to degree for transfers from Maryland community colleges. The broader implications of his research are informed by his comprehensive experiences as a college administrator. His areas of scholarly interest include: 1) Broadening participation in engineering through community college pathways and 2) Experiences of first and second-generation African diasporic Americans in engineering undergraduate programs.

Dr. Mohamed F. Chouikha, Prairie View A&M University

Dr. Mohamed Chouikha is a professor and chair of the Department of Electrical and Computer Engineering at Howard University. He received his M.S. and Ph.D. in Electrical Engineering from the University of Colorado–Boulder. Dr. Chouikha's research interests include machine learning, intelligent control, and multimedia signal processing communications for secure networks, among other areas. He also focuses on enhancing recruitment and retention of underrepresented minorities in the STEM areas in general, engineering in particular.

Prof. Miguel Velez-Reyes P.E., The University of Iowa

Dr. Miguel Velez-Reyes is the George W. Edwards Distinguished Professor in Engineering and Chair of the ECE Department at University of Texas at El Paso. He received his BSEE degree from the University of Puerto Rico at Mayaguez (UPRM) in 1985, and his SM

Dr. Barry J. Sullivan, Electrical & Computer Engineering Department Heads Assn

Barry J. Sullivan is Director of Program Development for the Inclusive Engineering Consortium. His 40-year career includes significant experience as a researcher, educator, and executive in industry, academia, and the non-profit sector. He has developed

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Michelle Klein, Electrical and Computer Engineering Dept. Heads Assoc. (ECEDHA)
Yeimidy Lagunas, Inclusive Engineering Consortium
Milford Muskett
Amanda Nastiuk
Sinais Alvarado
Elizabeth Hibbler, Conference for Industry and Education Collaboration (CIEC)

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The 2TO4 Project - Facilitated Transition from 2-Year to 4-Year Engineering Studies (WIP)

Abstract: The Inclusive Engineering Consortium (IEC) is a nonprofit organization that enables collective efforts through equitable partnerships between its 20 MSI members, 12 PWI members and 7 corporate members. The IEC 2TO4 Project builds on its Pathways to Success program to support students who begin their studies at a community college or other 2-year institution by providing financial support (scholarships, internships, academic year stipends), mentoring and other transition support, professional guidance, and community engagement.

The 2TO4 network of community colleges (CCs) consists of 20 sub-networks built around the 20 HBCUs, HSIs and TCUs that form the core membership of IEC. Generally, a small number (1-3) of CCs located near a core member educate a few students who transfer to the local 4-year MSI ECE program. Some IEC core members have well-developed relationships with their local CCs and see much larger numbers of transfer students. The vision of 2TO4 is to at least double the total number of students following this pathway to their BS degree in ECE by sharing best practices and providing a robust transition support infrastructure and increased financial support for those students who should have MSIs on their radar as they complete their associates degrees. Participating CCs become members of IEC and engage in equitable partnerships with 4-year MSIs and PWIs, industry and DoD labs to implement the various building blocks of 2TO4.

During the first year of this multi-year effort, a base version of 2TO4 is being created. Program leadership is connecting with DoDSTEM and the other CC programs it funds, defining the parameters of 2TO4 1.0 (formalizing the relationship between MSI core members and their key local CCs), and working through institutional challenges with the 60+ program partners. Regular meetings are scheduled, and a general communication infrastructure is being rolled out. The first cohort of student participants is being selected along with individual faculty and staff who are creating and often delivering student support resources. A key element of 2TO4 is students supporting other students. Since all students are new to the program, a significant fraction of the first cohort includes students who have already transferred to their chosen 4-year school. While they have not benefited from any of the IEC 2TO4 transition infrastructure, their experiences provide valuable insights on what works and what does not and their stories are well received by their more junior peers.

In this early phase, assessment is focused on the extent to which each programmatic component is implemented with fidelity and the program has built the necessary capacity to support students. Formative feedback from each participant is collected and student progress is tracked. Key to this stage of the project is building trust and equitable partnerships, along with making necessary programmatic changes. There is a lot for each partner to learn from the other program partners.

The 2TO4 Project - Facilitated Transition from 2-Year to 4-Year Engineering Studies (WIP)

Introduction

The IEC 2TO4 program is funded by the Department of Defense (DoD[1]) to facilitate transition from 2-year to 4-year studies in pursuit of a degree in Electrical and/or Computer Engineering. (Please see the footnote for a list of acronyms used in this paper.) Student support provided by this program falls in four different categories:

- Financial: tuition, stipends and summer internships
- Professional Development: leadership, teamwork, communication, career planning
- Transition Support: transfer portal, academic advisors, peer networking, supplemental resources, community engagement
- Active Engagement: ambassadors, peer mentors, student organization liaison

Tuition and stipend support can be up to $10,000 each, depending on student circumstances. Most of the various types of student support involve direct student engagement so students are both receiving and providing support.

The IEC is a nonprofit organization founded in 2019 to enable its core Electrical and Computer Engineering (ECE) programs at Minority Serving Institutions (MSIs) to work together collectively to address opportunities and problems that they find difficult or impossible to deal with individually. Its core Members have historically been under-resourced [1] and typical faculty loading (teaching and advising) is very high [2], often leaving little time to dedicate to new initiatives. IEC is evolving to operate as a type of super department of its MSI members, working with affiliate programs from Predominantly White Institutions (PWIs) with very strong research enterprises, corporate members and affiliate community colleges.

The IEC is building, implementing, and supporting a consortium of community colleges with the goal of at least doubling the number of community college (CC) students transferring into its 4-year partner institutions or other 4-year schools, always based on what is best for each student. The 2-year to 4-year pathways through 4-year Engineering programs at Minority Serving Institutions (MSIs) is underdeveloped and underutilized at present. (Note that, in this document, CC and 2-year will be used interchangeably.) Each of the 20 IEC MSI 4-year programs has

[1] **Terminology (Acronyms used in this paper)** DoD: Department of Defense MSI: Minority Serving Institution PWI: Primarily White Institution ECE: Electrical & Computer Engineering HBCU: Historically Black Colleges & Universities HSI: Hispanic Serving Institution TCU: Tribal Colleges & Universities NSF: National Science Foundation K-12: Pre-College Schools CC: Community College IEC: Inclusive Engineering Consortium BS: Bachelor of Science GPA: Grade Point Average IEF: Inclusive Engineering Foundation ASEE: American Society of Engineering Education ECP: Experiment Centric Pedagogy ECEDHA: Electrical & Computer Engineering Department Heads Association AI: Artificial Intelligence MOU: Memorandum of Understanding STEM: Science Technology Engineering & Mathematics ARPELS: Anti-Racism Practice in Engineering: Exploring, Learning & Solutions CROP: Centering BIPOC voices, Respect others, Open-mindedness, Perspective taking BIPOC: Black, Indigenous, People of Color URM: Under Represented Minority Ind: Industry AS: Associate in Science IEEE: Institute of Electrical and Electronics Engineers HKN: ECE Honor Society NSBE: National Society of Black Engineers SHPE: Society of Hispanic Professional Engineers AISES: American Indian Science and Engineering Society SWE: Society of Women Engineers

existing relationships with community colleges. The lone IEC community college - the Southwestern Indian Polytechnic Institute - has similar relationships based on verbal agreements with 4-year schools in New Mexico. These 4-year MSIs are among the largest overall producers of minority engineers, and they can do the same for students who start their studies at 2-year schools. With these programs as local hubs (see Figure 1), the IEC will greatly expand its membership to include, as equitable partners, the key community colleges whose students are pursuing BS degrees in IEC MSI ECE programs and provide the backbone organization for a nationwide network of community colleges uniquely able to support the vision of a diverse and sustainable talent pool in Electrical and Computer Engineering.

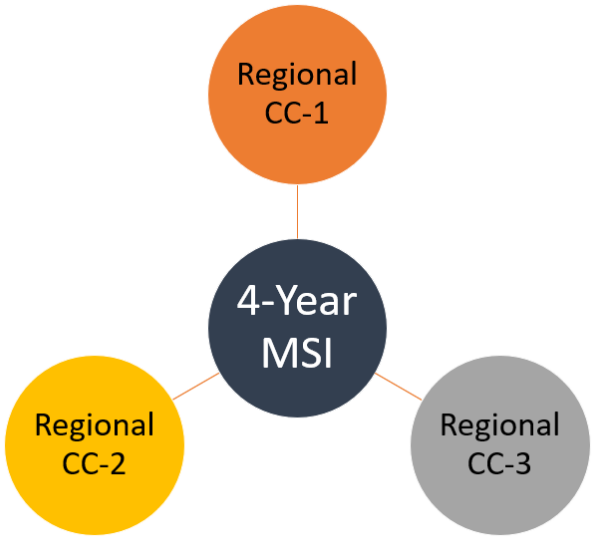


Figure 1: Regional Hub Built Around Core 4-Year IEC MSI With 1-3 Community Colleges

IEC grew slowly and purposefully from an original group of 13 HBCUs, starting with a pre-IEC NSF funded project in 2013 that built an effective collaborative network to implement Experiment Centric Pedagogy (ECP) at all partner ECE programs. [3] It was not until after the new IEC non-profit began its life in early 2019 that its MSI membership expanded to its present 21 programs. In addition to these original core members, IEC began to add growing numbers of affiliate members – Predominantly White Institutions (PWIs) with strong research enterprises – in late 2020. It also began recruiting corporate members. These membership categories bring significant new resources – financial, intellectual and infrastructure – that enable IEC to develop and deliver new services, programs, events, etc. to MSIs. There are presently 15 PWI affiliates and 7 industrial members. [4]

IEC is working to build equitable partnerships that engage multiple MSI, PWI and industry members to address common interests in education, research, and service. It is developing a virtual super department model that includes over 5000 students and 200 faculty at its MSI members alone. The expansion of IEC membership to include at least 20, and very likely more than 50, community colleges, is the next logical step.

A major focus of IEC is transitions, especially the transition to a 4-year ECE program, whether from high school or community college. For example, the Smart Cities REU/RET (SCR2) mega site, led by Morgan State and involving all IEC MSI members, includes community college teachers and students. The Inclusive Engineering Foundation (IEF) has also launched a new Pathways to Success program to increase opportunities for IEC MSI undergraduates to find internships with IEC industry partners, by preparing participants to make the best of these opportunities. Pathways will guide students, particularly those who are the first in their family to attend college, throughout their college career by providing mentoring and a variety of educational workshops and other resources so they are ready for each transitional period in their studies.

In the 2TO4 program, IEC member organizations work together to share best practices to create and sustain the infrastructure necessary to guide community college students on their pathways to ECE careers. Students are provided with the information they need to understand the educational options they have at both MSIs and PWIs and continuing personal support and scholarships after they move to their new 4-year college or university.

In the following section, we describe the student-focused overall **Program Vision of IEC 2TO4** and provide some examples of the type of scaffolding being provided to facilitate student success. Because IEC is a new organization built on some ideas that are not presently common in academia, the next two sections provide information on **Building on the Existing Relationships and Infrastructure that is IEC** and **IEC: A Developing Super Department Model for Multi-University Collaboration.** We then address the **Principles, Strategies and Structures** and **Goals** of IEC 2TO4, most notably what it takes to build and sustain the kind of Equitable Partnerships that can lead to successful collaborations. Finally, we summarize the key **First Year Accomplishments** of this project.

Program Vision

The overall vision of the proposed IEC 2TO4 program puts its focus on the community college student, especially those from underserved communities and particularly on the first-generation student. Its purpose is to create a clear, informed pathway to an Engineering degree and career for such students. Each student starts from their own place, has their own set of values and criteria, and has their own specific career goal. The program must be agile and flexible so that any student with the talent and drive to succeed can achieve their goals. It is the job of 2TO4 to identify and reduce any barriers or roadblocks that cloud this vision and to enable students to take full advantage of all learning opportunities open to them, both inside and outside the classroom. A variety of existing efforts, especially those developed or being developed within IEC, are being leveraged for maximum impact. At the highest level, this vision can be visualized in either engineering or educational terms as creating the scaffolding at the interface between 2- and 4-year schools that reaches well into both types of institutions to prepare and support students through each stage of their educational journey, as shown in Figure 1.

Examples of IEC supported scaffolding:

- Development of course transfer mapping for CCs and core IEC institutions.

- Identification of specific course transfer issues for students from a particular CC to a particular IEC MSI: The Physics course sequence from one of our CCs is not fully accepted at one of our core institutions, but it is accepted at others.
- Professional Growth Development Webinars: Organized and delivered by IEC corporate partners on topics such as resume preparation (with feedback on student resumes), navigating the internship process, understanding the workplace …
- Promoting participation in activities on IEC core member campuses while the CC student is still pursuing their AS degree. Events sponsored by IEEE, HKN, NSBE, SHPE, AISES, SWE, etc. chapters are communicated to CC students. Student liaisons for each on-campus organization help CC students take advantage of these opportunities.
- Peer-to-Peer Mentoring: Senior students now attending an IEC core institution are connected with junior student participants to help guide them on their pathway.
- Advisor-to-Advisor Communication: CC and 4-year advisors are connected to share information and provide guidance for students along all parts of their pathway.
- Student Journaling and Portfolio Development: Students are guided in maintaining an active personal portfolio, regular journaling and documenting their personal narrative to assist both themselves and other students.
- Regular meetings for learning, sharing, and building personal networks: The application process includes individual conversations with applicants to develop a better understanding of each student's needs and to facilitate an environment that encourages sharing and building trust. There are also themed monthly meetings with Q&A sessions to address any topics of interest and facilitate the sharing of information between students, faculty, advisors, working professionals, etc.

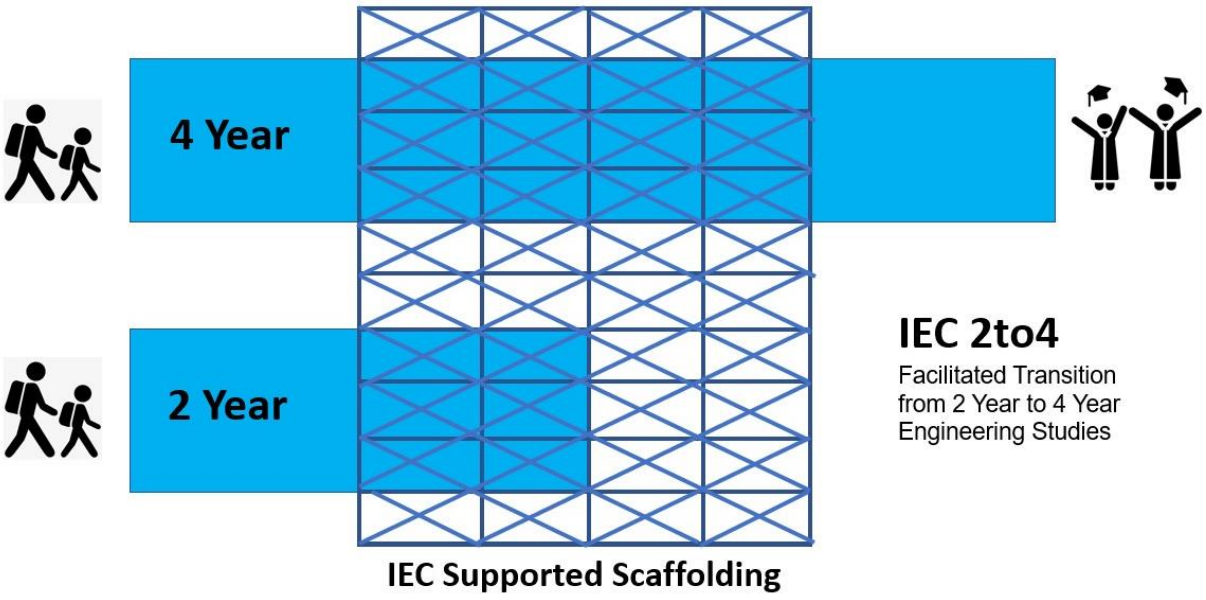
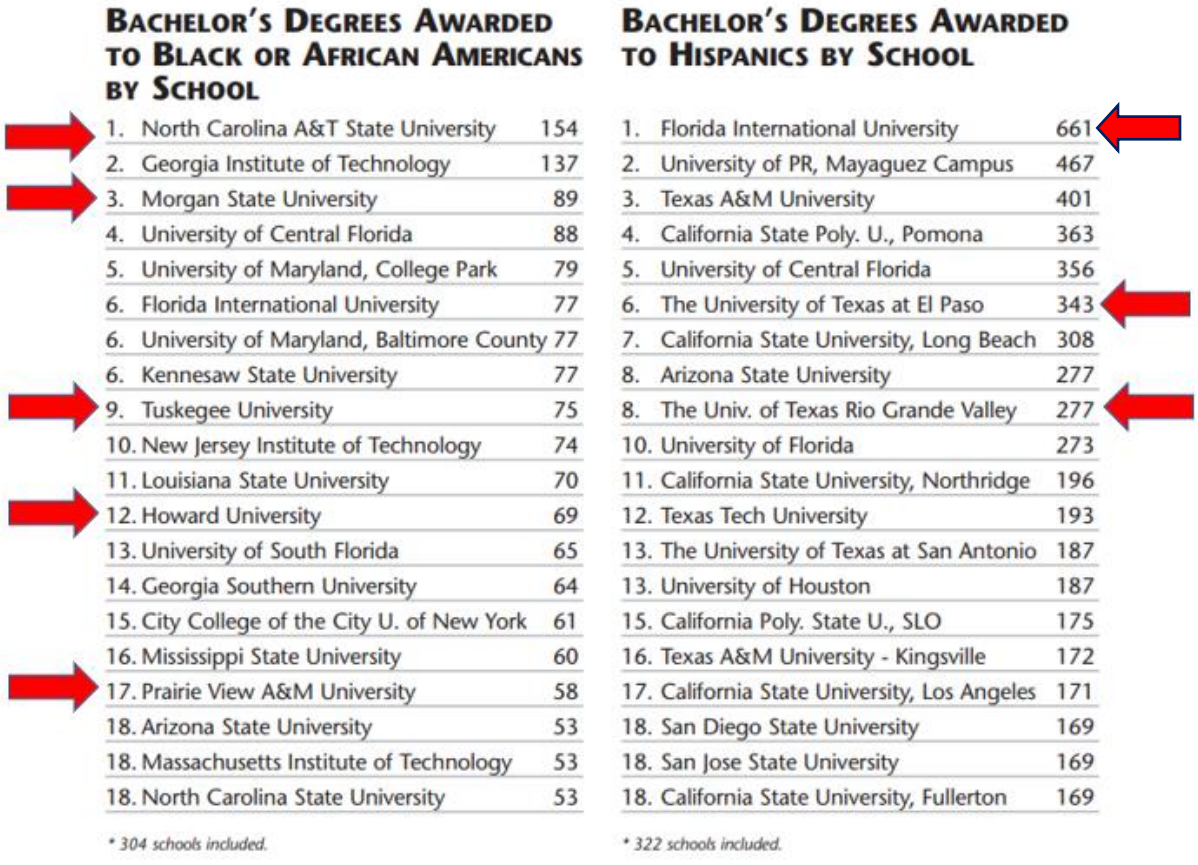


Figure 1: 2TO4 Project Vision

Building on the Existing Relationships and Infrastructure that is IEC

To see why IEC has embarked on this effort, it is helpful to explore its history and look at the institutions involved and how they came together over the last several years. The core members of IEC are all MSIs with very long-term commitments to the communities they serve. The 15 HBCUs are Alabama A&M, Florida A&M, Hampton, Howard, Jackson State, Maryland Eastern Shore, Morgan State, North Carolina A&T, Norfolk State, Prairie View A&M, Southern, Tennessee State, Tuskegee, University of the District of Columbia, and Virginia State. The 4 HSIs are Ana G Mendez Gurabo, Texas El Paso, and Texas Rio Grande Valley. The 2 TCUs are Navajo Tech and SIPI. These schools play a remarkable role in educating a large fraction of minority engineers. From ASEE Engineering by The Numbers, 5 of the top producers of black engineers and 3 of the top producers of Hispanic engineers are represented. Note that NCA&T is #1 on this list even though the entire university is about the same size as the Engineering school as NC State at #18. Most IEC core member institutions have also been focused on serving their primary communities for a very long time.



BACHELOR'S DEGREES AWARDED TO BLACK OR AFRICAN AMERICANS BY SCHOOL

1.	North Carolina A&T State University	154
2.	Georgia Institute of Technology	137
3.	Morgan State University	89
4.	University of Central Florida	88
5.	University of Maryland, College Park	79
6.	Florida International University	77
6.	University of Maryland, Baltimore County	77
6.	Kennesaw State University	77
9.	Tuskegee University	75
10.	New Jersey Institute of Technology	74
11.	Louisiana State University	70
12.	Howard University	69
13.	University of South Florida	65
14.	Georgia Southern University	64
15.	City College of the City U. of New York	61
16.	Mississippi State University	60
17.	Prairie View A&M University	58
18.	Arizona State University	53
18.	Massachusetts Institute of Technology	53
18.	North Carolina State University	53

* 304 schools included.

BACHELOR'S DEGREES AWARDED TO HISPANICS BY SCHOOL

1.	Florida International University	661
2.	University of PR, Mayaguez Campus	467
3.	Texas A&M University	401
4.	California State Poly. U., Pomona	363
5.	University of Central Florida	356
6.	The University of Texas at El Paso	343
7.	California State University, Long Beach	308
8.	Arizona State University	277
8.	The Univ. of Texas Rio Grande Valley	277
10.	University of Florida	273
11.	California State University, Northridge	196
12.	Texas Tech University	193
13.	The University of Texas at San Antonio	187
13.	University of Houston	187
15.	California Poly. State U., SLO	175
16.	Texas A&M University - Kingsville	172
17.	California State University, Los Angeles	171
18.	San Diego State University	169
18.	San Jose State University	169
18.	California State University, Fullerton	169

* 322 schools included.

Figure 2: Bachelor's Degrees Awarded to Black and African American and Hispanics by School (Source: ASEE)

IEC: A Developing Super Department Model for Multi-University Collaboration

Figure 3: Map of IEC MSI, PWI Affiliate, and Corporate Members

Starting in 2013, a collaboration of 13 HBCU Electrical and Computer Engineering (ECE) programs has been working together to implement Experiment Centric Pedagogy (ECP) to improve the student learning experience at all partner institutions (NSF Award #1255441). The lessons learned and best practices of this effort encouraged the 13 partners to expand the scope of their collaboration to address the full learning and working experience of students, faculty and staff and to include other Minority Serving Institutions (MSIs). Recently, the group has added 2 additional HBCUs, 4 Hispanic Serving Institutions (HSIs) and 2 Tribal Colleges and Universities (TCUs) and received funding for a Mega REU/RET site with a team led by Morgan State University (NSF Award # 1849454), along with funding for several workshops. Key to the success of this collaboration has been a solid virtual working community of practice sustained through regular meetings including weekly video conferencing and in-person workshops; online resource sharing, and highly collaborative publication/dissemination of results at ASEE conferences.

While the original 13 partners worked to solidify and sustain the impact of ECP on improving the learning experiences of their students and the augmented group developed new technical research collaborations, a leadership working group explored how to realize the most effective working infrastructure for the evolving consortium. By identifying the primary barriers to success, it became clear that a new support organization was necessary if MSI collaborations (like ECP) are to work together as one. With the assistance of the Electrical and Computer Engineering Department Heads Association (ECEDHA), the group created the IEC, consisting of

a core group of collaborators and a second, much larger group of affiliated members from other universities, industry and professional societies.

The overall IEC vision is to be at its core a collaboration of *Minority Serving Institutions Working as One to Advance the ECE Enterprise.* It is organized as a virtual super department with broadly based strengths in education, scholarship, and service. Collectively, IEC can function as the equal of any ECE program, accomplish more and have a greater impact through access to resources and opportunities not available individually. IEC works to more fully engage MSIs in the US education and research enterprise; graduate more and better prepared minority engineers; increase efficiency and productivity at MSIs; and develop a sustainable and effective infrastructure to support minority students, faculty and staff at all universities. In time, IEC will grow, and the model being developed can be replicated and implemented for other disciplines.

The ECP project created an *HBCU Engineering Network* which successfully demonstrated that an experimental centric pedagogy combined with hands-on educational technology stimulates student interest in the STEM area, promotes content acquisition and problem solving, and retention. As the ECP project wound down, the group reflected on what lessons there are to be learned from this experience. First and foremost, the project succeeded because many schools worked together as one to collectively improve the learning experiences of their students. What enabled the group to succeed? (1) Experienced faculty, who worked together on previous projects, trained faculty at both in-person workshops and regular online meetings. (2) Participants engaged in effective, regular communication through online meetings. (3) Common assessment tools were developed and implemented with guidance from an experienced team of evaluators. (4) Activities and accomplishments were collectively documented at ASEE meetings. (5) The project actively involved both department heads and teaching faculty. (6) Overall, the project developed a very productive network of participants based on mutual respect, trust and confidence in the group's ability to collectively produce high quality work.

What the ECP project participants discovered independently was essentially what is called Collective Impact [5], with one notable exception. The research of Kania and Kramer 'shows that successful collective impact initiatives typically have five conditions that together produce true alignment and lead to powerful results: a common agenda, shared measurement systems, mutually reinforcing activities, continuous communication, and backbone support organizations.'

The missing ingredient can be found in the barriers that impeded the group's ability to achieve its goals as quickly and effectively as it had hoped. (1) The support infrastructure at participating schools was often not adequate to support collaborations. (2) It was not possible to create and maintain an effective external web presence. (3) Experience doing collaborative research is limited and, when opportunities to do so occur, the participant schools are almost always brought into collaborations late in the game after the project is nearly fully developed. (4) Faculty at participating institutions have very large teaching and advising responsibilities and are given inadequate opportunities to learn how to be leaders and how to build research programs. [1,2] (5) The ECE programs that make up the collaboration are generally under-resourced. The only approach available to address any of these barriers individually is personal intervention, which is exceptionally challenging for under-resourced faculty with large teaching and advising loads. All

of these barriers can be addressed by an effective backbone support organization that provides training, opportunities for convenings, additional resources, and general solutions to problems without requiring large amounts of faculty time.

It is the purpose of the IEC to provide this missing backbone organization to handle funding, program support and general infrastructure. The collective group of schools that are members can function as, in effect, a super department, so it is possible to collaborate with outside schools and other institutions as equals rather than as an afterthought. Two changes help address leadership. First, by using an external organization to handle funding and general infrastructure, all partners operate on an equal footing (no prime). The new organization does not compete with the departments, but rather magnifies their capabilities. Second, infrastructure includes leadership and teamwork training through workshops and mentoring, especially for writing proposals and doing collaborative research. Sustainability requires that the external entity be a formal, legal entity – a 501(c)(3) non-profit.

Based largely on the experience of the original 13 IEC members in the ECP project, the driving hypotheses being explored by the organization are: (1) many activities historically undertaken by traditional departments can achieve either higher levels of success and/or success in new areas when developed and implemented by multi-institutional teams; (2) resources and support programs can be effectively shared across many institutions; (3) improvement science, specifically professional development addressing key topics such as teaching, advising, team science, communication, leadership and program management can build capabilities at all partner institutions and breakdown historical barriers to collaboration; (4) the combination of collective experiences and resources with diverse student populations can enable students to achieve greater success and to build personal networks; and (5) alliances built with outside entities can be established and nurtured on a level playing field with external entities by working collectively with other organization partners rather than as individual departments.

The IEC was established as a non-profit early in 2019. Prior to that time, the group of collaborators received multi-year funding for the Experiment Centric Pedagogy project and the SCR^2 Mega REU/RET site. Howard was the lead school for the former and Morgan State is the lead for the latter. Both projects involved nearly all IEC partner institutions and cover the period from 2013 to the present. These two projects have produced over 20 publications. [6] An additional grant was obtained by Morgan State to expand the application of ECP beyond ECE (NSF Award # 1915614), which is supported, in part, by IEC. About a year was required before IEC obtained basic approval to submit proposals to NSF. At that time, what remained were the final steps in the process that are only taken once an organization has a grant proposal that is approved for funding. This did not occur until February of 2021.

Prior to receiving full approval, all NSF proposals were submitted through partner organizations, as they were before IEC was founded. In the summer of 2019, NSF partially funded a workshop (NSF Award # 1935545) held at Intel headquarters in Oregon. [7] This grant was funded through North Carolina A&T. A second workshop grant was also funded by NSF (NSF Award # 2019308) through Tuskegee for a workshop that was to be held at the annual ECEDHA meeting in Florida in March 2020. This workshop was cancelled due to COVID and was replaced by a

series of mini-workshops offered online between May 2020 and February 2021. [8] In addition to these funded workshops, IEC also received NSF RAPID Grant funding (NSF Award # 2031717) to study the impact of COVID-19 on the Minority Serving Institutions it serves. [9] This grant was funded through IEC's partner organization ECEDHA. The first grant received directly by IEC from NSF (NSF Award # 2123186) funded the workshop series Anti-Racist Practices in Engineering: Exploring, Learning & Solutions (ARPELS) throughout 2021 [10]. The activities funded through these grants have actively involved faculty and students from nearly all IEC partner departments. In addition, IEC supports multi-university teams that have received NASA INCLUDES planning grant funding through North Carolina A&T and Texas El Paso. The combination of the mini-workshops and NASA INCLUDES planning grant workshops resulted in about 20 total IEC workshop sessions, with durations between one and two hours on multiple days, addressing topics including team science, autonomous systems, minority faculty working with and at predominantly white institutions, multi-institutional alliances and initiatives, engaging with industry, women in STEM, and anti-racism practice in engineering. All of the five hypotheses listed above were addressed in these workshops. Additional information on these workshops and other IEC activities can be found on the IEC website (iec.org).

IEC is also developing partnerships with other organizations and universities. It has recently signed an MOU with a southeastern university to collaborate in its AI initiative and participates in the 50k Coalition. IEC has six corporate partners and is working to expand that number and actively pursuing foundation support. There are also 12 strong PWI research universities with affiliate membership that are exploring opportunities for building equitable partnerships in education, service, and research, with more to come.

The most exciting new IEC initiative was made possible by the formation of the Inclusive Engineering Foundation (iecfd.org) in 2021: The Pathways to Success Program. Pathways is designed to give minority undergraduates, particularly first-generation college students, the network needed to thrive academically and professionally in Electrical and Computer Engineering. It guides students throughout their college career by providing academic mentorship, a variety of educational workshops, and a summer internship. The first cohort of students was recruited for internships in the summer of 2022. It is supported by Iridium, Qualcomm, TDS and Tektronix.

Principles, Strategies and Structures

During its first year, IEC 2TO4 began an investigation of best practices, barriers, opportunities, etc. found throughout STEM higher education. Before fully building the scaffolding necessary to help students achieve a successful 2TO4 transition and obtain their 4-year degree, the best possible approaches will be identified. However, there are IEC activities that can be leveraged from the very start. The most obvious is the Pathways to Success program, supported by industry through the IEF, which has been expanded to include CC students and will be the basis of long-term sustainability. Pathways will expand along with IEC 2TO4 and will support the 2TO4 transition when the funding for the proposed program ends.

A second IEC effort is also being leveraged to help jump-start IEC 2TO4. Because IEC engages faculty and students from all the HBCUs with Engineering programs, it is able to effectively collaborate with scholars whose research requires ready access to its member schools. Bruk Berhane of Florida International University, a school that has just become a member of IEC, recently received an NSF CAREER Award (NSF # 2145961) **'CAREER: Better Together: Leveraging the Shared Commitment of Community Colleges and HBCUs to Optimize Black Engineering Student Pathways.** He helps recruit community colleges for the project and is responsible for the research that will inform the continuous improvement process that will enable the project to achieve better results each year.

One of the most important reasons why IEC needs to exist is often hard for everyone except MSIs to hear. All MSI STEM programs regularly are asked a variation of the following question. Can you give me the names of your 2 or 3 top students? We are trying to fill some positions in our company, lab, grad school, etc. That is the full extent of the interaction. Most MSIs are also regularly asked to join a research team that is submitting a proposal to a federal agency whose requirements include team diversity. The rest of the team is already in place. The proposal is written. The MSI only must find some faculty and students to participate. Because the 'diversity school' is brought in late in the process, they are rarely able to contribute effectively to the project mission. IEC core MSI members, with their 5000+ students and 200+ faculty, have the size, breadth, and depth to hold their own in any effort. Now, when someone approaches the organization, the first condition insisted on for joining any team is that the participants selected from member programs be at the table from the beginning. This is the first condition for what is termed an equitable partnership. What such a partnership needs to be to reach its maximum potential is a developing idea, but some substantive progress has been made.

Several of the recent IEC workshops, notably the ARPELS (Anti-Racism) workshops, have helped to add substance to the notion of what is equitable [11]. The facilitator for ARPELS (Delia Saenz from Arizona State) is adept at formulating simple acronyms to remind everyone of key principles to follow in any kind of human interaction. One of the first she introduced is **CROP** which stands for **C**enter the voices of BIPOC participants; **R**espect others; **O**pen-mindedness; and **P**erspective-taking. Workshop participants were asked to listen to everyone, especially BIPOC participants, respect one another, keep an open mind, and to look at each issue from the perspectives of the others at the table. Next, basic principles from the science of team science, introduced by Russ Korte of George Washington University at IEC mini workshops in the fall of 2020, also help teams to be equitable. Topics include 1) group characteristics and establishing groups; 2) what a group or team is; 3) sharing a common goal; 4) social aspects of a group; and 5) structure and clarity around tasks and personal engagement. The fourth item – social aspects – has been found to make or break teams and is often overlooked by STEM teams. IEC participants from MSIs recognize that

Figure 4: MSI-PWI-Industry Equitable Partnerships

the success of their previous collaborations came from such good social interactions. Workshop participants also discovered the value of diverse teams involving people from MSIs, PWIs and industry. When representatives of PWIs or industry approach IEC MSI members, they are educated on these basic principles of equitable partnerships. This is rarely a simple, quick discussion. It takes some time to find a way to express these ideas in a common language which points to the importance of the social aspects of team formation and utilization.

There is one more characteristic of equitable partnerships that must be highlighted and that is working culture. Teams formed from both the academy and industry will clearly have teammates from very different working cultures. Often these differences produce barriers experienced in every aspect of building a functional team. However, it is not just the academy/industry split that matters. There are also, in general, very large differences between the culture at the IEC MSI schools and IEC PWI schools. MSIs tend to be teaching focused and faculty invest a lot of time building strong relationships with their students. They usually teach 4 courses per term, which leaves them little time for research. Many have no or few graduate students. The PWIs who are IEC affiliate members have a very strong research focus, light teaching loads, lots of graduate students and well-established research enterprises. Faculty each bring very important talents and resources to the table, especially when a key goal of a collaboration is increasing the number of Engineering degrees received by URM students. Learning to value the cultural differences also takes time, particularly when the individuals involved are only interested in the scholarship of discovery, and not the other types of scholarship identified by Boyer. [12]

The IEC 2TO4 program plans to build similar equitable partnerships between CCs, MSIs and industry by applying the lessons that have been learned for MSI, PWI, and industry partnerships. ECE programs at the IEC MSIs understand that they are in a very similar position relative to PWIs and industry as 2-year schools are with 4-year schools, so they are ready to apply the same ideas that help them build equitable partnerships in both types of relationships. Couple this with the demonstrated ability of MSIs to graduate significant numbers of URM students because of their focus on teaching and advising, and MSI ECE programs are seen as the right match for supporting the 2TO4 transition. One of the largest barriers to educating future engineers is also shared by MSIs

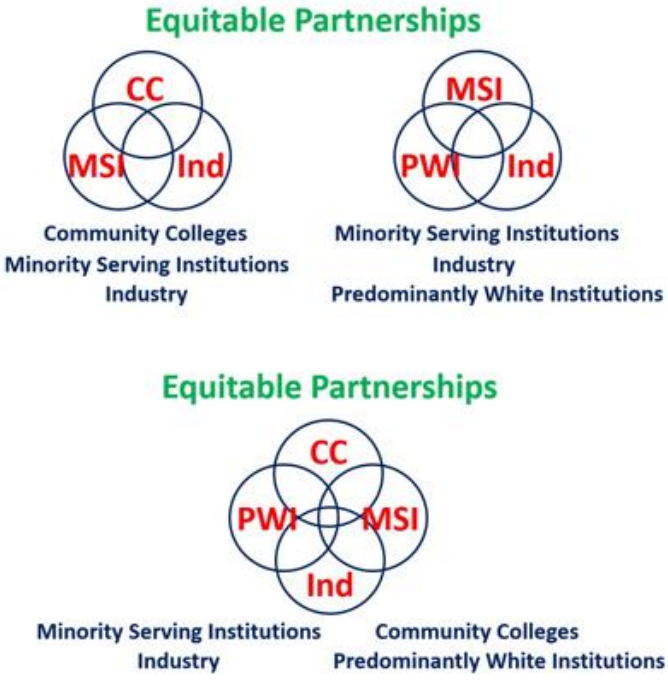


Figure 5: Equitable Partnerships with Community Colleges

and 2-year schools – student preparation, especially in math. One IEC member – Ana G Mendez Gurabo – has even created its own Associates Degree program to enable students who do not meet the requirements for admission to an Engineering BS program to eventually transfer in while also acquiring some practical skills to improve their immediate job prospects. Most of their degree recipients take this pathway.

Because the right choice of 4-year school belongs to the student, the longer-term goal for IEC 2TO4 is a 4-way partnership involving all types of IEC members. From its beginnings, it has been the intention of IEC leadership to add a membership category for 2-year schools because they play such an important role in the education of URM students. The IEC 2TO4 program will enable what is presently a long-term goal to be achieved in the next few years while developing the necessary infrastructure, programs, and support to enable more and better prepared students to navigate the pathway from 2-year to 4-year colleges and join the STEM workforce as an Electrical or Computer engineer.

Goals

To better understand the necessary scope of the project, IEC MSI core member departments were asked to estimate their present percentages of CC transfer students. The numbers varied widely with some at or near 0% and some exceeding 20 or even 50% (The latter being Ana G Mendez Gurabo – they do not participate directly in this program because more than 50% of their students are transfers from their AS program. They do, however, offer advice and share information from their program to help identify best practices.) The rough average number of CC transfer students is 5% or about 250. The long-term goal is to at least double this number to 500. To sustain that number once the program funding ends, will require substantial from corporate participants in the Pathways to Success program and continuous improvement of the overall student support experience provided by 2TO4.

There are two general types of improvement that IEC 2TO4 must address. The first is identifying and implementing new ideas that improve recruitment and retention of ever better prepared students. Project personnel, especially with the help of Bruk Berhane, will stay abreast of new advances in pedagogy and programs that can positively impact the number and quality of STEM graduates. The ideas that will appear are difficult to predict, so significant effort must be invested to find the best ways to improve the program.

The second area for improvement is as much an effort to avoid barriers to achieving the goals of the program as it is an opportunity for improvement. US higher education is in the midst of a period of rapid and dramatic change that has been building over the last few years but has been accelerated by the COVID pandemic. It is likely there will be consolidation as the larger, richer schools take students away, as the number of foreign students drops, and as educational technology and new pedagogy change what it means to attend college. The US semiconductor industry estimates that it may require about half the present output from all engineering programs to meet its workforce needs as it plans to move operations back to the US.

It will be necessary for project personnel to stay up with the ever-changing landscape of higher education and adjust plans at least on an annual basis. Fortunately, the general collaborative

model being developed by IEC that engages multiple constituencies in all its activities should be a very productive approach to moving with the times. Among the many other encouraging trends that should help to build to our goals is the increased importance of research in Engineering Education. As more people get involved, more ideas will be developed and potential working relationships with the scholars involved will be explored. Bruk Berhane is just the first of many bright young people whose ideas will be considered. There is a lot of uncertainty, but there are also a lot of good ideas to consider, with more coming every day.

Finally, should community college education become free and more students decide to take advantage of the 2TO4 path to their degree, there will be an even greater need for a program like this and plans will have to be adjusted accordingly.

First Year Accomplishments

During the first year of this multi-year effort, a base version of 2TO4 is being created. Program leadership is connecting with DoDSTEM and the other CC programs it funds, defining the parameters of 2TO4 1.0 (formalizing the relationship between MSI core members and their key local CCs), and working through institutional challenges with the 60+ program partners. Regular meetings have been scheduled and a general communication infrastructure is being rolled out. The first cohort of student participants is being selected along with individual faculty and staff who are creating and often delivering student support resources. A key element of 2TO4 is students supporting other students. Since all students are new to the program, a significant fraction of the first cohort includes students who have already transferred to their chosen 4-year school. While they have not benefited from any of the IEC 2TO4 transition infrastructure, their experiences provide valuable insights on what works and what does not, and their stories are well received by their more junior peers. This peer-to-peer mentoring is part of an overall mentoring support structure that helps connect students with the people who have the answers and guidance they need to succeed. Some examples of who students are being connected with are shown in Figure 6.

In this early phase, assessment is focused on the extent to which each programmatic component is implemented with fidelity and the program has built the necessary capacity to support students. Formative feedback from each participant is being collected and student progress is tracked. Key to this stage of the project is building trust and equitable partnerships, along with making necessary programmatic changes. There is a lot for each partner to learn from the other program partners.

A key element of this program is focusing on each participating student as an individual, which is seen most clearly in the first year in the conversations we have conducted with each applicant. On paper, nearly all of these great young people look like good choices as participants. However, the interviews, which are really conversations meant to help us all get to know one another, have clearly demonstrated just how different each student is and why they are great choices. Few have stellar grades, but all clearly know how to work hard, show strong values, are eager to help other students, are looking for all productive opportunities to increase their chance of completing their degree program, etc. Some come from other countries, some have at least one engineer parent, nearly all work and pay part or all of their educational expenses. Some work nearly full-time at McDonalds (what we hope to minimize). Some work full-time in state supported apprenticeship

programs. Some have had internships, but most have not. Some have completed certifications; most do not know what certifications are. Some attended a community college while in high school, some are taking as many as 17 years to complete their BS degree because they had to learn English and support their growing family while attending school.

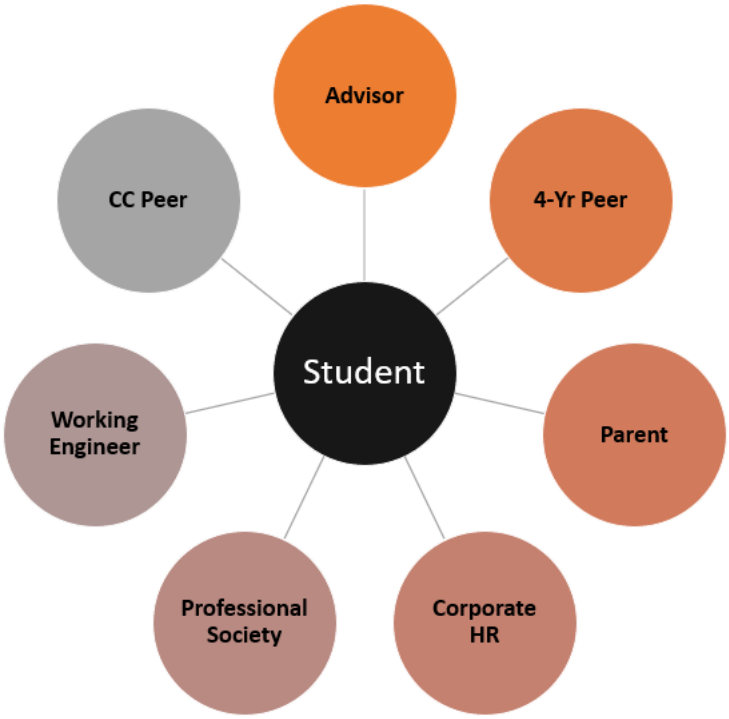


Figure 6: There are many student opportunities to both receive and provide mentoring

Another key element is developing an understanding of the transfer process at each 4-year school. This has enabled us to identify significant barriers to transfer. In one case, an HBCU does not consider the basic freshman Physics course from a large, nearby community college AS in Engineering program as equivalent to theirs, while a nearby, very strong R1 institution does. This has led some of the CC students to choose the larger and more challenging R1 (a PWI) over the HBCU where the support infrastructure will likely serve them better. People in the Dean's office at the HBCU say the first CC Physics course does not have a lab, and students who take the lab have a significantly higher rate of success. We are slowly identifying the key people at each partner institution who can help us find the answers for students when they are navigating their pathway from their 2-year school to their 4-year school. These include administrators and the faculty the students learn from every day. The level of dedication on the part of the faculty is extraordinary.

There is indeed a great deal to learn, but fortunately, everyone is learning from everyone else. Students carry around a lot of misinformation, but they also turn out to be great sources of important information. One area where their knowledge base has been exceptionally valuable is scholarship support. We found out, for example, that one student has a scholarship that is only available for students at his local community college who attend a particular HBCU. Faculty

information on scholarships has been even more important. Students in one state all have a $2500 per term lottery supported scholarship. Students in another state pay no tuition at their 4-year school if they first attend a community college. In yet another state, all students will soon attend public universities and colleges for free. There are so many variations that we always must come back to our focus on each individual or we may miss something.

We would not have our first cohort of students without many meetings with faculty and students, bombarding participating institutions with information, getting a simple web-based application process up and running, etc. So far there have been surprises every day, some big, mostly small. Flexibility and, once again, focus on individual students are essential.

We are also learning the challenges of providing support scaffolding to students when they are used to solving all of their problems on their own and they have a lot of personal responsibilities separate from their education. Attendance at our Professional Growth Seminars, which are open to all students at IEC member institutions, is small but growing. Even finding times for our initial conversations with applicants has been a challenge. However, each event provides another step in the process of building trust and showing students that we can work together to help them along their pathway in many ways they cannot manage alone. Of course, helping them pay their tuition bills and providing stipend support so they can earn some money while doing things that more directly help them achieve their goal of a BS degree in ECE go a long way in keeping the other types of support we provide on their radar.

To reach our goal of 250 additional students in our 4-year programs, we must grow the number of students directly supported to 40 by next year. Our goal for year one was 20, which we have already exceeded. We also must determine how many students we will help succeed by giving them access to our support scaffolding whether we provide any direct financial support. We will not be able to begin assessing the breadth of our impact until we are well into year two.

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