



*Creating Solutions. Inspiring Action.*

**Business Engagement Models  
to Increase Undergraduate  
STEM Student Persistence**

April 5, 2017

National Academy of Sciences  
Washington, D.C.

### ABOUT BHEF

The Business-Higher Education Forum (BHEF) is the nation's oldest membership organization of Fortune 500 CEOs, college and university presidents, and other leaders dedicated to the creation of a highly skilled future workforce. BHEF members collaborate and form strategic partnerships to build new undergraduate pathways; improve alignment between higher education and the workforce; and produce a diverse, highly skilled talent pool to meet demand in emerging fields.

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### ACKNOWLEDGEMENTS

BHEF would like to thank the following individuals for providing detailed information and insights about the development of their respective programs.

- Carmen Aguilar, Associate Scientist, School of Freshwater Sciences, University of Wisconsin-Milwaukee
- Djuradj Babic, Director, School of Engineering and Technology, Miami Dade College
- Leah Ben-Ami, Director of Academic Operations, Lowell Institute School, College of Professional Studies, Northeastern University
- Susan Campbell, Senior Advisor to the Dean for Advising and Career Planning, Lowell Institute School, College of Professional Studies, Northeastern University
- Kemi Jona, Founding Director of the Lowell Institute School, Associate Dean for Undergraduate Programs at the College of Professional Studies, Northeastern University
- Phyllis King, Vice Provost, University of Wisconsin-Milwaukee
- Siu Ming Luie, Senior Advisor to the Dean for Academic and Curricular Planning, Lowell Institute School, College of Professional Studies, Northeastern University
- Joseph O'Sullivan, Samuel C. Sachs Professor of Electrical Engineering and Dean of UMSL/WashU Joint Undergraduate Engineering Program, University of Washington in St. Louis
- Bernice Rosenzweig, Research Associate, Environmental Sciences Initiative, Advanced Science Research Center, The City University of New York
- Kurt Thoroughman, Associate Professor, Biomedical Engineering, Washington University in St. Louis

Lead BHEF staff for this publication include Steve Barkanic, Janet Chen, Brian Fitzgerald, and Debbie Hughes.

This work was funded by the National Science Foundation.

# Business Engagement Models to Increase Undergraduate STEM Student Persistence



**PROJECTIONS OF THE U.S. WORKFORCE INDICATE A GROWING DEMAND** for employees with a baccalaureate degree in high-demand science, technology, engineering, and mathematics (STEM) fields. However, significant challenges, including attrition, impede the ability of the U.S. education system to meet this increasing demand. The community college section of the pipeline, ideally combined with interventions such as research internships and summer bridging programs, offers one way to increase the supply and diversity of college students studying STEM as well as the college attendance rates of minority populations.

Former President Obama and other leaders have suggested that business engagement might be one solution to improving STEM student outcomes. Business and industry could commit their substantial but underutilized STEM resources, such as world-class STEM experts, laboratories, and research and development centers, to improve undergraduate STEM education. However, little to no outcome data have been collected on industry partnerships with higher education or the specific contributions that industry can make to affect STEM student retention. Moreover, because business has been a largely underutilized resource in undergraduate STEM education, little, if any, research has been conducted to understand where industry can best boost STEM retention, especially among STEM transfer students. This report will begin to fill this knowledge gap by shedding light on the role of and best practices for business in STEM transfer and persistence as well as its impact on expanding STEM capacity.

## THE CHALLENGE

Projections of the U.S. workforce indicate a growing demand for employees with a baccalaureate degree in high-demand STEM fields. Carnevale, Smith, and Melton (2011) project a 17% increase in the demand for highly trained graduates in STEM and technical fields. Although the policy conversation has often focused on the role of associate's degree programs to address this need, Carnevale and colleagues (2011) note that about 65% of STEM job openings will require a bachelor's degree or higher by 2018. This country's changing demographics ensure that many of

these jobs will need to be filled by women and underrepresented minorities (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2011).

Significant challenges impede the ability of the U.S. education system to meet this increasing demand. BHEF's 2012 analysis of a large national sample of ACT data indicates that only 17% of 12th graders are both interested in STEM careers and college ready in math—the most likely candidates for STEM majors (Business-Higher Education Forum [BHEF], 2012). Although 85% of these students enroll in 4-year colleges

upon graduation, less than 40% of students who declare STEM majors go on to earn STEM degrees (BHEF, 2012; Carnevale, Smith, and Melton, 2011; President's Council of Advisors on Science and Technology [PCAST], 2012). Attrition of STEM students is particularly severe in the first 2 years of the undergraduate experience and for women and students from underrepresented minority groups (PCAST, 2012).

The community college section of the pipeline offers one way to increase the supply and diversity of college students studying STEM. Fourteen percent of all high school seniors are STEM-interested but not college-ready in math (BHEF, 2012). For many of these students, their first postsecondary institution will be a community college. The more than 1,100 U.S. community colleges enroll more than 6.8 million degree-seeking students, representing 43% of all U.S. undergraduates and 40% of first-time freshmen (National Center for Education Statistics [NCES], 2007). Community colleges are a critical gateway into 4-year baccalaureate programs, with between 50-80% of all incoming community college students seeking to transfer and earn a bachelor's degree (Horn, 2009).

Community colleges also play a crucial role in increasing college attendance rates of minority populations. A National Academy of Sciences, National Academy of Engineering, and Institute of Medicine report (2011) chronicles the widening gaps in STEM degree completion between African American and Latino students and their white and Asian counterparts. Nationally, 40% of community college students are members of minority groups, and 42% are the first generation in their families to attend an institution of higher education (NCES, 2007). However, students who begin undergraduate STEM programs at community colleges are less likely to earn baccalaureate degrees: only 7.3% of community college students who started STEM courses earned a baccalaureate degree in a STEM field within 6 years (Bowen, Chingos, & McPherson, 2009; Institute for Education Sciences [IES], 2009). Moreover, in an analysis of community college transfers within a large public university system, Gupta (2010) found that only 3% of students transferred from community colleges into engineering and computer science programs.

In recent years, interventions demonstrating increases in STEM student recruitment and retention have been the subject of considerable research. Examples of such interventions include research internships (Junge, Quiñones, Kakietek, Teodorescu, & Marsteller, 2010; Lopatto, 2007), summer bridging programs (Gleason et al., 2009), student cohort and living/learning communities (Stassen, 2003), and course redesign focused on active learning (Cabrera, Colbeck, & Terenzini, 2001; Wieman, Perkins, & Gilbert, 2010). Research has shown that simultaneous

implementation of multiple interventions can have a significant impact on the retention and academic success of undergraduates, particularly women and underrepresented minorities (Summers & Hrabowski, 2006). These interventions have potential for increasing the retention and completion of students transitioning from 2- to 4-year STEM programs because they address the “transfer shock” caused by the academic and social challenges that many students face (Hills, 1965; Rhine, Milligan, & Nelson, 2000).

Former President Obama and other leaders have suggested that business engagement might be one solution to improving STEM student outcomes. Business and industry could commit their substantial but underutilized STEM resources, such as world-class STEM experts, laboratories, and research and development centers, to improve undergraduate STEM education. In 2012, the President's Council on Jobs and Competitiveness issued a national call for greater business engagement in STEM, particularly in engineering disciplines. Although several reports and articles suggest ways to effectively engage industry in higher education (Kessels & Kwakman, 2007; Weston, Way, & Hutcheson, 2003), little to no outcome data have been collected on these partnerships or the specific contributions that industry can make to these interventions to affect STEM student retention. Moreover, because business has been a largely underutilized resource in undergraduate STEM education, little, if any, research has been conducted to understand where industry can best boost STEM retention, especially among STEM transfer students.

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## THE SOLUTION

Through the collaboration of its business and academic members, the Business-Higher Education Forum (BHEF) launched the National Higher Education and Workforce Initiative (HEWI), a set of long-term regional projects in selected states focused on university-business partnerships, as well as national efforts to disseminate insights from the projects and scale up effective practices. Created in 2012, BHEF's HEWI promotes its Strategic Business Engagement (SBE) Model. Traditional models of business engagement are “transactional”—relationships limited to low-touch, piecemeal interactions with higher education such as on-campus recruiting and support of research on business products and services. BHEF's SBE Model shifts away from this traditional model to a strategic one in which four of the corporate “levers”—corporate/executive leadership, corporate philanthropy, employee engagement, and core competencies and expertise—are aligned and dedicated to improving educational outcomes and workforce alignment.

Building upon its success, BHEF developed a correlating effort—the Partnership Implementation Process—which resulted from work with several business-higher education partnerships. The process provides a framework to build on and lead to consensus on shared outcomes, such as a new major, minor, or career pathway. The elements of the process are:

- Analyze Job Market Landscape and Skills
- Profile Competencies and Skills
- Map Skills and Curricular Gaps
- Select Academic Credentials
- Integrate High-Impact Practices
- Develop Industry-Engaged Programs
- Update Curriculum Continuously
- Change Talent Development and Recruitment

Through a National Science Foundation (NSF) grant, five business-higher education partnerships are applying the process to increase the persistence of STEM students transferring from 2-year to 4-year higher education institutions.

#### Public Meeting

BHEF is collaborating with the National Academies of Sciences, Engineering, and Medicine Board on Higher Education and Workforce (BHEW) to host a *Summit on the Intersection of Higher Education and the Workforce: Broadening the Role of Business in STEM Transfer and Persistence* in Washington, DC. This public, half-day event will focus on broadening the role of business in STEM transfer and persistence among the nation's students. The Summit will provide participants with the opportunity to learn about and engage in deeper discussions on high-impact practices and business engagement models aimed at increasing undergraduate STEM student persistence and workforce readiness, especially for community college transfer in STEM.

The goal of the Summit is to highlight the learning from pilot programs around STEM persistence that can be broadly applied, generate a broader community, and increase visibility around the topic of business engagement and partnerships to facilitate student diversity and success in STEM fields and the future workforce. The discussion will be guided by three main ideas, which are essential to increasing undergraduate STEM student persistence and workforce readiness:

- High-impact practices and collective impact
- Business engagement and partnerships
- Transfer from 2- to 4-year programs

In summer 2017, BHEF will publish a report stemming from the Summit that describes the key themes and findings around how business can contribute to students transferring from community colleges and persisting in STEM degrees.

#### Project Overview

In 2014, NSF awarded BHEF a 5-year grant to implement and evaluate models for business engagement to increase undergraduate STEM student persistence. Through this project, BHEF has aimed to significantly advance knowledge in a largely unexplored area of 4-year undergraduate STEM education: developing validated evidence-based models for effective, strategic, and sustainable private industry engagement with higher education to increase the persistence of STEM students, particularly women and underrepresented minorities, and expand the workforce in key high-demand STEM fields. The project has identified the transfer of students from 2-year to 4-year institutions as a key juncture that, if addressed, could significantly increase both the diversity and numbers of students earning STEM baccalaureate degrees. Specifically, this project addresses the research question: *What types of business engagement most effectively augment the delivery of evidence-based, high-impact interventions designed to increase the persistence of STEM students transferring from 2-year to 4-year higher education institutions?* The goals for this project fall within three categories:

- Create a data collection infrastructure for measuring the impact of corporate involvement in undergraduates' postsecondary experiences on their ability to transfer from community college and persist in STEM disciplines;
- Launch five new multidimensional programs that will serve as learning and demonstration sites, and offer students access to a series of evidence-based, high-impact practices (HIPs) that are strategically enhanced by corporate engagement in the broader Undergraduate STEM Interventions with Industry (USI<sup>2</sup>) Consortium; and
- Disseminate the learning and best practices from the data collection effort and regional projects to a national audience, thus influencing policy and practice around community college transfer in STEM, corporate engagement, measurement of partnerships, and efficacy of high-impact practice.

Building on past and current activities, the project’s five learning demonstration sites and domains of interest are:

- The City University of New York and IBM: large-scale data analytics and urban sustainability
- Miami Dade College and NextEra Energy: Data science and analytics
- Northeastern University and Raytheon: Information technology and cybersecurity
- University of Wisconsin-Milwaukee (UW-Milwaukee) and The Water Council: Water science
- Washington University in St. Louis and The Boeing Company: Engineering.

**Key Findings to Date**

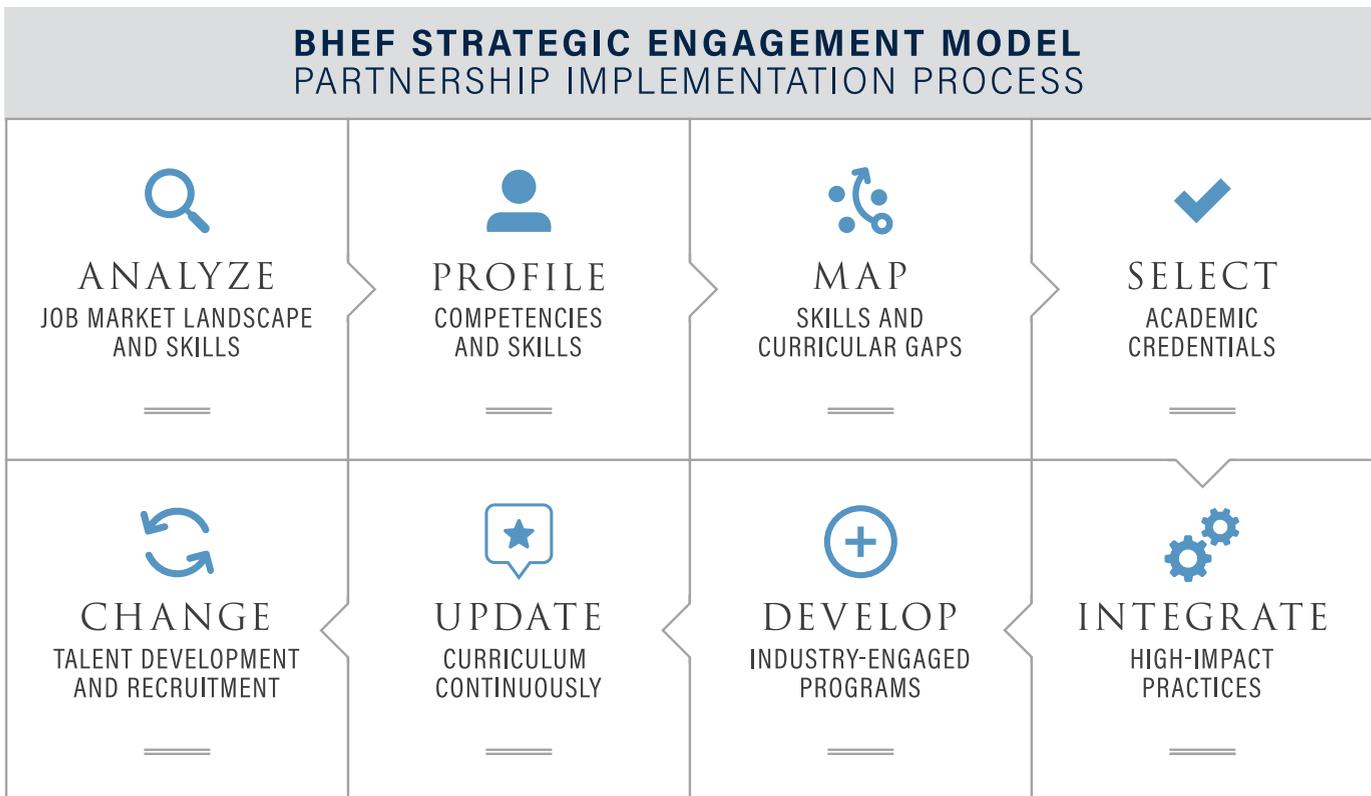
Now in their third year, the five learning demonstration sites have provided several invaluable insights and takeaways, including:

**The role of the 4-year institution as a trusted actor.**

These NSF programs are shedding light on a new model for how 4-year institutions can serve as a “middle man” between business and community colleges. Many companies have highly proscribed practices for how and where they recruit

talent and are having trouble finding diverse candidates in their usual academic talent pools. However, companies involved in the project have started to recognize that community college students comprise a diverse pool of potential employees. The placement of a trusted university partner in the middle of the community college transfer process provides the company with a partner it knows. The university can ensure that community college transfer students receive the support they need prior to transfer and through to graduation, with the additional support of the company. By having the university serve as the “middle man” that aligns community college transfers and links them to the industry partner, companies can expand their scope through the normal channels.

**The process for developing effective regional workforce projects.** Through the NSF program, BHEF has created and documented and is now testing the process for developing regional workforce projects at non-NSF partner locations around the country. The process is depicted in the graphic below. The first step provides context and understanding around the needs for a program. Then, the company articulates its needs for specific skills and the institution crosswalks its offering with the company’s needs. From this exercise, a robust dialogue shapes new programs, credentials, and courses, as well as a



framework for understanding HIPs and how companies can support students on an ongoing basis. The end goal is changed hiring practices.

**The applicability of STEM skills to non-STEM fields.**

Through this work, BHEF has explored how STEM skills can be developed in non-STEM major programs. The disciplines most directly impacted are business and humanities. The programs created through this grant, particularly Miami Dade College (MDC), The City University of New York (CUNY), Northeastern University (Northeastern), and University of Wisconsin-Milwaukee (UW-Milwaukee), are researching the role of an individual “enabled” in a field. In the case of data science and analytics (DSA), BHEF is exploring how students could earn the “DSA-enabled” designation in the business and liberal arts schools. Furthermore, UW-Milwaukee is exploring how all students can be exposed to the water sciences through a foundations course. In the case of cybersecurity, programs are contemplating how foundations courses can be offered to nontechnical students. The NSF project sites’ deep understanding of the emerging fields of DSA, water sciences, and cyber offer meaningful insights into the applicability of STEM skills to the humanities and other nontechnical disciplines.

**The need for change in a company’s human resource strategy.** The industry partners have realized that their human resource strategies must be reviewed in light of their support of nontraditional STEM students in these programs. For example, Washington University’s new engineering pathway has sparked internal discussions at Boeing, which typically recruits from nationally prominent academic institutions, about the need to recruit and retain engineers from diverse backgrounds and institutional sources, particularly those who began their academic work at 2-year colleges. IBM typically focuses its educational outreach on K-12 STEM, notably through its support of the Pathways in Technology Early College High Schools (P-TECH) program, and graduate education through fellowships, technology sharing, and other approaches. Its NSF-funded partnership with CUNY has demonstrated the value of engaging at the undergraduate level, particularly at the juncture between 2- and 4-year STEM programs, to develop diverse talent.

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## CREATING A CONSORTIUM AND LEARNING COMMUNITY

BHEF formed the USI<sup>2</sup> Consortium to develop, implement, and examine evidence-based models of strategic, effective, and sustainable engagement of industries in curricular strategies/ activities and student support services designed to increase STEM student persistence and degree completion. Beginning in October 2014, the USI<sup>2</sup> Consortium includes representatives from BHEF, the Consortium for Undergraduate STEM Success (CUSTEMS), NORC at the University of Chicago (NORC), Miami Dade College, the University of Wisconsin System (UW-System), Washington University in St. Louis (WUSTL), Northeastern University, The City University of New York, NextEra Energy, Inc. (NextEra Energy), The Boeing Company (Boeing), Raytheon Company (Raytheon), IBM Corporation (IBM), and The Water Council.

The Consortium is designed to be a hub for learning and knowledge sharing. The Consortium has quarterly calls, meets in person once every other year, and has ongoing email dialogue. Central implementation activities take place within the context of the Consortium. In its first year, the Consortium focused on common definitions for HIPs that were then embedded into the various partner programs. In its second year, activities focused on two fronts, student evaluation tools and regional/national models. As the Consortium grows, it will benefit from broader engagement with the addition of new partners committed to its work.

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## DESCRIPTION OF THE DEMONSTRATION PROJECTS

Focused on a variety of STEM sectors, each learning demonstration site highlights different ways to engage business, employ HIPs, and develop new STEM majors, minors, and pathways. The sites also demonstrate how small projects can be used to launch large initiatives and to create a big footprint, impacting the policies and practices of businesses, higher education institutions, and other stakeholders on a grand scale. In addition, each site serves as an example of major themes around STEM transfer and persistence in action.

## THE CITY UNIVERSITY OF NEW YORK AND IBM CORPORATION: LARGE-SCALE DATA ANALYTICS AND URBAN SUSTAINABILITY

The United States economy, political leadership, and quality of life depend on science-based innovation. However, a major concern is that the nation will be unable to produce enough talent in high-demand fields over the next several decades. Thus, an important part of the nation's innovation strategy involves increasing the number and qualifications of STEM graduates.

In partnership with IBM, CUNY is developing programs that will support transfer students in STEM. The Transformational Research and Experiential Learning for Leadership (TRELLIS) project is its pilot initiative. Using evidence-based interventions, the project supports students transferring from community college to the City College of New York (CCNY) in completing their degrees and pursuing high-skill, high-wage jobs in the regional economy.

The TRELLIS project is focused on data science and urban sustainability science, both high-skill and high-demand fields with applications for many industry sectors. Researchers train participating students at the Advanced Science Research Center, CUNY's state-of-the-art facility for cutting-edge, interdisciplinary science.

In fall 2015, CUNY successfully hired a student communications liaison, launched a project website, and executed a series of outreach and networking events at Bronx Community College (BCC) for the TRELLIS project. The first BCC event featured representatives from IBM, along with CCNY's National Oceanic and Atmospheric Administration-Cooperative Remote Sensing Science and Technology Center (NOAA-CREST) and the Grove School of Engineering, who presented on their work, career opportunities in STEM, and the skills and training needed for a successful career. Subsequent events focused on administrative procedures for transferring from a CUNY community college to a 4-year college, analytics and computer science, and existing CUNY programming to support STEM students. In addition, CUNY expanded its outreach efforts to its other affiliated community colleges. Through these efforts, community college students who were accepted to a CUNY 4-year college in spring 2016 became eligible to apply to the TRELLIS project. The TRELLIS project consists of two key components:

1. *Summer Intensive.* A 3-week summer bridge program for students transferring from a CUNY community college to CCNY.
2. *Senior Capstone Research Project.* Funding and support for successful CCNY transfer students to conduct research projects in their senior year under the mentorship of CCNY faculty and IBM representatives.

In August 2016, transfer students completed the TRELLIS Summer Intensive, a 3-week summer bridge program. In this program, students

- Received direct training in data analysis methods,
- Participated in a collaborative research project on urban climate change analytics,
- Networked with CUNY faculty and STEM industry researchers, and
- Received a stipend.

Through the use of real-world, New York City (NYC)-based data on climate change impacts, climate vulnerabilities, and adaptation efforts from sources such as NASA and NOAA-CREST, students learned to analyze large and heterogeneous digital datasets and to work collaboratively to solve quantitative problems. Students also gained experience in basic computer programming and oral presentation and benefited from networking opportunities with CUNY faculty, administrators, and STEM industry professionals. The interdisciplinary nature of studying climate change resilience meant that students also gained experience in working across fields. IBM staff partnered with faculty on curriculum development and made presentations at two of the summer bridge sessions. CUNY used pre- and post-surveys for student assessment of the bridge program.

In fall 2017, CUNY plans to implement the TRELLIS Senior Capstone Research Project. The TRELLIS project will provide funding for selected, high-performing transfer students to conduct a capstone research project in their senior year. This project will serve as the culmination of the students' undergraduate experience and will prepare them for graduate school or the scientific workplace. Students invited to participate will

- Work directly with a CCNY faculty mentor,
- Be paired with an industry mentor from IBM, and
- Receive a stipend and funding for research expenses.

In addition to implementing the senior capstone experience, CUNY plans to have regular events with the first cohort, enabling them to network and form a community with each other and upper-division students.

### Website

<http://cunytrellis.org/about.html>

## MIAMI DADE COLLEGE AND NEXTERA ENERGY, INC.: DATA SCIENCE AND ANALYTICS

DSA skills are a core workforce need across the public and private sectors, including business, education, energy, finance, government, healthcare, manufacturing, and science. According to a 2011 McKinsey Global Institute report, national unmet demand for data analysts is predicted to reach 140,000 to 190,000 people by 2018 (Manyika et al., 2011). Gartner estimates that every big data–related role in the United States will create employment for three people outside of information technology (IT) (Gartner, Inc., 2012). However, DSA degrees are primarily only offered to graduate students; thus, undergraduate students have little to no coursework or experience directly related to the field.

To meet the demand for workers with DSA skills, MDC is engaging in the following activities:

- Develop a DSA workshop to increase faculty capacity for teaching high-demand DSA skills
- Embed industry-led DSA undergraduate research as a HIP into introductory programming courses, which have the highest student attrition rate
- Develop a first-of-its-kind DSA workforce-driven program pathway consisting of shorter-term credentials: College Credit Certificate in Business Intelligence Professional, Associate in Science in Business Intelligence, and Bachelor of Science in Data Analytics (BS-DA)
- Build a scalable DSA framework that can be adopted and replicated nationally through collaboration with the Business Roundtable and the Association of Public and Land-grant Universities (APLU)

In collaboration with BHEF and the Business Roundtable, MDC recruited strategic industry partners to support the project, including Accenture, Miami Children's Hospital, Miami-Dade County's Information Technology Department, Oracle Corporation, SAS Institute, Siemens Energy, and NextEra Energy as project lead partner. In March 2015, representatives from each industry partner participated in a storyboarding focus group to create an occupational profile outlining the major duties, knowledge, skills, software tools, tasks, and traits required for data analysts.

An interdisciplinary team of MDC faculty and administrators from the School of Engineering and Technology (EnTec), School of Business, and Mathematics Department used the information from the focus group to develop a curriculum for a new BS-DA degree that meets employer needs, including identifying specific courses and course sequencing. Ten new courses were developed including: Applied Business Analytics, Big Data, Business Intelligence, Data Mining, Data Security

& Governance, Data Visualization, Predictive Analytics Algorithms, Regression Analysis, and a culminating Data Analytics Capstone, providing students with the opportunity to synthesize their learning by solving industry-led problems.

Also in response to the focus group discussion, MDC successfully launched its 15-hour College Training and Development (CT&D) workshop for faculty in fall 2015. This workshop trained faculty to engage students in data analytics research projects using Excel and serves as a prerequisite for faculty interested in participating in the BS-DA degree program. Participants learned how to teach research methods using data analytics concepts such as forecasting, inventory modeling, and optimization.

In February 2015, approximately 100 academic and business leaders from MDC attended the BHEF semi-annual member meeting, which allowed them to interact with other institutions and gain insight into the opportunities and challenges in DSA. With BHEF's help, businesses also played a key role in the Developing a Curriculum or DACUM process for the program.

MDC's first cohort for the BS-DA degree started in spring 2015. In the introductory programming course, students joined a dynamic learning community that fostered relationships with faculty members. Students also began a two-semester undergraduate research experience, which they could continue over the summer semester. MDC provided stipends for nontraditional and commuter college students who chose to engage in summer research. MDC's industry partners provided real-world datasets for students to use in their research, guest lectures, and mentorship to students during the summer research experience. The objective of these efforts was to increase student persistence and graduation rates as well as to equip participating EnTec students with core workforce DSA skills regardless of their chosen pathway of study.

In fall 2016, students who completed their undergraduate research experience could present scientific posters at the MDC School of Science Annual STEM Research Symposium. MDC is using pre- and post-surveys for student assessment of the new program. Moving forward, MDC plans to redesign the CT&D faculty workshop for the fall semester, analyze the retention and graduation rates of students who participated in the program, and prepare for the next cohort of students in the spring. MDC is also developing a DSA framework for national application and replication through a collaboration with the Business Roundtable and APLU to develop undergraduate DSA workforce-driven program pathways nationwide.

### Website

<http://entec.mdc.edu/BS-DA.htm>

## NORTHEASTERN UNIVERSITY AND RAYTHEON COMPANY: IT AND CYBERSECURITY

In 2013, there were 209,749 postings for cybersecurity-related jobs in the United States (Burning Glass Technologies, 2014). Cybersecurity jobs accounted for nearly 10% of all IT jobs, and cybersecurity job postings grew by 74% from 2007 to 2013 (Burning Glass Technologies, 2014). More than twice that of all IT jobs, this growth rate was predicted to continue to rise.

To meet this demand, Northeastern partnered with Raytheon to create an industry-informed curriculum in IT with a focus on cybersecurity through the Lowell Institute School at the College of Professional Studies in 2015. The goal was to increase the transfer, persistence, and completion rates of students from Massachusetts community college programs into one of the Lowell Institute School's degree completion programs such as the Bachelor of Science in Information Technology (BSIT).

The Lowell Institute School is well-suited to achieve this goal. It serves as an integrated model for institutional action to increase bachelor's degree completion in STEM fields. The school's comprehensive approach to student learning draws and builds upon effective educational practices for successful degree completion, particularly for those at high risk of not completing baccalaureate programs such as adult, female, first-generation, and low-income students. The Lowell Institute School provides a comprehensive student services network for learning support, effective and innovative instructional practices with a focus on curricular alignment, experiential learning opportunities, and flexible degree pathways.

The Lowell Institute School is especially interested in partnerships with community colleges and industry to increase the numbers and degree completion of students transferring from Massachusetts community college programs into a Lowell Institute School program in STEM. To do this, the Lowell Institute School focuses on three interrelated project elements.

1. Develop an industry-informed curriculum in IT with a focus on cybersecurity that responds to workforce needs and supports industry engagement with students.
2. Align key gateway courses in logic and technology to support student readiness for and success in the BSIT program.
3. Incorporate HIPs into instruction and support systems to improve student engagement and communities associated with higher rates of retention, graduation, and career placement rates among underrepresented groups in the BSIT program with a cybersecurity focus.

Northeastern made substantial progress on developing an industry-informed curriculum in IT with a focus on

cybersecurity in the 2015-2016 academic year. In particular, Northeastern partnered with Shearwater International, a local start-up with expertise in online student support programs, to build out a three-tiered mentoring program that will engage students with industry, alumni, and peers. Northeastern also worked with its industry partners, including Boston Children's Hospital, Brigham and Women's Hospital, and lead partner Raytheon, to successfully host 12 speakers for its speaker series. In response to student enthusiasm for the speaker series, Northeastern recorded sessions for its online learner population. Northeastern also piloted a STEM seminar, which, along with the speaker series, enabled students to engage in self- and career exploration to make informed decisions about their future. This focus on the student experience is a key component of the program. It is reflected in the academic advising and career planning conversations that Northeastern has with its students, which allow them to reflect on their academic pathway and the relationship of that pathway to their career goals and motivation.

In addition, Northeastern is collaborating with community colleges to strengthen the entire cybersecurity pipeline. Northeastern currently works with eight faculty members from four different community colleges: Bunker Hill Community College, North Shore Community College, Quincy College, and Quinsigamond Community College. Northeastern meets with its community college partners to align curricula with industry needs, incorporate HIPs, and develop an experiential network project, which would provide a scalable and sustainable model for industry engagement in experiential learning in higher education. With the help of its new founding director and associate dean for undergraduate education at the Lowell Institute School, Dr. Menachem (Kemi) Jona, Northeastern has made rapid progress in building all components of its program.

Thus far, Northeastern has evaluated its program using satisfaction surveys for events and course evaluations for the STEM seminar. In the future, Northeastern will seek curriculum approval and additional articulation agreements and will launch its mentoring program. Northeastern looks forward to refining the use of experiential learning as an effective HIP across student populations and to supporting its community college partners in their efforts to engage students.

### Website

<http://www.cps.neu.edu/degree-programs/undergraduate/bachelors-degrees/bachelors-information-technology.php>

## UNIVERSITY OF WISCONSIN-MILWAUKEE AND THE WATER COUNCIL: WATER SCIENCE

The World Economic Forum states that water stress is the number one global risk to society (World Economic Forum, 2015). Furthermore, the Pacific Institute and VOX Global report that 79% of U.S. companies currently face water challenges (Schulte et al., 2014). The city of Milwaukee is uniquely qualified to address these challenges. Known as a water-centric city, Milwaukee hosts more than 200 water technology businesses and was recognized as the “freshwater capital of the world” by U.S. Environmental Protection Agency Administrator Gina McCarthy in 2014 (The Water Council, 2015). It is also home to the only school of freshwater sciences in the nation, the UW-Milwaukee School of Freshwater Sciences (SFS), and The Water Council, a nonprofit that brings together the region’s freshwater public, private, and academic sectors to uncover innovative solutions to global water issues.

Building on this unique position and expertise, the UW-Milwaukee SFS and The Water Council created the WATER SYS-STEM: See Yourself Succeeding in STEM program. The program’s goal is to help students transfer to a 4-year STEM degree while gaining both academic and industry experience. The partnership works with three local technical colleges to recruit students interested in water science for transfer to UW-Milwaukee, prepare them for arrival on campus, and support their persistence toward bachelor’s degree completion. Eligible students from Gateway Technical College, Milwaukee Area Technical College, and Waukesha County Technical College must have completed at least 1 year of technical college in a water-related career and must be first generation or from a low-income or underrepresented background. The WATER SYS-STEM program features:

- A paid summer internship in a water-related industry
- Research experiences with SFS research scientists
- Support for UW-Milwaukee transfer students to complete a 4-year degree in STEM
- Professional seminars and workshops
- UW-Milwaukee faculty and industry mentors

Accepted students are paired with a faculty member and an industry mentor. For 10 weeks, the students participate in several research experiences. In the first week, students participate in an experiential component at SFS, which includes expeditions to Lake Michigan and discussions about professional decorum for internships. In the second to ninth weeks, students engage in an 8-week paid internship. Students return to SFS in the tenth week to report on their internships through poster presentations.

The program’s curriculum focuses on repeated hands-on experience in real-world research and exposure to personal and professional development through seminars, discussions, and on-site visits. The program also has a mentorship component in that students from early cohorts can peer mentor students from new cohorts.

In summer 2016, eight business partners from The Water Council offered paid internships: Advanced Waste Services (now COVANTA Environmental Solutions), City of Milwaukee Health Department, City of Racine Health Department, Evoqua Water Technologies, GRAEF, Milwaukee Metropolitan Sewerage District, Sage Water, and Watertech of America, Inc. In addition to internships, The Water Council provides students with mentorships and exposure to diverse technologies—drawing from its diverse network of more than 200 corporate water technology members worldwide.

Students provide weekly reflections and complete evaluations in the middle and at the end of the program. Industry mentors also complete an evaluation at the end of the program. WATER SYS-STEM students have begun matriculating into UW-Milwaukee in the 2016-2017 academic year. In fall 2016, engineering professors began touring the campus with the students to help them adjust. In addition, UW-Milwaukee is working to strengthen internship commitments from companies, start student recruitment at community colleges earlier, seek ways to help under-resourced companies hire interns from the program, and create opportunities for students and companies to network with each other for internships. UW-Milwaukee will work closely with the UW-System office to share learning and assist with replicating the program at campuses throughout the system. Through this project, UW-Milwaukee has learned the importance of initiating internship relationships early to establish continuity from one year to the next and of repeated hands-on experience in real-world research to compliment academic learning and industry internships.

### Website

<http://uwm.edu/freshwater/watersystem>

## WASHINGTON UNIVERSITY IN ST. LOUIS AND THE BOEING COMPANY: ENGINEERING

A critical challenge for educators in STEM, and engineering in particular, is to connect curriculum to a student's personal identity and professional aspiration, to create a real-world and holistic educational experience that provides both depth and breadth of skills (Thoroughman & O'Sullivan, 2016). To address this problem, WUSTL and the University of Missouri-St. Louis (UMSL) have formed a unique partnership called the Joint Undergraduate Engineering Program, which provides accredited engineering education to nontraditional students in the St. Louis region. The program offers bachelor of science degrees in civil, electrical, and mechanical engineering. A major objective of this program is to build a pipeline of diverse, highly skilled engineering talent for the St. Louis region.

Many students begin the program by completing introductory material and scientific foundational course work at either UMSL or a local community college before transitioning into WUSTL, where the upper-division traditional engineering courses are offered. Students originate primarily from seven community colleges: Jefferson College, Southwestern Illinois College, St. Charles Community College, and St. Louis Community College's four campuses, including Florissant Valley, Forest Park, Meramec, and Wildwood. The most difficult transition for students in the program, and for many students nationwide, is from the community college to the upper-division level.

In partnership with Boeing, WUSTL is creating the Boeing Washington University Joint Engineering Leadership Development Program (JELDP), which provides an array of enriched learning opportunities to a special cohort of students, to help them persist with their bachelor's degree and career-readiness in engineering for highly competitive companies such as Boeing. The program offers a pathway into engineering education and careers to students who would have limited or no access to such opportunities, especially women, veterans, and underrepresented minorities. Boeing engages with its academic partners and brings corporate resources, particularly the company's engineering professionals, to support JELDP students through recruitment, transition, preparation, and employment readiness. Although the program will begin while students are at UMSL or a community college, most the activities will occur once the students arrive at WUSTL and begin their engineering course work. The JELDP consists of the following focus areas:

- Part-time intern program
- Capstone projects
- Mentoring
- Scholarships
- Ethics and leadership development

Launched in fall 2015, the JELDP features a new required one-credit seminar that serves as a "first-year" experience for students beginning their engineering coursework on the WUSTL campus to accommodate the different rates at which students might enter the program. The seminar consists of modules that feature topics such as ethics, leadership, and diversity and allows students to engage with a practicing engineer, either the course lecturer or a visiting expert, on those topics. This helps students connect traditional coursework with the real world, developing a professional identity and an understanding of business, ethics, and society through engagement with industry leaders as well as their peers. WUSTL has also incorporated upper-division seminars focused on developing career goals and professional skills in each of three engineering majors (civil, electrical, and mechanical) to deepen the holistic, real-world connections in a student's chosen field of study.

With its corporate resources and the program's academic partners, Boeing supports JELDP students through recruitment, transition, preparation, and employment readiness. In the first year, Boeing made three key contributions: (1) part-time, year-round internships exclusive to students in the program, (2) a mentorship program, a first for the joint engineering program students, and (3) \$50,000 in additional tuition scholarship funds for select students. Boeing also plans to help deliver content in the program's engineering studio courses and the one-credit seminar courses. Upon completion, students may be considered for Boeing's Graduate Residency Program, which allows graduate students the opportunity to work 32 hours a week at Boeing while earning their advanced engineering degree.

The first JELDP cohort is expected to graduate in spring 2018. WUSTL looks forward to building on the success of this program, including expanding its partnership with Boeing, implementing program evaluations, and creating a learning community where students can engage in hands-on projects in a dedicated research space.

### Website

<http://www.umsl.edu/divisions/engineering/>

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## CONCLUSION

This project is beginning to demonstrate the unique role that industry can play in engaging with academic institutions and developing human capital beyond the traditional modes of interaction, such as funding research. It is expected that the project, as it develops, will create a mosaic of effective practices that academia and external partners, such as public-sector agencies and cultural institutions, can adopt or adapt to extend the reach beyond STEM fields. The high-impact practices that each project develops could be applied to virtually any field in the social sciences and arts and humanities disciplines.

Because each project is focused on developing diverse regional workforce capacity in high-need fields, BHEF is also demonstrating the powerful role that industry-academic partnerships can play in community development, job creation, and increased social mobility, particularly in disadvantaged communities. BHEF is now exploring with private foundations the role that data science can play across liberal arts disciplines and is encouraging the kinds of partnerships supported by the NSF grant. Moving forward, the partnerships will focus on evaluation, including measuring the impact of corporate involvement in an undergraduate's postsecondary experience on his or her ability to transfer from community college and persist in STEM disciplines.

Effective business engagement models are critical to increasing undergraduate STEM student persistence. By sharing insights and lessons learned from these partnerships with a broader audience, BHEF hopes to advance policy and practice around community college transfer in STEM, corporate engagement, measurement of partnerships, and efficacy of high-impact practices.

## REFERENCES

- Bowen, W.G., Chingos, M.M., & McPherson, M.S. (2009). *Crossing the finish line*. Princeton: Princeton University Press.
- Burning Glass Technologies. (2014). *Job market intelligence: Report on the growth of cybersecurity jobs*. Retrieved from <http://burning-glass.com/wp-content/uploads/Burning-Glass-Report-on-Cybersecurity-Jobs.pdf>.
- Business-Higher Education Forum (BHEF). (2012). STEM interest among college students: Where they enroll. Retrieved from <http://www.bhef.com/publications/research-briefs.asp>.
- Cabrera, A., Colbeck, C., & Terenzini, P. (2001). Developing performance indicators for assessing classroom teaching practices and student learning: The case of engineering. *Research in Higher Education*, 42, 327–352.
- Carnevale, A., Smith, N., and Melton, M. (2011). STEM. Washington, DC: Georgetown University Center on Education and the Workforce.
- Gartner, Inc. (2012). Gartner says big data creates big jobs: 4.4 million IT jobs globally to support big data by 2015. Retrieved from <http://www.gartner.com/newsroom/id/2207915>.
- Gleason, J., Boykin, K., Johnson, P., Bowen, L., Whitaker, K., Micu, C., Raju, D., & Slappey, C. (2009). Integrated engineering math-based summer bridge program for student retention. *Advances in Engineering Education*, American Society for Engineering Education.
- Gupta, A. (2010). *An investigative analysis of community college transcripts*. Unpublished report. University System of Maryland: Adelphi, MD.
- Hills, J. (1965). Transfer shock: The academic performance of the junior college transfer. *Journal of Experimental Education*, 33, 201–216.
- Horn, L. (2009). *On track to complete? A taxonomy of beginning community college students and their outcomes 3 years after enrolling: 2003–04 through 2006* (NCES 2009-152). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC.
- Institute for Education Statistics. (2009). *Students who study science, technology, engineering, and mathematics (STEM) in postsecondary education*. Washington, DC: U.S. Department of Education.
- Junge, B., Quiñones, C., Kakietek, J., Teodorescu, D., and Marsteller, P. (2010). Promoting undergraduate interest, preparedness, and professional pursuit in the sciences: An outcomes evaluation of the SURE Program at Emory University. *CBE—Life Sciences Education*, 9(2), 119–132.
- Kessels, J., & Kwakman, K. (2007). Interface: Establishing knowledge networks between higher vocational education and businesses. *Higher Education*, 54(5), 689–703.
- Lopatto, D. (2007). Undergraduate research experiences support science career decisions and active learning. *CBE—Life Sciences Education* 6: 297–306.
- Manyika, J., Chui, M., Brown, B., Bughin, J., Dobbs, R., Roxburgh, C., & Byers, A.H. (2011). Big data: The next frontier for innovation, competition, and productivity. McKinsey Global Institute. Available at <http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/big-data-the-next-frontier-for-innovation>.
- National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. (2011). *Expanding underrepresented minority participation: America's science and technology talent at the Crossroads*. Washington, DC: National Academies Press.
- National Center for Education Statistics (NCES). (2007). *Integrated Postsecondary Education Data System (IPEDS) completion survey* [Data file]. Washington, DC: U.S. Department of Education.
- President's Council of Advisors on Science and Technology (PCAST). (2012). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics*. Retrieved from [www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final\\_2-25-12.pdf](http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_2-25-12.pdf).
- Rhine, T.J., Milligan, D.M., & Nelson, L.R. (2000). Alleviating transfer shock: Creating an environment for more successful transfer students. *Community College Journal of Research and Practice*, 24, 443–453.
- Schulte, P., Morrison, J., Woodward, S., Anderson, J., Calandro, T., Howell, S., & Stonefield, L. (2014). *Bridging concern with action: Are U.S. companies prepared for looming water challenges?* Pacific Institute and VOX Global. Retrieved from <http://pacinst.org/app/uploads/2014/04/bridging-concern-with-action.pdf>.
- Stassen, M.L.A. (2003). The impact of varying living-learning community models. *Research in Higher Education*, 44(5), 581–613.
- Summers, M.F., & Hrabowski, F.A. (2006). Preparing minority scientists and engineers. *Science*, 311(5769), 1870–1871.
- The Water Council. (2015). *The center of U.S. water technology innovation*. Retrieved from [http://thewatercouncil.com/wp-content/uploads/TWC\\_AttractionPiece\\_Milwaukee\\_06-09-15\\_v4-Combined-WEB.pdf](http://thewatercouncil.com/wp-content/uploads/TWC_AttractionPiece_Milwaukee_06-09-15_v4-Combined-WEB.pdf).
- Thoroughman, K., & O'Sullivan, J. (2016). High impact practices toward personal and professional identity in introductory and advanced engineering seminar courses. Frontiers in Education Conference. Retrieved from <http://ieeexplore.ieee.org/document/7757713/>.
- Weston, W.D., Way, R.F., & Hutcheson, P. (2003). A cooperative approach to work-based learning and college transitions: University college and high school partnerships.
- Wieman, C.E., Perkins, K., & Gilbert, S. (2010). Transforming science education at large research intensive universities: A case study in progress. *Change*. March–April. Retrieved from <http://www.changemag.org/Archives/Back%20Issues/March-April%202010/transforming-sciencefull.html>.
- World Economic Forum. (2015). *Global risks 2015: 10th edition*. Retrieved from [http://www3.weforum.org/docs/WEF\\_Global\\_Risks\\_2015\\_Report15.pdf](http://www3.weforum.org/docs/WEF_Global_Risks_2015_Report15.pdf).



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2025 M Street NW, Suite 800, Washington, DC 20036

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202.367.1189 / [info@bhef.com](mailto:info@bhef.com) / [www.bhef.com](http://www.bhef.com)

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