

Engagement in Practice: Increasing the Researcher/Inclusion Staff Collaboration Culture for Inspiration of Diverse Learners in Science Technology Engineering and Mathematics (STEM)

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Professor Tonya Peeples joined the department of Chemical and Biochemical Engineering at the University of Iowa in 1995, and in her 20+ years at UI, has served to advance diversity and promote opportunities for all students to pursue education and careers in Science Technology Engineering and Mathematics (STEM). As an individual researcher, an administrator and as a leader in the state and national community, Dr. Peeples has made an impact on improving the STEM pipeline through personal commitment, local partnerships, institutional leadership and effective collaboration. Dr. Peeples has mentored a diverse group of high school, undergraduate and graduate students including three high school students, 64 undergraduate and 13 graduate students, and three postdoctoral fellows in her biochemical engineering laboratories. Five of her current and former doctoral students are underrepresented minority students who are also U. S. citizens, and four are U.S. women. Several of her graduate and undergraduate student researchers have won local, regional and national awards for their work. As the first Associate Dean for Diversity and Outreach for the College of Engineering Dr. Peeples is influencing faculty and institutional leaders. She has implemented search committee training on implicit bias and best practices for recruiting diverse faculty. As a leader in the University Center for Exemplary Mentoring funded by the Alfred P. Sloan Foundation, she trains faculty in mentoring minority students. These activities are "game changers" for CoE which is seeing record enrollment growth and increasing numbers of women and minority students. She has established collaborations to extend a welcoming environment to all students. These efforts leverage Dr. Peeples' experience as a longstanding director of programs and initiatives such as the Ethnic Inclusion Effort for Iowa Engineering and the Multi- Ethnic Engineering and Science Association tutoring program, providing leadership and guidance for the MESA tutoring program since 2006 and establishing policies to ensure that all volunteers are trained and vetted for weekly homework sessions that are executed professionally by student, faculty and community volunteers. She also wrote and administers the University of Iowa, College of Engineering Graduate Assistantships in Areas of National Need (GAANN) training program, funded by the U.S. Department of Education. Peeples is a member of the Advisory Board for the SE Regional STEM Hub and works within that board to increase STEM access and awareness in Eastern Iowa. She has received numerous awards for service to the local state and national STEM communities, including Outstanding Service Award from the American Institute of Chemical Engineers (AIChE) Minority Affairs Committee, the Collegiate Service Award from the UI CoE, the Michael J. Brody Award for Faculty Excellence in Service, the UI Diversity Catalyst Award. In 2015 she was the recipient of the Pioneers of Diversity Award from AIChE. In 2016 she was a fellow of the Executive Leadership in Academic Technology and Engineering (ELATE) program.

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Abstract: Through the establishment of an Outreach, Admissions, Scholarship and Inclusion Services (OASIS) team, the University of Iowa College of Engineering has greatly expanded the activities of faculty, staff and students to benefit the broader community. A key activity of the OASIS group is the connection of researchers, student organizations and academic programs, with programs that engage special populations to expand the reach of the academic community and to advance the broader impacts of research for the benefit of society. Partnerships with institutional programs such as Upward Bound, regional community organizations such as the Boys and Girls Clubs and the municipal partnerships with corporations and school districts have enabled innovative programs. Activities across these partnerships increased 200% over a period of three years. Program assessments align with results reported by the Iowa Governor’s STEM Advisory Council, which has revealed increased STEM learning and STEM interest among a variety of K-12 participants. Efforts to continue the collaboration culture of researchers, diversity professionals, corporations and community organizations continue. The result has been a community of scholars willing to “share their STEM stories” with diverse groups. These outreach and community engagement activities provide “cradle to career” service to students and their mentors; training for teachers who implement new practices in K-12 classes, and access to educational and career opportunities for learners across the state.

Introduction

Industries in the United States (U.S.) are not finding enough people trained in science, technology engineering and mathematics (STEM) fields to fill their growing needs.¹ Jobs in computer science, information technology and selected engineering, science, and mathematics areas are expected to grow faster than those in other sectors through 2024.² To address these challenges, business and professional organizations as well as K-12 and higher education are striving to build STEM capacity in students and teachers across the country. In both the U. S. and abroad, outreach activities run by universities have been demonstrated to make an impact on learners by increasing interest in science, technology engineering and mathematics (STEM).³⁻⁵ These elements of informal education are particularly important in engineering and related fields that are not generally presented as career options to all K-12 students.

A complicating factor is the need not only to have more students and teachers engaging with STEM, but also to broaden the participation of people who have been traditionally marginalized in STEM disciplines. Despite activities over the past 40 years to broaden participation of American women and underrepresented minority students in the science, technology, engineering and mathematics (STEM) workforce, there have been “only modest gains.”¹ In fact, for some groups the numbers are declining.⁶⁻¹³ These discouraging numbers highlight the fact that current efforts to recruit and prepare graduates are missing elements for success. There is an opportunity gap that must be filled to engage diverse learners across the United States (U.S.). In addition to building academic STEM capacity among U.S. students, activities to inspire the next generation of diverse problem solvers are needed.

In June of 2013, the College of Engineering established a new Associate Dean for Diversity and Outreach role to enhance and leverage programs that promote inclusion throughout the science, technology, engineering and mathematics (STEM) pipeline. In supporting these efforts, the College brought together several successful programs including Women in Science and Engineering, Project Lead the Way™ (PLTW), For Inspiration and Recognition of Science and Technology (FIRST®) Tech Challenge along with activities critical to the successful matriculation of students into engineering majors and managed by the Director of Admissions and First Year experience. In addition, a Scholarships and Recruitment Coordinator and a Diversity and K-12 outreach coordinator, as well as an Administrative Assistant were hired. The diversity and outreach team spent the first year sustaining and organizing key efforts. During this year the team engaged in 1) information sharing, 2) community building, and 3) developing a unit identity. Efforts to forge a community of practice resulted in a new name-- the Outreach, Admissions, Scholarships and Inclusion Services (OASIS) unit. The OASIS unit organized activities to enable the College of Engineering to address critical issues of increasing the pathways for students into STEM with the sustainable support systems that enable participants of all ages (pre-K-12, college, graduate students, and beyond) to thrive. In working with the Associate Dean, this group set a goal of providing strategies and support to create a welcoming environment for learning and scholarship within the college and across campus as well as for emerging STEM participants from the K-12 sector. The central questions addressed by the OASIS unit were: *1) What are the most effective ways to increase teacher preparation for encouraging diverse STEM learners; 2) what are ways to engage students from a multitude of perspectives to broaden participation, enhance success and create a welcoming environment for all US students?*

Methods

Since the development of the OASIS unit, programs to reach out and tell the story of STEM in general (and the college of engineering specifically) have included partnerships with businesses, school districts, and community organizations to help increase teacher STEM knowledge and to inspire students of all demographics to explore and enter STEM careers. STEM engagement activities have either been led by the OASIS unit or by students, faculty and community members, with programming support from OASIS team members.

One key factor contributing to the success of this unit launch was the funding from the National Science Foundation Experimental Program to Stimulate Competitive Research (EPSCoR). The Iowa EPSCoR project entitled “*Harnessing Energy Flows from the Biosphere*” brought together the Iowa Regents Institutions (Iowa State University (ISU), The University of Iowa and the University of Northern Iowa (UNI)) along with Iowa 4-year colleges and community colleges to collaborate in research and workforce development. The diversity and outreach members of the UI College of engineering OASIS unit, supported the “broader impacts plank” for the UI EPSCoR efforts in terms of diversity and workforce development.

A second factor that contributed to the success of the unit launch was Iowa Governor's STEM advisory council.¹⁴ In 2011, the Iowa governor established a STEM advisory council to help develop the workforce within the state. Led by the lieutenant governor, a group of leaders in higher education, business, Pre-K through 12 educators, along with state and local government officials comprise a council of advisors to stimulate interest and build capacity in STEM across the state. A signature effort of the council is to proliferate evidence based STEM programs across the state. In this effort, the state was divided into six regions that implemented programs certified for "scale-up" and supported with small grants from the STEM council.

With UI College of Engineering initiatives, EPSCoR broader impacts activities, and state scale-up efforts, the OASIS programs implemented expanded outreach and began to assess the impact of collaborative engagement on outcomes for STEM teachers and learners. EPSCoR supported the hiring of a "diversity/implementation" coach to enhance strategies for inclusion of diverse students in K-12 pre engineering education programs such as PLTW. In addition, OASIS staff members supported faculty as they developed broader impacts efforts for research proposals. In these endeavors, EPSCoR funds supported a diversity and outreach graduate assistant, a science education PhD student to help with program development and evaluation. In terms of expanding the impact of the college, outreach and community engagement provided *cradle to career* service to students and their mentors; resulted in training teachers who implement new practices in their classes, and helped provide access to educational and career opportunities for people across the state.

Internally, efforts to produce lasting cultural shifts in inclusion on the college campus were undertaken. These efforts included: i) sharing best practices in implicit bias training for faculty searches; ii) fostering collaborations between diversity/inclusion leaders with researchers to design and implement broader impacts activities; and iii) institutionalizing collaboration with evaluation and assessment experts.

Through the efforts of the STEM council the engineering outreach programs are able to benefit from efforts of a regents university consortium of evaluation programs. These include ISU's Research Institute for Studies in Education (RISE), UI's Iowa Testing Program, and UNI's Center for Social and Behavioral Research (CSBR).¹⁵ CSBR provided guidance and training on assessment logic models and instrument development. EPSCoR provided a template for tracking participation of a variety of constituents in engagement and outreach. Programming and evaluation projects engaging youth with STEM were presented to the UI institutional review board for a Human Subjects Research Determination (HSRD). Assessment activities of the projects were approved for use in program improvement and were not undertaken as research.

Nationally Affiliated Programs

Since the OASIS unit was formed, outreach team members have engaged the Governor's STEM initiatives. As a result, the large nationally recognized outreach activities, PLTW and FIRST® Tech Challenge (FTC), had the largest reach in the state (See Figure 1). Both FTC and PLTW were included as part of the Governor's STEM scale-up program, which facilitated growth.

The UI College of Engineering serves as the affiliate partner, leading statewide FTC activities in collaboration with corporate partner Rockwell Collins. FTC was originally designated as a "STEM Scale-Up" program through the Iowa Governor's STEM Advisory Council during 2014-2015. As a scale-up provider, the FTC manager provided professional development to teachers and community groups in forming new teams. As affiliate partner FTC facilitated leagues and competitions throughout the state. In 2013-2014, 58 Iowa counties had FTC teams with over 150 students participating (90% between ages 14-18, 88% in grades 9-12, 24% of students were female, 19% of students were ethnic minorities). By 2015-16 FTC had grown to 192 teams across the state in 63 Iowa counties with more than 1,500 Iowa middle and high school students participating. Of these students, 40% were female, 16% were underrepresented minority and 58% were from rural areas.

In 2013 PLTW included 220 schools and 15 community college centers in Iowa, managed by co-affiliate Colleges of Engineering at The University of Iowa and Iowa State University. PLTW leaders provide professional development to teachers, and visits to help schools and community colleges implement college credit for high school participants. PLTW had several courses that were scale-ups across the state including: "Principles of Engineering", "PLTW Gateway", "PLTW Launch" and "PLTW Computer Science." In terms of participation, 18,945 Iowa students enrolled in PLTW classes (9048 high school, 9447 middle school) and 83 counties had PLTW programs in 2013-14. By 2015-16 PLTW had grown to serve 24,060 Iowa students in classes (7,709 high school and 15,230 middle school).

Signature Local Programs

The hiring of the Director for Diversity Programs and K-12 Outreach, enabled the college to reinstate pre-engineering camp programs. Pre-Engineering Camps strive to develop and enhance participants' problem solving and critical thinking skills, provide an opportunity for creative expression, and foster students' curiosity about science and technology through fun-filled engineering projects. Students are encouraged to use what they know about science, math and engineering to explore this new challenge. Camps, based primarily on the Lego Robotics platform are hands-on, project-based activities. Through EPSCoR activities instruments were developed to assess the impact of camps on participants. The evaluation of camp provided an opportunity for a STEM undergraduate major to learn about assessment while providing data for the program.¹⁶

The primary assessment question for the camps was: "*Would a one-week course increase the interest and knowledge of STEM (Science, Technology, Engineering, and Math) in K-12 students?*" Pre and post surveys tested knowledge of machine components, for Lego Learners and attitudes about science and math for Lego Robotics and Tetrix robotics. Camp activities increased student knowledge significantly for the elementary age students and showed a slight increase in favorable attitudes towards science for Tetrix and Lego Robotics campers. Participant data showed that as camps moved from first grade level to high school the percentage of participants who were girls decreased. Even with lower percentages of female students, pre-engineering camp opportunities were increased 200% from 2013 to 2016, including increases in the total number of children and the total number of children who were women increased.

The need for targeted programs for women and girls as well as for underrepresented minority groups continues to drive faculty, staff, and students to develop programming targeted to these specific groups. To support such community efforts, the OASIS team collaborates to promote diversity in all of our broader impacts programs. Diversity implementation and collaboration with PLTW and FIRST has included both teacher and coach training and sharing these opportunities students from groups which are traditionally underrepresented in STEM. OASIS staff members have collaborated with diversity student organizations including the Society of Hispanic Professional Engineers (SHPE), the National Society of Black Engineers (NSBE), and the National Organization for the Professional Advancement of Black Chemists and Chemical Engineers (NOBCChE) as well as Women in Science and Engineering (WiSE) Ambassadors and the Society of Women Engineers (SWE) to reach diverse students. The most notable sustained collaboration has been with the Upward Bound (UB) Program. Beyond serving 120 students in Muscatine, West Liberty and Columbus Junction, IA, OASIS team members have expanded to work with the UB group serving students in Waterloo, IA (with a higher African-American population).

In all of the outreach activities, OASIS team members have strived to develop and implement, low cost, mobile and replicable programs to increase interest of students in STEM fields. One example program is the Wind STEM Talent Expansion Program (WindSTEP).¹⁷ Originally implemented by faculty and staff at the University of Minnesota Morris as outreach to Native American students, WindSTEP introduces students in geographic information systems for mapping of wind turbines. Working through Iowa EPSCoR, the OASIS group collaborated with the UI Center for Diversity and Enrichment to implement this program with Black Youth Achieving Excellence (BYAE) and with Iowa First Nations (IFN) in 2014 and 2015. IFN provides Native American students the opportunity to live on campus and experience the university setting, explore majors, and gain an appreciation for the variety of opportunities on the UI campus and higher education in general. High school students in good standing who are entering the 9th, 10th, 11th or 12th grade participated in the WindSTEP curriculum.

As OASIS implemented WindSTEP with BYAE, the evaluation was centered on the question: *Would a one-week summer program in wind energy increase STEM interest in under-represented youth?* The BYAE worked to engage 8th and 9th grade African American males from the Iowa City/Cedar Rapids area challenging them to develop a model wind energy turbine system for Johnson County. The 1-week commuter camp took place on the UI campus. Activities of the program included: pre-test and post-test to gauge knowledge and interest; field trips to demonstrate green energy; professional STEM presenters; ArcGIS® software training to demonstrate geographical constraints. Field trips associated with the program included visits to the Iowa Flood Center, to Iowa Hydraulics Modules and to the Kirkwood Community College Wind Turbine. The students worked in pairs and had to answer the question: *Which geographical factors are most important when placing a wind turbine?* Students presented the results of their mapping exercise to their peers and mentors. Comparison of pre and post STEM interest surveys were used to reveal the program impact, and provided guidance for further improvement of the program.¹⁷

In addition to stand alone programs such as WIND Step, OASIS supports collaborative student and faculty engaged outreach and STEM festivals. Signature programs include the Multi-Ethnic Engineering and Science Association (MESA) tutoring program, the *Noche de Ciencias* programs supported by the SHPE student chapter, and the *Black Girls Do Science program* initiated through the NSBE student chapter in collaboration with Iowa EPSCoR. These programs have been sustained through 2017 and draw a broad number of K-12 participants.

Community Partnerships

Continuing STEM outreach and broadening participation efforts have resulted in community partnership programs to deliver STEM activities. A new initiative to engage the Marshalltown IA community was conducted in 2015. The CoE hosted pre-engineering camps for the community serving 120 students in Marshalltown. This effort is in collaboration with Marshalltown Schools, community and business leaders, and the ISU extension. These camps expanded in 2016 to include the Meskwaki nation and with the Boys and Girls clubs of Cedar Rapids to engage the robot design curriculum and to engage diverse learners.

Outside of engineering collaborators include organizations such as CoderDojo, Iowa Tech Chicks, The Neighborhood Centers of Johnson County, the Minority Association of Premedical Students, Delta Sigma Theta and Alpha Kappa Alpha sororities and Delta Upsilon fraternity. This coalition of outreach providers helps to encourage URM students to consider STEM opportunities.

Collaboration in community continues and has increased the visibility and reach of the UI College of engineering at state, regional and national levels touching the lives of thousands of K-16 students, educator, parents and other members of public audiences.

Creating a Welcoming Collegiate Environment

The UI College of engineering has been experiencing record enrollment growth and an increase in the percentages of women and underrepresented minorities in the undergraduate student body. The growth is encouraging and supports the idea that STEM outreach benefits the college in increasing the pipeline. A preliminary measure of this was a first-year student survey distributed by the Director of Admissions and First-year Experience. The responding students demonstrated that 35% of the first-year students participated in PLTW and 7% of student participated in FTC prior to entering college. The college also attributes this growth to the commitment to create a culture of welcome.

In addition to outreach to ethnic minorities and women, OASIS team members have participated in college fairs at the Iowa Governor's Conference for LGBT youth in Des Moines. This enabled UI College of engineering personnel to engage students prior to starting college. Making note of his interest, we started by hosting some reception for LGBT students to give students who identify with this community an opportunity to form community and support. This grew into connections with STEM students across campus and our first LGBT STEM student org on campus which is connected to the national organization Out in STEM (O-STEM).

As the university is considering how to better serve female students on campus and also to connect to the girls and women encountered in the community, the college of engineering developed a new leadership structure for Women in Science and Engineering. The college welcomed two part time co-directors. One co-director works with K-12 students and helps K-12 teachers with strategies to bring girls into STEM programs. The second co-director supports on campus programs for current students who identify as female.

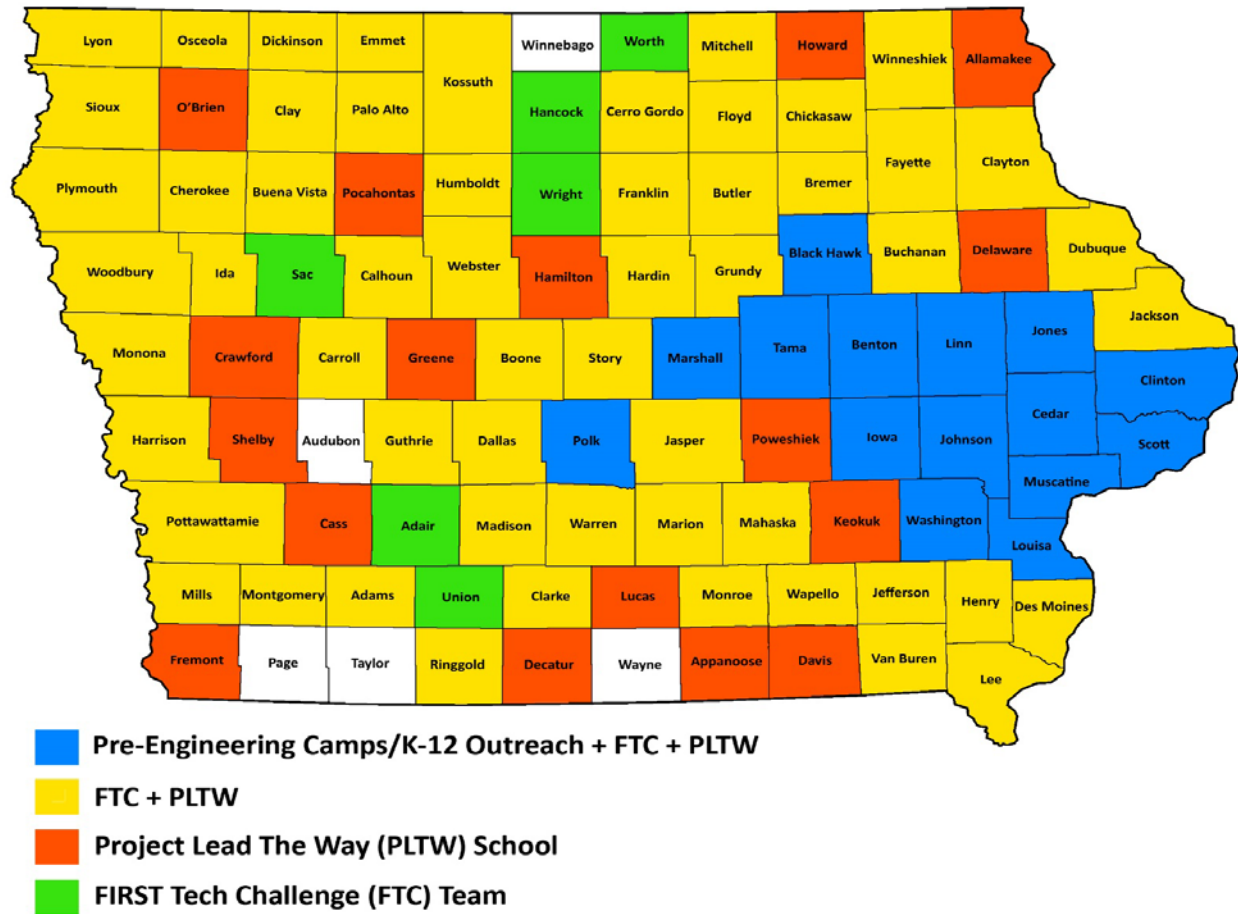


Figure 1 Map of Outreach Programs across Iowa Counties. The University of Iowa, College of Engineering Outreach Map 2010-2016

Integration of Diversity and Outreach with Faculty Development

In further creating a welcoming environment for diverse learners, activities of the OASIS team with the Associate Dean have been to build faculty skills at recruiting diverse colleagues, at mentoring diverse graduate and undergraduate students, and at developing compelling broader impacts proposals. Support of Iowa EPSCoR enabled the initiation of targeted activities to

address these issues. For faculty hiring, “best practices” in faculty recruitment were engaged to address implicit bias based on the University of Washington ADVANCE¹⁹, ISU Advance and the Education Recruitment Consortium in collaboration with the Office of the vice president for research and the office of the Provost.

In facilitating best practices in mentoring, diversity and outreach efforts were enriched by the Sloan Foundation University Center for Exemplary Mentoring Award. The Sloan UCEM provided a great infrastructure for faculty collaboration and community building for students who are underrepresented ethnic/racial minorities. OASIS as also leveraged collaboration with the Iowa Illinois Nebraska STEM Partnership in Research and Education (IINSPiRE) program which is an NSF Louis Stokes-Alliance for Minority Participation (LSAMP). IINSPiRE LSAMP engages Iowa Regents institutions, community college and 4-year college programs to improve STEM outcomes for underrepresented minority college students. OASIS has managed the EPSCoR summer internship program at UI which has served these students. College student interns including underrepresented minority (URM) community college students were matched into STEM research labs in general and EPSCoR labs in particular.

Finally, the Diversity and Outreach unit took on the intention of connecting faculty with outreach providers in ways that support early career faculty success. These efforts lead to synergies as faculty identify their compelling interest to engaging society in their work efforts. One example, a female assistant professor noted that the number of women in the pre- engineering camps was low and decided to develop a photonics camp for girls with the support of WiSE and K-12 outreach. She was able to pilot the camp, connect with evaluators in the Iowa Center for Evaluation and Assessment and write this activity into her NSF CAREER proposal.

Over the first years of the OASIS unit, efforts to support faculty development have resulted in processes to connect outreach to research proposals with 10 to 15 broader impacts projects citing OASIS support at any given time, to build mentoring capacity for welcoming diverse learners, and to facilitate training for hiring diverse colleagues.

Sustaining Diversity and Outreach Efforts and Practices Beyond Federal Support

Based on data collection mechanisms developed through Iowa EPSCoR, for every program that OASIS coordinates or supports, data are collected on gender, ethnicity, K-12, College, teacher, student or other community member. For specific K-12 programs data are collected on socioeconomic status, first generation status, veteran or child of veteran status for accountability to diverse institutional and private funding groups and for general assessment. In addition to participant data, pre- and post assessments designed to gauge participant learning, and interest in STEM are designed for each program.

In 2015-2016 OASIS activities over 146,000 people interacted with College of Engineering Diversity and Outreach programs. Outreach efforts have reached 94 of the 99 Iowa Counties. These activities continue to support efforts to shape the engineering incoming student body. Although obtaining direct data is challenging, the college has been experiencing the entrance of a large, high ability (by standard measures), and stably diverse groups of students.

Because the state of Iowa is in a STEM-rich climate, activities to assess the specific impact of one program are challenges. An increasing number of schools and teachers have access to multiple scale-up programs designed to grow STEM interest. Results from the independent evaluation of STEM council efforts show that students who participate in scale-up programs had greater interest in studying STEM subjects and in pursuing STEM careers than non-participants. Students who participated in Scale-Up programs also demonstrated higher scores on Iowa Assessments in math and science (an average of 6 percentage points higher) than their peers.

In addition to the systems for tracking participation are practices compliance with youth programs policies, for execution of campus visits and for collaboration and shared agreements for grant writing and broader impacts development.

The OASIS unit has expanded collaborations and connected outreach organizations and groups with research faculty. Summer camps have been scaled up and expanded to initiate work in local communities with support from Iowa business. OASIS team members along with STEM faculty have increased collaborations with the research scholars in the Undergraduate and PreK-12 education as well as with professional evaluators for proposal development. This will ultimately lead to improved evaluation of the broader impacts of STEM research on society. The assessments of diversity and outreach are still in the developing stage. The original larger questions have been refined in each project and activity to assess specific interventions. Continued efforts to coordinate with on-campus groups will also help the group expand the evidence base for effective engagement in support of collegiate, institutional and societal priorities.

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