

# The Pre-Engineering Education Collaboratives

## Outcomes and Recommendations



by Paul Boyer

# Introduction

The Pre-Engineering Education Collaboratives (PEEC) is a National Science Foundation-funded initiative supporting development of pre-engineering degree programs within tribally controlled and other Native-serving colleges. PEEC is also helping students from these institutions continue their education at mainstream universities where they can earn four-year and graduate engineering degrees.

Ultimately, the goal of the \$15 million initiative is to increase the number of American Indians with the skills needed to develop reservations and Native communities.

Funded in 2010, PEEC represents a unique partnership between more than a dozen Native-serving colleges and several public universities with strong engineering degree programs. Working together through regional “collaboratives,” the project has three key goals:

- First, PEEC is working to develop new and expanded two-year pre-engineering degree programs within tribal colleges, as well as community colleges within the University of Hawaii system.
- Second, the initiative works to promote the successful transfer of Indian and Native students into engineering degree programs offered by the mainstream university partners.
- Third, the project is also developing approaches to teaching and learning that promote academic success of American Indian and Native Hawaiian students within tribal, Native-serving, and mainstream institutions.

*Cover: University of Hawaii PEEC students building a payload that will be launched on a rocket and able to perform telemetry throughout the entire flight.*

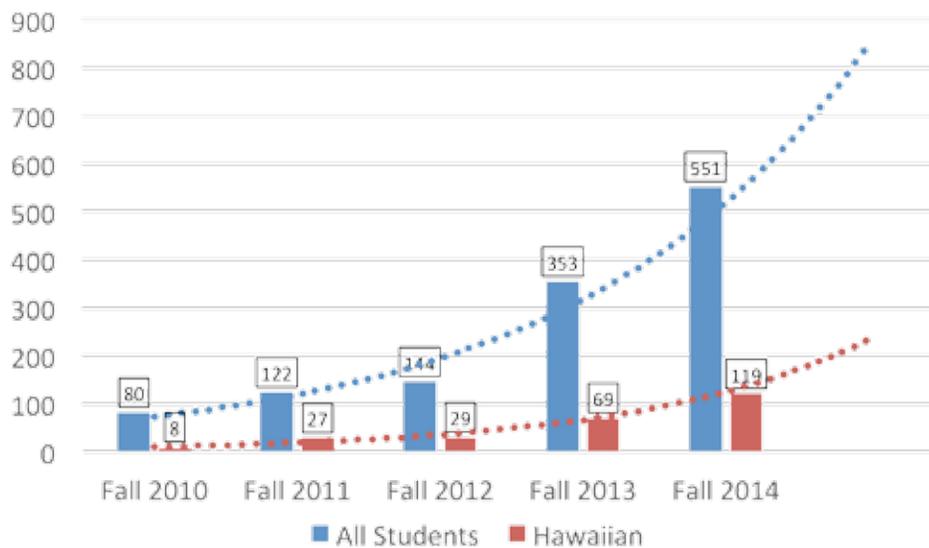
*Below: South Dakota PEEC students in the field with Oglala Lakota College staff member Requaw West (shown with clipboard), radio tagging ornate box turtles on the Pine Ridge Reservation near Scenic, South Dakota.*



*Above: University summer bridge program students learning about agriculture in the field within Hawaii.*

As PEEC grants enter their fifth and final year, the National Science Foundation funded a networking conference in December 2014 to discuss the progress and outcomes of this initiative. Hosted by Sisseton Wahpeton College, participants included faculty, staff, and administrators from all seventeen colleges and universities funded through PEEC, as well as representatives from the National Science Foundation and several outside presenters. Through discussions and presentations, participants reflected on their successes and the challenges they faced as they worked to develop pre-engineering programs, recruit students, and support retention of Indian and Native Hawaiian students.

From this gathering, it is clear that PEEC has fulfilled many of the National Science Foundation's goals and, additionally, that new approaches to instruction are, in fact, being developed. At the same time, workshop participants also discussed the challenges of recruiting and supporting the academic success of students, especially those from isolated and impoverished reservations. The goal of this publication is to summarize the themes discussed at this gathering of educators, highlight their findings, and look to the future.



*The NSF PEEC project has contributed to accelerated growth in pre-engineering enrollment of both Native Hawaiian and other students in Hawaii. ~22% (119 NH students) of all students (551 total students) transferring to the University of Hawaii College of Engineering in 2014 were Native Hawaiian. Prior to the NSF PEEC the percentage of Native Hawaiian students enrolled in pre-engineering was less than 10% (8 NH student).*

# The Origins of the Pre-Engineering Education Collaboratives

*Below: Donna Riley, program director/cluster leader, Division of Engineering Education and Centers, National Science Foundation.*

*Bottom: Lori Alfson, pre-engineering instructor, Fort Berthold Community College; Koreen Ressler, vice president of academics, Sitting Bull College; Lane Azure, vice president for academic affairs, Cankdeska Cikana Community College; and Michael Parker, engineering/math instructor, Cankdeska Cikana Community College.*

At the start of the workshop, participants were reminded of the program's origins. Although the first awards were made in 2010, PEEC has its roots in several earlier NSF-funded programs, according to Dr. Carty Monette, past president of Turtle Mountain Community College, who served as a workshop facilitator.

In the mid 1990's the National Science Foundation funded a major initiative to strengthen math and science education at the K-12 level in regions of high poverty, including large portions of Indian Country. Tribal colleges contributed to this program by providing support and academic enrichment services to schools serving Indian students across the northern plains and southwest. It was, Monette noted, an opportunity for many tribal colleges to receive their first NSF grants. Additionally, Foundation leaders were introduced to the important work of tribal colleges.

This relationship deepened in 2001 when the National Science Foundation created a program specifically focused on supporting the tribal colleges, called the Tribal Colleges and Universities Program (TCUP). Working to help tribal colleges develop strong undergraduate STEM programs, TCUP has made awards to most



of the nation's nearly three-dozen Indian and Native-serving colleges eligible for funding. It is widely viewed as the largest and most important source of funding for STEM capacity building within the tribal colleges.

These programs nurtured a strong relationship between the National Science Foundation and Native-serving colleges. TCUP program officer Dr. Jody Chase has “become our champion,” Monette said, and noted that NSF administrators have made it a priority to visit tribal colleges and learn as much as possible about the communities they serve.

Tribal college leaders first discussed the need for engineering degree programs in 2005. This was, at the time, a bold and ambitious vision. Most tribal colleges supported only a limited range of lower division math and science courses; development of two-year engineering degrees would require a significant expansion of the STEM curriculum, especially in the smaller and most isolated tribal colleges.

By 2009, consensus emerged that the National Science Foundation should focus on supporting development of pre-engineering programs and that the growth of these programs could be aided through regional partnerships with mainstream universities. Additionally, NSF staff and tribal college faculty involved in the planning phase were also eager to test innovative approaches to instruction. For example, there was interest in promoting retention through student cohorts and making difficult gatekeeper courses more accessible through self-paced learning modules, among other strategies.

With this structure and these strategies in mind, the program was jointly developed and funded by the National Science Foundation's Tribal Colleges and Universities Program and the Directorate for Engineering.

*Hannan LaGarry, co-chair of Oglala Lakota College's Math, Science and Technology Department.*



# The Strength of Culture; The Realities of Poverty

From the outset, project leaders understood that Indian and Native students face multiple barriers as they pursue college degrees and that completion of an engineering degree is a particularly arduous undertaking. Poverty, geographic isolation, and poor academic preparation conspire to limited interest in STEM careers and can discourage all but the most determined Native scholars. Every pre-engineering collaborative had to recognize and respond to these hurdles.

First, PEEC leaders knew that student recruitment would be difficult. While there is a need for engineers in reservations, few Indian or Native students choose this academic path simply because they have not met any engineers and have not learned about career opportunities in engineering fields. Workshop participant Hannan LaGarry, a member of the science faculty at Oglala Lakota College on the Pine Ridge Reservation of South Dakota, stated that there is no “pent-up demand” for engineering degrees on his reservation. The first task, he and others implied, was to introduce the discipline, explain what engineers do, and argue for its value to tribal communities. Interest must be created before students will enroll.

This is a time-consuming process. While enrollment in STEM-related degrees is expanding rapidly at tribal colleges, many students still feel that math and the sciences are difficult and “non-Indian” disciplines. Dr. Suzette Burckhard, professor of water resources and environmental engineering at South Dakota State University,

argued that this sense of isolation is reinforced by the “excluding culture of engineering,” which tends to celebrate its rigorous, technical, and jargon-rich curriculum. Too often, Indian and Native students find this intimidating and impenetrable.

Additionally, limited interest in STEM reflects poor academic



*Top: Kimberlynn Cameron was the first woman from the Standing Rock Reservation to graduate with an engineering degree. She earned a BS degree in geological engineering in 2014 from the South Dakota School of Mines and Technology.*

*Bottom: University of Hawaii PEEC students doing research on the best medium for cultivation of native plants with medicinal properties.*

preparation within K–12 schools that serve Indian and Native students. Several workshop participants noted that most tribal college students require remedial instruction in math before they are ready to complete introductory level college courses. In addition, far too many high schools fail to provide an adequate foundation in the sciences. The gap between what incoming students know and what they need to learn in a STEM degree program is very wide, often requiring several additional semesters of study.

Geographic isolation was also acknowledged as a barrier in the development of pre-engineering degrees, especially as the smallest and most isolated colleges struggled to recruit faculty. Dr. Koreen Ressler, vice president for academics at Sitting Bull College, which is located on the most rural of North Dakota's five reservations, reported that her institution devoted eighteen months to recruitment of a single faculty member for their pre-engineering program. Low pay, lack of tenure, and limited contact with professional peers are among the factors that thwart efforts by many tribal colleges to recruit instructors in STEM fields.

While much of the discussion focused on these and other barriers, participants repeatedly emphasized that students also bring strengths. Several tribal college faculty noted, for example, that their students have a strong desire serve their tribe and make life better for their people. When students see how engineering can be used to build affordable homes, provide clean water, repair infrastructure, create jobs, and prevent destruction to their homelands, interest is more easily piqued.

*Top: Flooding on the Fort Peck Reservation in eastern Montana in 2012 vividly illustrated the need for engineering expertise. This particular photo was used in an NDSU engineering course to illustrate how "engineering is more than the simple application of formulas to a situation, and also how engineering can be used to improve lives," according to Dr. Robert Pieri.*

*Middle: Dr. Cody Martin, an instructor at the College of Menominee Nation, demonstrating instruments and experiments in Engineering Physics.*

*Bottom: Louise Pagotto, vice chancellor, UH-Kapi'olani; Mark Hoffman, assistant professor, electronic and computer engineering technology, UH-Maui; Hannah Keikiokanani Aldridge, PEEC pre-engineering specialist, UH-Leeward; Tasha Kawamata-Ryan, PEEC retention coordinator, UH-Manoa; Herve Collin, assistant professor, math and science, UH-Kapi'olani; and Heather Stroupe, assessment specialist, UH-Windward.*

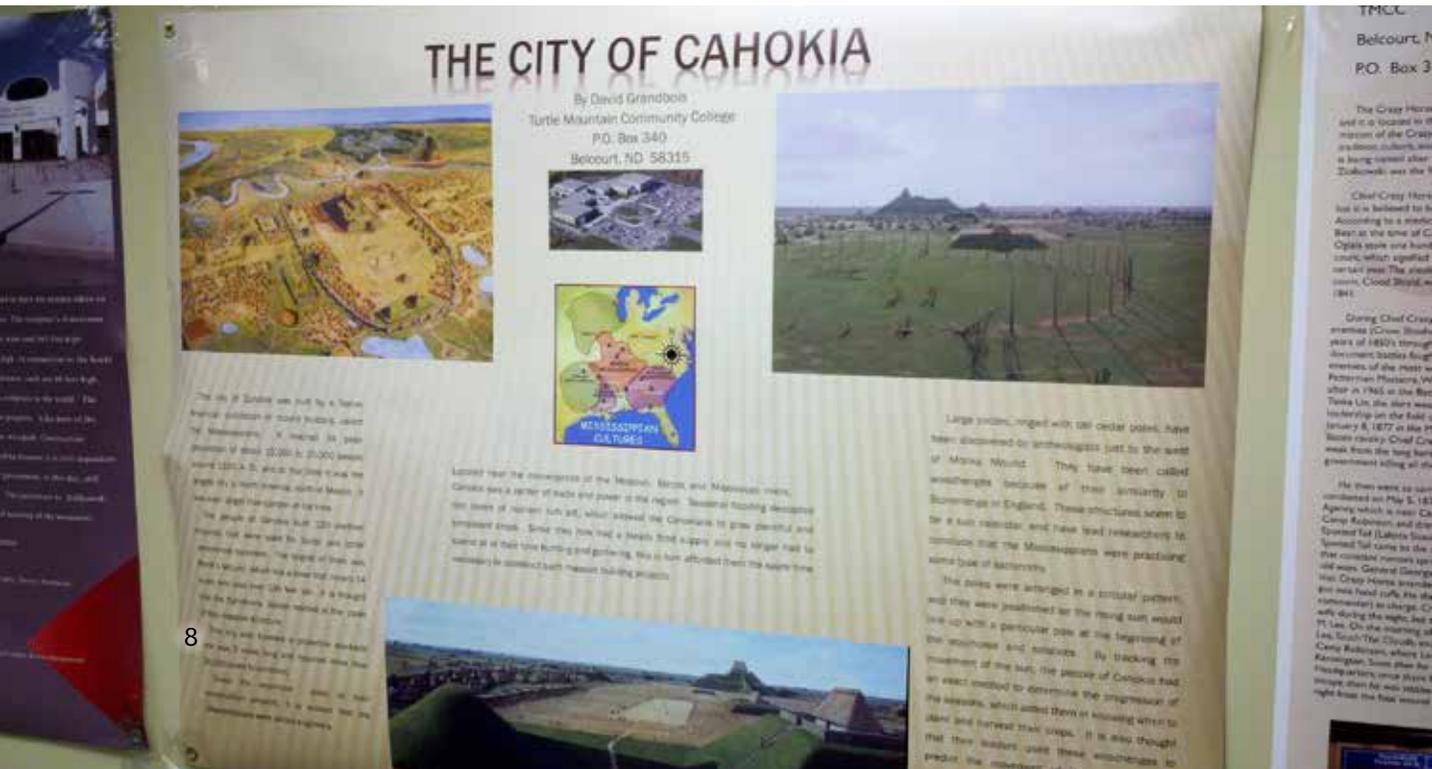


# Accomplishments

Over the past five years, all tribal and Native-serving colleges participating in the Pre-Engineering Education Collaboratives have worked to overcome barriers, build on their strengths and, ultimately, develop opportunities for students to pursue engineering degrees. Significant progress has been made within each of the collaboratives. Specifically,

- All tribal and Native-serving colleges have developed and now offer complete pre-engineering degree programs.
- All tribal and Native-serving colleges have developed agreements with mainstream universities to assure the seamless transfer of students into four-year degree programs.
- All tribal and Native-serving colleges have enrolled students into their pre-engineering programs and most have had students continue their studies at mainstream universities. Numbers range from a small handful at the smallest tribal colleges to over 120 Native Hawaiian pre-engineering/engineering students within the University of Hawaii Community College system.
- All mainstream university partners assert that they have added or improved the quality and variety of support services offered to Native students enrolled in their institutions. Several reported that engineering faculty have a better appreciation for the needs and strengths of Indian students.

*Academic work often incorporates cultural issues and concerns. This poster was completed by a Turtle Mountain Community College student for an Introduction to Engineering with CADD course taught by Dr. Robert Pieri at NDSU over the university's IVN network. The student's project documents the role of engineering in traditional Native societies.*



- All mainstream university partners have developed or strengthened their relationships with tribal colleges through faculty exchanges, summer research programs, or distance learning courses.

To explain these successes, participants from each of the four collaboratives provided in-depth discussion of their programs, focusing on innovative approaches to recruitment, retention, and instruction. Their stories reveal the diversity and creativity of the various collaborations. However, four common themes emerged from the two-day conversation:

### Summer Academies and Other Outreach Programs Promote Interest and Awareness in Engineering

When recruiting students from tribal and Native communities, it's not enough to have an attractive website or colorful brochures. Instead, colleges need to be advocates for engineering as a profession.

For most collaboratives, this effort focused on reaching out to high school students by offering creative, project-based enrichment programs. Within the Wisconsin collaborative's "Explore Engineering" summer program, for example, students from in and around the Menominee reservation worked with tribal colleges and University of Wisconsin-Platteville faculty on projects that related to physics, mechanical engineering, and sustainable design. Project leaders noted that participating students demonstrated greater academic success in STEM courses.

Outreach and enrichment programs also included visits to university career fairs and on-reservation Sunday "science academies" for students and their families. These programs are part of a long term strategy to engage student interest, overcome limited STEM instruction in many K-12 schools, and build relationships between reservation schools and institutions of higher learning. According to Dr. Robert Pieri, a professor of mechanical engineering at North Dakota State University, "This interest would transition into program support as more understanding about the program and its opportunities became evident."



*Tours of industries located on or near reservations introduced students to career opportunities. Here, Fort Berthold Community College students are touring the Embridge tanker loading facility in Berthold, ND.*



*North Dakota State University student Austin Allard, from the Turtle Mountain Reservation, teaching a math review session to one of the first summer PEEC camps at North Dakota State University. He is currently pursuing a Ph.D in civil engineering in Texas.*

## Distance Learning Overcomes Geographic Isolation

Most tribal colleges focused on building capacity by adding courses, upgrading science facilities, and hiring faculty within their own institutions. However, two collaboratives are also sharing courses via distance learning in cooperation with the mainstream university partner.

This focus on Internet-based instruction was central the Hawai'i Pre-Engineering Education Collaborative. Here, online classes provide easy access to STEM courses and avoid unnecessary duplication of instruction among the various community colleges. In the Hawai'i PEEC, program leaders reported that 85 percent of pre-engineering courses are now online; only lab courses are exclusively classroom based.

The North Dakota collaborative also saw the value of sharing courses through distance instruction. Here, extreme geographic isolation, compounded by harsh winter weather, makes travel difficult for much of the year. In addition, several of the smaller tribal colleges do not yet have sufficient student enrollment to support a complete, free-standing pre-engineering program without incurring disproportionate program costs. Through existing distance delivery technology, even the smallest institutions are now able to provide members of their community with the academic resources of much larger institutions.

## Place-Based Learning Makes Engineering Relevant and “Real”

Traditional engineering degree programs focus on textbook-based classroom instruction during the first years of study. Only later are students given opportunities to leave campus and put their skills to use. In contrast, several tribal colleges take the opposite approach. They encourage students to work on real-world engineering problems even during their first semester of study. The goal, project leaders explained, is to engage student interest and show how engineering can be used to build stronger Native communities and tribal nations.

*College of Menominee Nation faculty member Dr. Lisa Bosman demonstrating the use of solar energy performance, efficiency, and valuation in Industrial Engineering.*



This philosophy shapes much of Oglala Lakota College's work on the Pine Ridge Reservation. In that community, students are encouraged to actively work on projects that serve the needs of the reservation. One group, for example, worked on restoring a World War II memorial, learning how to stabilize the monument's foundation and repair the crumbling stonework.

Similarly, Oglala Lakota College students are also participating in development of a unique tribally-controlled community housing project that focuses on low cost and environmentally sustainable construction—including use of solar heating and low water use systems. These and similar projects at other colleges reflect tribal values, support community development, and allow students to learn key engineering concepts through meaningful work.

## Tutoring, Summer Programs, and Peer Support Enhance Retention

All of the pre-engineering collaboratives offer tutoring, academic enrichment, and culturally-focused activities. These programs, often developed and hosted by mainstream university partners, play a key role in promoting retention and assuring a successful transition to four-year colleges and universities.

Summer enrichment programs are an integral part of the North Dakota Pre-Engineering Education Collaborative. There, students from all four tribal colleges have the opportunity to strengthen core academic skills, earn credit, and build collegial relationships during Summer Sessions held each year at North Dakota State University. Blending rigorous academic work with field experiences and cultural events, students are also able to experience life on a large university

*Top: Thunder Valley Sustainable Community Design Charrette, held July 2014. Students and members of the Pine Ridge Reservation discussed strategies for community development, focusing on sustainable design. More than a dozen PEEC students participated.*

*Bottom: Oglala Lakota College student and NSF PEEC participant Lilly Sanovia (left), NSF PEEC CoPI and research mentor Dr. Hannan LaGarry (center), and Chadron State College collaborator and MS candidate Steve Welch (right) in the field at the Whiteclay Fault in southern Shannon County, SD in the summer of 2013. Lilly was awarded an NSF Graduate Research Fellowship in 2014 and currently attends SDSU as an MS student in geology.*



campus, making their eventual transition to a four-year degree program less intimidating.

In Hawai'i, summer enrichment programs are also a key component of their pre-engineering collaborative. While online courses allow students to complete much of their coursework independently, Summer Engineering Experiences (SEE) held at various campuses within the university system help reinforce academic concepts (especially in math) and—of equal importance—help build a sense of community among students and with faculty. “The whole idea is to get [students] excited about engineering and raise their math level,” said Dr. Herve Collin, assistant professor of math and science from Kapi'olani Community College.

Students participating in the University of Hawai'i's Summer Bridge program take part in engineering projects ranging from robotics to guitar-building. They also learn about Hawaiian cultural traditions, and complete intensive math instruction through a self-paced program known as Math Emporium. Working independently, but with strong tutoring support, Math Emporium allows students to skip over familiar material and spend more time mastering difficult concepts. Modules allow students to work methodically without feeling overwhelmed.

Finally, several institutions also recognize that Indian students face financial constraints as they pursue engineering degrees. Full time study often means a loss of income, exacerbating the poverty of reservation life. For this reason, several colleges, including College of Menominee Nation, provide stipends to

students who are enrolled and making satisfactory progress toward their degrees. This is a pragmatic response to the problem of affordability in higher education, one that is tailored to the special needs of Indian and Native communities.

*University of Hawaii PEEC students working in the Kalo patch (Lo'i) and restoring the land.*



# PEEC: Seventeen Colleges and Universities; Four Collaboratives

The Pre-Engineering Education Collaboratives involves seventeen institutions. They include six tribally controlled colleges, which are institutions of higher learning founded by American Indians, chartered by tribes and, in most cases, located on reservations. Also included in PEEC are five community colleges within the University of Hawai'i system. These public two-year institutions also have a mandate to serve the state's Native Hawaiian population. Finally, collaboratives include six mainstream university partners that offer four-year and graduate degrees in engineering.

Organized regionally, each "collaborative" includes at least one Native-serving college and at least one mainstream partner. The four collaboratives include:

## North Dakota

Cankdeska Cikana Community College  
Fort Berthold Community College  
Turtle Mountain Community College  
Sitting Bull College  
North Dakota State University

## South Dakota

Oglala Lakota College  
South Dakota State University  
South Dakota School of Mines and Technology

## Hawai'i

Kapi'olani Community College  
Leeward Community College  
Maui College  
Windward Community College  
Honolulu Community College  
University of Hawai'i-Manoa, College of Engineering

## Wisconsin

College of Menominee Nation  
University of Wisconsin-Madison  
University of Wisconsin-Platteville



*University of Hawaii PEEC students making traditional Hawaiian sleds.*

# Lessons Learned and Recommendations



As the various Pre-Engineering Education Collaboratives complete their first years of development, workshop participants also discussed the lessons learned. Building on five years of experience, they found that some outreach and educational strategies were more successful than others. Additionally, various ways to improve coordination between tribal colleges and mainstream universities were also noted. Specifically:

## Community involvement builds stronger and more relevant programs:

At Oglala Lakota College, Hannan LaGarry felt strongly that one of their most important and successful outreach efforts was sponsorship of community charette where tribal members discussed specific ways to develop and strengthen the reservation. The ideas they generated helped set priorities for community-based research at the tribal college. LaGarry's only regret was that this meeting was not held earlier in the development of the pre-engineering program. He argued for its value and believed similar gatherings should be held annually.



## Student cohorts are hard to sustain:

In the early planning phase, there was strong interest in incorporating cohort-based learning into the pre-engineering programs and summer bridge programs. It was felt that student cohorts would promote social and academic support needed to succeed and were an integral part of several programs, including the Hawai'i PEEC. However, John Rand, director of STEM education within the University of Hawai'i System Office, noted that cohorts are hard to maintain in community colleges where part-time study is common and students arrive with different skill levels. Other ways to promote social and academic engagement are needed.



Top to bottom: Dr. Jody Chase, program director, Tribal Colleges and Universities Program, National Science Foundation; Dr. Rebecca Bates, program director, National Science Foundation; and Dr. Robert Pieri, professor of mechanical engineering, North Dakota State University.

**Year-round programs may help promote retention:** John Rand also noted that there is value in keeping community college students engaged all year. Summer is viewed by many as a break, but Rand cautioned, “you might lose them.” He argued for the value of multiple “bridge” programs, linking each academic year.

**Student recruitment requires more time and resources than anticipated:** Precisely because recruitment is troublesome for the colleges, workshop participants focused much discussion on strengthening their efforts. There was general agreement that colleges needed to more actively promote engineering to high school students and also support efforts to strengthen the quality of STEM education at the K–12 level.

Finally, workshop participants cautioned that the **growth of pre-engineering programs is an incremental process.** Emphasizing the challenge of building interest in engineering and overcoming poor academic preparation, they stressed that engineering degree programs will take longer to mature. However, they also asserted that today’s graduates are already making a difference in their communities and, of equal importance, they are serving as role models for the next generation of students. Through the partnerships that have been established and the innovative academic programs now in place, engineering has become, for the first time, an accessible and relevant profession for thousands of American Indians and Native Hawaiians.



*Top to bottom: Manuela Romero, interim associate dean for undergraduate affairs, UW-Madison; Ann Vallie, pre-engineering instructor, Turtle Mountain Community College; and Dr. Carty Monette, senior associate, Tribal College Research Group.*

# Workshop Participants to Nov, 26, 2014

## Hawai'i

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UH-Kapi'olani Community College

Heather Stroupe  
Assessment Specialist  
UH-Windward Community College

Hannah Keikiokanani Aldridge  
PEEC Pre-Engineering Specialist  
UH-Leeward Community College

Tasha Kawamata-Ryan  
PEEC Retention Coordinator  
UH-Manoa

Joshua Kaakua  
Coordinator, College of Engineering  
UH-Manoa

Mark Hoffman  
Assistant Professor, Electronic &  
Computer Engineering Technology  
UH-Maui

John Rand  
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UH System Office

Peter Crouch  
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Sitting Bull College

Lane Azure  
Vice President, Academic Affairs  
Cankdeska Cikana Community College

Rhonda Gustafson  
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## About the Author

Paul Boyer authored two reports on the tribal college movement for the Carnegie Foundation for the Advancement of Teaching and is founding editor of the Tribal College Journal. Recent books and policy reports include *Building Community: Reforming Math and Science Education in Rural Schools* (University of Alaska Press, 2006) and *Ancient Wisdom, Modern Science: The Integration of Native Knowledge in Math and Science at Tribally Controlled Colleges and Universities* (Salish Kootenai College Press, 2010). He holds a doctorate in Educational theory and policy from The Pennsylvania State University.

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