

Bringing Engineering to Indians



A Status Report on the
National Science Foundation's
Pre-Engineering Education
Collaborative

By Paul Boyer





Introduction

IN THE FALL OF 2010 the National Science Foundation awarded \$15 million for development of two-year pre-engineering degree programs within the nation's tribally controlled colleges and Native Hawaiian serving community colleges. Known as the Pre-Engineering Education Collaboratives (PEEC), the activity is also expected to promote the successful transfer of tribal college and Native Hawaiian students into four-year engineering programs within mainstream universities.

Recognizing the importance of communication between all institutions participating in these collaboratives, the National Science Foundation funded a two-day networking conference in the summer of 2012. Hosted by Sisseton Wahpeton College, the "National Science Foundation Pre-Engineering Education Collaboratives Workshop" convened representatives of every PEEC award along with key National Science Foundation staff for discussion of the program's goals, early successes, and challenges as awardees concluded their second year of implementation.

While the first round of PEEC grants will not end until 2016, presentations and discussions at this workshop revealed several promising trends.

Colleges are building strong relationships with each other and some efforts—in math acceleration, undergraduate research, and K–12 outreach, among others—are already yielding positive results. Reports from each of the collaboratives made it clear that colleges are already strengthening their STEM programs and developing new approaches to instruction.

At the same time, participants candidly acknowledged the difficulty of their task. The challenges of student recruitment, academic remediation, and project sustainability loomed large in presentations and discussions. Frequently, conversations touched on deeper, even philosophical questions: Is engineering compatible with traditional cultural values? Are all Native students capable of high academic achievement and to what extent should faculty nurture struggling students? Are difficult "gatekeeper" courses, such as calculus, necessary prerequisites for entry into engineering programs, or unnecessary barriers for otherwise promising students?

A willingness to engage in a cordial discussion of these and other issues suggested that workshop participants were searching for a new and richer understanding of their profession. Deeply committed to both the advancement of Native communities and the enrichment of the engineering profession, participants allowed themselves to test long held assumptions and learn from each other's work. Some of these discussions and recommendations are captured in this brief report.



The Pre-Engineering Education Collaboratives: An Overview

THE GOAL OF PEEC is to support the growth and development of two-year pre-engineering degree programs within tribally controlled colleges and Hawai'i's network of community colleges. Specifically, the threefold task of PEEC is to:

- ◆ Identify approaches to teaching and learning that increase enrollment, retention and graduation rates of Native pre-engineering students.
- ◆ Support development of new and expanded engineering programs within tribal colleges.
- ◆ Strengthen collaboration between tribal colleges and mainstream colleges and universities in engineering education.

Collectively, these strategies are expected to work together, creating “a curriculum and education experience with learning level flexibility,

meaningful community relevance, and preparation for higher level learning,” according to Michael Reischman, former deputy assistant director of engineering, who was instrumental in developing PEEC. “It’s not a numbers game,” he added. “It’s the impact you have.”

The NSF awarded four PEEC collaboratives in the fall of 2010. However, several projects represent two or more tribal colleges. In addition, every collaborative includes at least one mainstream university partner. As a result, PEEC actually involves twelve awards and seventeen separate institutions: six tribally controlled colleges, five Native Hawaiian-serving community colleges, and six mainstream state university campuses.



Workshop Participants

PARTICIPANTS IN THE PEEC workshop included representatives of three key stakeholders. Their unique roles contributed to the richness of the workshop's presentations and discussions.

The National Science Foundation

The Pre-Engineering Education Collaboratives is jointly sponsored by the National Science Foundation's Directorate of Engineering and the Tribal Colleges and Universities Program (TCUP), which is part of the Directorate for Education and Human Resources. Reflecting the foundation's commitment to this initiative, the workshop was

attended by the assistant director of engineering, program officers and program directors from both directorates (a complete list of all participants is included at the end of this report).

PEEC builds on a longstanding commitment to tribal colleges and Native communities within the NSF. For more than a decade, the foundation's Tribal Colleges and Universities Program has funded programs that strengthen math and science education within the nation's tribally controlled colleges and universities, as well as other Native serving colleges in Hawai'i and Alaska. The development of new undergraduate degree



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programs in environmental science, computer engineering, science education, and other fields is the direct result of TCUP support.

Tribal Colleges and Native Hawaiian Serving Colleges

Tribally controlled colleges are at the center of the initiative. Located on or near reservations, these institutions train students for jobs that are locally available and focus on programs that promote social and economic development of their tribal nations. Because they are an integral part of the communities they serve, tribal colleges have a nuanced understanding of the barriers Indian students face and special insight into strategies that promote their academic success. For this reason, faculty, staff and administrators from each tribal college funded under PEEC played an especially important role in the discussion.

In addition, the Pre-Engineering Education Collaboratives also included five community colleges within the University of Hawai'i system. Unlike tribal colleges, these community colleges are public, state supported institutions with a

mandate to serve all residents. However, they do have a recognized responsibility to support the particular needs of Native Hawaiian students who, like tribal college students, are deeply committed to culture and community service. In this way, the needs and priorities of the Hawai'i collaborative parallels tribal communities on the mainland.

Mainstream University Partners

Finally, the workshop included faculty and administrators from colleges of engineering within the partnering mainstream universities. These mainstream universities play a vital role in fulfilling the vision of PEEC by supporting academic programs offered by the tribal colleges and providing opportunities for graduates from pre-engineering programs to complete four-year engineering degrees. In turn, mainstream university partners anticipate increased enrollment of minority students in their engineering programs and hope to benefit from the unique insights brought by students from tribal and Native communities.



RUSS MCDONALD

PEEC in Context

THROUGH PRESENTATIONS and wide ranging discussions, workshop participants addressed the larger social, cultural, and educational forces that influence their work. These themes provide context to the PEEC project and help identify both opportunities and challenges faced by each collaborative. Four key themes were emphasized throughout the discussion:

First, participants acknowledged that engineering is poorly understood within Native communities and its value is not widely appreciated.

Tribal college participants frequently noted that Native American students know very little about engineering. Because tribal colleges are located in rural and impoverished communities, most students have never met an engineer and have, at best, only a vague understanding of the profession. “People don’t know what they do,” said Russ

CARTY MONETTE



McDonald, vice president of academic affairs at Cankdeska Cikana Community College. Not surprisingly, very few tribal members think about becoming engineers when they enroll in college.

But the problem extends beyond a lack of exposure to the engineering profession. Another, and potentially greater, barrier is the belief that engineering is a ‘non-Indian’ field of study, irrelevant to the needs of tribal communities and distant from tribal culture and values. “We need to explain how it might help the community,” observed Diana Morris, chief academic officer at the College of Menominee Nation. Tribal colleges must “challenge the view that math and science are opposed to traditional ways of getting things done.”

Second, participants were reminded that tribal colleges serve poor communities and academically under-prepared students. While there is great diversity among native communities, most suffer from extremely high rates of unemployment—60 percent or more is common—and are served by K–12 schools with high drop out rates and, frequently, low levels of academic achievement.

In this context, most Native students who enroll in college need extensive remedial coursework before they are ready to earn college credit and many struggle financially, even when supported by loans and scholarships. It is common for students to drop out or stop out from college, not for academic reasons, but because a car breaks down, an elderly relative needs care, or other family emergencies emerge. Demanding programs, such as engineering, must acknowledge these barriers by providing strong academic and financial support, according to many workshop participants.

Tribal college leaders also reminded participants that they represent young and

under-funded institutions that are still building capacity in STEM education. Most are small (enrollments range from under 300 to around 2,000 students) and because they are not state supported and serve communities that lack a tax base “they have nowhere to turn but the federal government,” noted Carty Monette, former president of Turtle Mountain College who served as a consultant for the PEEC workshop. However, federal funding does not keep pace with the colleges’ growth, which means that most receive less funding per student than mainstream colleges and universities and necessarily operate on shoestring budgets.

Tribal college leaders note that the National Science Foundation has had a strong impact on the growth of STEM programs within the movement. But all agree that most colleges are still building capacity in their core math and science programs. Resources that most public universities take for granted—such lab facilities and student support staff—exist at a more rudimentary level on many tribal college campuses.

Third, participants recognized barriers to collaboration. Faculty and administrators praised the quality of collaboration between tribal and mainstream partners. At the same time, attendees acknowledged that they must overcome both cultural and institutional barriers in order to create strong and sustainable relationships.

When addressing this theme, participants tended to focus on barriers that exist within their own institutions. Tribal college leaders, for example, emphasized their own responsibility for developing courses that fulfill university prerequisites and prepare their students for the rigors of university life. Universities can only fulfill their role in PEEC, noted Diana Morris, “after the





TOM PETERSON

College of Menominee Nation is able to get students ready for transfer.”

Mainstream institutions, meanwhile, stressed the importance of learning from their tribal and community college colleagues. Tom Peterson, assistant director for engineering at NSF, urged his colleagues in mainstream institutions to recognize the leadership role of tribal colleges, despite their small size and relative poverty. “We must eat a little humble pie,” he said, “and turn to the colleges that have greater success in educating Native students.”

Participants also identified barriers to greater involvement from mainstream university faculty. PEEC emphasizes community service and undergraduate instruction, work that is not always rewarded in institutions that view research as the most reliable path to promotion and tenure. There is “pressure at the top” to increase research at mainstream universities, observed Jason Tinant, chair of the math and science department at Oglala Lakota College. In addition, some faculty simply do not want to change how they teach or participate in projects that might require more coaching and remediation.

While PEEC cannot resolve this debate over research or force faculty interest, all agreed that support from university leaders is essential. Administrative buy-in is needed to assure sustainability, argued Michael Reichman, adding that lack of involvement from top administrators is one of the main

threats facing the pre-engineering collaboratives. Some within mainstream institutions agreed that support from university leaders is, in some cases, “nominal at best.”

Finally, workshop participants acknowledged that they work in a climate of accountability. To satisfy the needs of the National Science Foundation, Congress, and the Office and Management and Budget, it will be important to document success with hard numbers, asserted Tom Peterson. The NSF is feeling “pressure to get quantitative outcomes to share with legislators,” he said. Collaboratives should gather evidence of increased enrollment and retention of Native and Indian students in order to satisfy the “bottom line” concerns of Washington.

On the other hand, “outcomes” are often viewed more holistically in Native communities, according to tribal college leaders. Because tribal colleges are small and most serve small reservations, the total number of graduates will also be relatively small. However, even a handful of Native engineers will have a tremendous impact on tribal communities in the decades to come. A single Native engineer can help promote tribal self governance and raise expectations for future generations. In addition, the development of strong pre-engineering programs will enrich a college’s entire STEM curriculum. Ignoring these broader and qualitative outcomes risks missing the full impact of the initiative over time.

The task is to reconcile the needs of both constituents. According to Carol Davis, former academic dean at Turtle Mountain Community College, the best strategy is to collect both data and stories that put the work of PEEC in a larger social and cultural context. Invited to speak about culturally-based assessment, she advised grantees to “document everything”—both quantitative and qualitative—but to remain grounded



CAROL DAVIS



“ There is evidence that these strategies are engaging student interest, strengthening the STEM curriculum, and building a strong academic foundation. ”

in the values and needs of the community. “Tribal colleges reflect tribal values,” she asserted. “Our evaluations need to tell our story.”

Supporting this more holistic view of assessment, TCUP Program Director Jody Chase stressed that the primary goal of the program is capacity building within TCU’s and other TCUP-eligible institutions. When evaluating the success of a project funded through TCUP, her first question is “Did you have it before?” Her second question is “Do you have it now?” If the answer to the first question is “no” and the answer to the second is “yes,” she said, “that’s capacity building.” Implementation and sustainability are areas that significantly affect a project’s success. She is not as concerned about low numbers of students

served during the early years of a project. Allaying concerns of grantees, she expressed confidence, based on a decade of experience, that new degree opportunities will attract students.

Finally, there was repeated discussion over the “scalability” of the projects. While the goal of PEEC is to build pre-engineering programs within the four collaboratives, is it also testing several new approaches to instruction (which will be discussed later in this report). For some, the ability to replicate promising innovations at other institutions was another program goal. However, others emphasized the unique context of every tribal college site. “When you have seen one reservation, you have only seen one reservation,” said Russ McDonald.

Status Reports: Testing Ideas, Building Relationships, Looking for Results

ALL COLLABORATIVES are working to develop pre-engineering degrees and seamless transfer programs for students entering mainstream universities. However, approaches to student recruitment and instruction vary. During the workshop, project leaders shared information about their successes, focusing on their distinctive approaches to implementation.

Collectively, the four collaboratives are each testing one or more pieces of a “conceptual curriculum” developed in the early formation of the project. It includes four specific strategies:

- ◆ Promoting K–12 outreach in order to develop interest in engineering careers;
- ◆ Forming student cohorts for social and academic support;

- ◆ Integrating individualized, computer-based learning, especially in core math courses;
- ◆ Testing new approaches to instruction that incorporate student research and community-based projects.

This “conceptual curriculum” is not prescriptive; grantees are free to develop projects that best reflect their own needs and resources. But each project is using at least one of the four elements and workshop presentations highlighted their experiences with these strategies. While it is too early to evaluate results, there is evidence that these strategies are engaging student interest, strengthening the STEM curriculum, and building a strong academic foundation.



Hawai'i Collaborative: Online Learning with Summer Academic Enrichment

HAWAI'I'S PRE-ENGINEERING collaborative, which it calls the Indigenous Knowledge in Engineering (IKE) project, involves five state community college campuses and the University of Hawai'i at Manoa. Serving multiple campuses on two islands, the Hawai'i PEEC is emphasizing development of online and computer-based instruction for most core math and science courses. In addition, the project has developed three summer enrichment experiences (called Summer Engineering Experiences) for cohorts of Native Hawaiian students enrolled in the various community college campuses.

Workshop presentations by faculty involved in the Hawai'i collaborative focused, in particular, on computer-based instruction in a range of math courses, from pre-Calculus to Calculus III, a difficult but required gatekeeper course in the pre-engineering curriculum. Employing the increasingly popular “Math Emporium Model”, which provides individualized, computer-based instruction, students move through the material at an accelerated six-week pace, building skills through guided exercises, quizzes and periodic tests.

Students are also offered a range of academic support services, such as instructional videos and one-on-one peer mentor and faculty support—and new services are being added as the program evolves.

For example, project

leaders incorporated mandatory participation in tutorials after the first year in order reach students who were struggling academically but not seeking help, according to Hervé Collin, assistant professor of physics at Kapi'olani Community College. Looking to the future, project leaders see a need for more academic support in online coursework. “Students want lectures,” one noted.

Online courses and computer-based instruction are enriched with summer academic experiences held on two of the community colleges and UH Mānoa. These Summer Engineering Experiences, which range from making guitars to working on wind and solar projects, apply engineering concepts and show the value of the profession in society. Project leaders also provide cultural experiences and social events that help build a sense of community and relate the engineering concepts to Native Hawaiian culture. Here, too, program leaders see the need for even more student engagement as the program evolves by increasing opportunities for social networking and mentoring.

There is emerging evidence that this work is promoting greater academic success and building interest in engineering among Native Hawaiian students. When surveyed, 65 percent of students participating in the Hawai'i PEEC strongly agreed that it enhanced their learning experiences as a STEM major; 71 percent strongly agreed it positively affected their decision to continue to a four-year institution; and 100 percent agreed or strongly agreed that they would recommend the program to other students.



JOSHUA KAAKUA

South Dakota Collaborative: Engineering for Tribal Development

THE SOUTH DAKOTA PEEC, which involves Oglala Lakota College and two mainstream universities, has also achieved many of its project goals. By the second year, the tribal college has developed a complete pre-engineering curriculum and established strong articulation agreements with its partner institutions, South Dakota State University and the South Dakota School of Mines and Technology.

However, it is clear that this collaborative is hoping to accomplish much more. Building on strong relationships, faculty from all three institutions are engaging students in a wide array of research projects that teach engineering skills and, of equal importance, address social, cultural and environmental concerns within the sprawling Pine Ridge Reservation. Here, development of an engineering program is clearly part of a larger effort to strengthen the impoverished tribal nation.

Projects include an effort to restore a deteriorating World War II memorial on the reservation, test water quality in reservation streams, and monitor data from a meteorological tower in order to identify possible development of wind energy turbines. These and several other projects serve a dual purpose, according to faculty. They teach skills and concepts that are at the foundation of the engineering profession while also providing information that is genuinely useful to the tribe.

There is a great deal of concern over water quality, for example. “People ask, ‘Is the water safe to drink?’” said Charles Jason Tinant, PEEC program coordinator at Oglala Lakota College. Tests conducted by PEEC students, under the

guidance of experienced faculty, will help answer that question. Meteorological and geological data will be used by tribal leaders to determine future energy and agriculture policy.

Project leaders also identified several other “serendipitous outcomes,” including an increased focus on research and fieldwork within the chemistry department as well as development of a tribal botanical collection. Of special importance, according to Tinant, is the college’s focus on building partnerships with tribal and non-governmental development agencies. For example, PEEC has helped the college become an active partner in the development of a new planned community within the reservation that is building energy efficient homes and relying on solar and wind energy. Similarly, rainfall analysis was collected at the request of the tribe and will be used to plan agricultural policy.

This focus on project-based learning reflects a belief that tribal college students will be drawn to engineering when they see how it can be used to make a difference in their community. And reports from faculty leaders suggest that this focus



“ By working together, tribal colleges are able to share resources and build a rich pre-engineering program for each participating college. ”

on active learning does indeed engage students and teach concepts that, in a conventional engineering program, might not be introduced until graduate school.

However, project leaders noted a range of challenges. A particular concern is the low level of math proficiency among incoming tribal college students. Many need extensive remediation before they can pursue higher level math courses and may require eight or nine years to complete an engineering degree. When faced with such a daunting task, recruitment and retention is

difficult. For example, some students attracted to engineering will nonetheless “migrate” to the natural sciences, where math is less of a barrier.

As the South Dakota PEEC moves forward, leaders will need to coordinate multiple, logistically complex projects; continue to address the need for recruitment and academic remediation; and strengthen institutional relationships with mainstream partners in order to increase both transfer and retention rates for OLC students pursuing four-year engineering degrees.

North Dakota Collaborative: Building Connections; Bridging Distances

WHILE INTRODUCING the North Dakota PEEC, Robert Pieri, professor of mechanical engineering at North Dakota State University, projected a map of his state and noted the location of the five participating tribal colleges and the state university. The distances between institutions were, he observed, greater than the distance between some of the Hawaiian Islands and, in winter, travel between each is often treacherous. In a sense, each college is like its own island, separated by miles of prairie.

Despite these barriers, cooperation is a fundamental part of this project. Because most of the four tribally controlled colleges are small, development of strong pre-engineering programs must be a shared effort. Individually, most do not have the faculty, student count or resources needed to support their own programs. “People say, we can do this ourselves,” said Russ McDonald, vice president of academic affairs at Cankdeska Cikana Community College, “but we’re

not there yet.” By working together, however, tribal colleges are able to share resources and build a rich pre-engineering program for each participating college.

To reach this goal, the North Dakota Collaborative is focusing on offering courses via distance learning technology and providing summer academic enrichment programs on the university campus. Working together, students are able to complete pre-engineering degree programs from even the smallest and remotest North Dakota reservation, while also having access to faculty and resources usually found only at the state university.

Workshop presenters emphasized the strength of their partnerships. Lane Azure, director of institutional assessment at Cankdeska Cikana College, characterized their work as “a true collaboration.” At the same time, faculty involved in the initiative also noted a variety of challenges. Distance learning technology is old and, some

TIMOTHY LEGG, JOSHUA KAAKUA, AND LANE AZURE

felt, outdated (others disagreed). Robert Pieri also said that instructors are not always experienced teachers and, in particular, are not always ready to work with distance learning technology. More training was suggested. The importance of providing on-site support for students enrolled in these courses was also noted.

Echoing findings at other PEEC sites, project leaders stressed the challenge of recruiting students into pre-engineering programs and reducing the time needed for academic remediation. The need for enrichment programs and social support was also stressed. “You *have* to bring [students] together,” said Pieri. “They *must* have face time.”

Finally, tribal college leaders placed special emphasis on the cultural context of their work. Indian controlled colleges in the state serve



multiple cultures, explained Russ McDonald. Each community has its own heritage, language, politics, and vision for the future. Cooperative work on a pre-engineering program cannot be a one size fits all effort. Instead, the work must serve the individual needs of each community and, ultimately, strengthen Native identities, he said.

Ultimately, McDonald said, “Initiatives like this build capacity so that we can do it on our own in the future.”

Wisconsin Collaborative: Student Support and High Expectations

INTRODUCING THE WISCONSIN pre-engineering collaborative, Diana Morris, chief academic officer at the College of Menominee Nation, reminded participants that, for Indian students, lack of academic achievement does not mean a lack of academic ability. Indian students can succeed, she said, when offered what all students need—support and high expectations.

This philosophy infuses the entire collaborative, which involves the College of Menominee Nation and two partnering mainstream institutions, University of Wisconsin-Madison and the University of Wisconsin-Platteville. As the tribal college works to build its pre-engineering program and prepare students for transfer to state universities, it is guided by a dual focus on

student support and academic rigor. The college’s mandate, Morris said, is to “walk” with students, but not to “carry” students. It is assumed that students will work hard and even “struggle” to master skills and concepts.

However, students are not expected to struggle in isolation. By setting high expectations for all students, the college is also expecting more from itself. Its approach focuses on academic support, active involvement of UW faculty advisors, and development of an effortless transfer experience for students. The college is also making use of student cohorts, which help form supportive learning communities for students.

Two years into the project, the college’s curriculum committee has approved the required



“ Mainstream university partners are also supporting development of the program through student recruitment and summer enrichment programs. ”

pre-engineering courses and hired necessary faculty. In addition, labs have been built and equipped, and three students have been recruited. While the college, like all tribal colleges, is open admissions, students must apply for entry into the engineering program and meet a set of academic expectations.

Mainstream university partners are also supporting development of the program through student recruitment and summer enrichment programs. For example, the “Explore Engineering” summer program provides high school students from the reservation an opportunity to learn about the profession while attending programs on a university campus. In addition, university liaisons and faculty are a regular presence at the college and reservation schools.

The degree to which the college and universities are working to create what Morris characterizes as one “seamless degree” was illustrated by

the story of a tribal college faculty member who is purposefully imitating the teaching style his students will find in a large university. Because most tribal college classes are small and informality is the rule, faculty generally invite discussion, minimize lectures, and sit facing students. However, this instructor made a point of lecturing at a board while facing away from his students in order to preview the lecture hall experience. In turn, UW faculty acknowledged that they could learn from the less formal, more personal instruction normally found in tribal colleges.

Here, too, leaders focus on recruitment and retention as their primary concerns. The goal of the project is to graduate and transfer twenty pre-engineering students by 2015. For a small college with high standards, this is an ambitious goal and will require close cooperation with its mainstream partners.

Findings and Next Steps

COLLECTIVELY, PRESENTERS told a story of success. Most sites have completed or nearly completed development of their pre-engineering curriculum. All have forged strong relationships among partnering institutions, allowing students to move from two-year programs into baccalaureate programs within state universities. These accomplishments satisfy a primary goal of the initiative.

In addition, project participants told stories of innovation. Experiments with student cohorts, self paced study, project-based learning, and community service indicate that PEEC is actively looking for new approaches to instruction in engineering and STEM fields generally. Preliminary

findings suggest that these approaches engage student interest, support the needs of tribal nations, and provide a richer, more relevant academic experience.

Discussions also revealed that this work is not always easy. There is, for example, widespread concern over the difficulty of student recruitment and academic remediation. Amid all of the innovation, project leaders are clearly wondering if their strategies will attract enough students and promote retention. Participants clearly appreciated the opportunity to share stories of success, recommend resources, and troubleshoot problems. In particular, workshop participants were eager to discuss ways to shorten time needed for

remediation, increase success rates in core math courses, and engage the interest of high school students.

However, the discussion frequently broadened to philosophical reflections on higher education and the engineering profession. Because the project requires collaboration across cultures and challenges educators to reach a community of learners traditionally overlooked by the engineering profession, workshop participants challenged each other by asking difficult, even potentially destabilizing questions: Are all students capable of being engineers? If not, how is aptitude identified? Are academic expectations too high or too narrowly defined? What role should engineering play in society?

In this conversation, representatives of tribal and Native serving colleges frequently emphasized the larger context of their work. Tribal college leaders, in particular, discussed their responsibility to serve the needs of their tribal nations. In their view, engineering is not only a path to employment, but also a tool for cultural, social and economic renewal. To succeed, engineering programs must demonstrate their relevance to Native peoples and tribal nations.

Similarly, tribal college leaders also emphasized their commitment to broadening student access. While engineering is traditionally viewed as a rigorous and, therefore, highly selective discipline, tribal and Native serving colleges are looking for ways to remove unnecessary barriers. Their self-imposed mandate is to reach and support students who would not otherwise pursue engineering—to gather instead of winnow.

To fulfill these larger goals, several participants argued that deeper, more systemic changes might be needed. Indeed, the conversation touched on several possible areas of reform and innovation, including:



- ◆ Rethinking the role of math in the pre-engineering curriculum. Must calculus be a necessary gatekeeper for entry into the engineering profession? Must all engineers be equally proficient in math? Alan Cheville, a program director within the Engineering Education and Centers Division of the National Science Foundation challenged his colleagues to explore these questions by “flipping” the relationship between math and engineering. What would happen, he asked, if the discipline put math in service to engineering, rather than view engineering as the “application of math”? Potentially, new paths would open for a wider range of students.
- ◆ Expanding project-based instruction. Several PEEC sites are focusing on hands-on learning, either in the pre-engineering curriculum or through summer enrichment programs. However, it might be possible to greatly expand this form of learning. Rebecca Bates, an AAAS Science & Technology Policy Fellow at National Science Foundation, discussed a new engineering degree program taught entirely through student-designed projects. Working in close collaboration with businesses and industries in northern Minnesota, the Iron Range Engineering model, sponsored by the Minnesota State



“ The strength of engineering is its understanding that ‘there are no universal truths.’ ”



University-Mankato, takes students who have completed community college coursework and offers a bachelor's degree program that eliminates all classroom study and is, instead, "one hundred percent project based," Bates said. Still in its infancy, the program is already graduating students who quickly find local employment or entry into graduate school.

◆ Connecting engineering to the liberal arts. Native students often view engineering as a "non-Indian" discipline. However, Diana Morris noted that engineering is, in fact, an integral part of the cultural heritage of Indigenous peoples in the Americas. Long before European settlement, various indigenous groups were building complex structures, whole cities, and sophisticated irrigation systems. Modern engineering feels alien, she argued, only because it uses unfamiliar words and specialized technology. Underlying concepts, however, are both accessible and "traditional." Integrating the study of

engineering with the disciplines of history, anthropology, and sociology, among others, can build a richer, more inclusive understanding of the profession and its role in all societies.

The profession should welcome these and other innovations, argued Alan Cheville. The strength of engineering is its understanding that "there are no universal truths," he said. Pragmatic and adaptable, engineers know that "context is everything in the execution of a project." A strong program of education, he suggested, should be responsive to the unique needs of the community serves. This openness to change also benefits the profession, noted Tom Peterson. Native and Indian students should be encouraged to bring new ideas into the discipline. Diversity is needed, he said, in "thinking and problem solving."

These and other visionary ideas suggest that PEEC has the potential to not only nurture the development of pre-engineering programs within the various sites, but to also develop a richer, more engaged model of engineering education for America. As the pre-engineering collaborative begins its work, its accomplishments are already becoming clear, but its full potential is still being discovered.





Workshop Participants

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